Assignment_8_draft

August 18, 2019

```python
[1]: # coding: utf-8

     # Program by Thomas W. Miller, August 16, 2018

     # Previous work involved gathering embeddings via chakin
     # Following methods described in
     #     https://github.com/chakki-works/chakin
     # The previous program, run-chakin-to-get-embeddings-v001.py
     # downloaded pre-trained GloVe embeddings, saved them in a zip archive,
     # and unzipped that archive to create the four word-to-embeddings
     # text files for use in language models.

     # This program sets uses word embeddings to set up defaultdict
     # dictionary data structures, that can them be employed in language
     # models. This is demonstrated with a simple RNN model for predicting
     # sentiment (thumbs-down versus thumbs-up) for movie reviews.

     from __future__ import absolute_import
     from __future__ import division
     from __future__ import print_function

     import numpy as np

     import os  # operating system functions
     import os.path  # for manipulation of file path names

     import re  # regular expressions

     from collections import defaultdict

     import nltk
     from nltk.tokenize import TreebankWordTokenizer

     import tensorflow as tf
```

```python
[2]: RANDOM_SEED = 9999
```

```python
# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

REMOVE_STOPWORDS = False  # no stopword removal

EVOCABSIZE = 10000  # specify desired size of pre-defined embedding vocabulary
```

```python
# ------------------------------------------------------------
# Select the pre-defined embeddings source
# Define vocabulary size for the language model
# Create a word_to_embedding_dict for GloVe.6B.50d
embeddings_directory = 'embeddings/gloVe.6B'
filename = 'glove.6B.50d.txt'
embeddings_filename = os.path.join(embeddings_directory, filename)
# ------------------------------------------------------------

# Utility function for loading embeddings follows methods described in
# https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
# Creates the Python defaultdict dictionary word_to_embedding_dict
# for the requested pre-trained word embeddings
#
# Note the use of defaultdict data structure from the Python Standard Library
# collections_defaultdict.py lets the caller specify a default value up front
# The default value will be retuned if the key is not a known dictionary key
# That is, unknown words are represented by a vector of zeros
# For word embeddings, this default value is a vector of zeros
# Documentation for the Python standard library:
#   Hellmann, D. 2017. The Python 3 Standard Library by Example. Boston:
#     Addison-Wesley. [ISBN-13: 978-0-13-429105-5]
def load_embedding_from_disks(embeddings_filename, with_indexes=True):
    """
    Read a embeddings txt file. If `with_indexes=True`,
    we return a tuple of two dictionnaries
    `(word_to_index_dict, index_to_embedding_array)`,
    otherwise we return only a direct
    `word_to_embedding_dict` dictionnary mapping
    from a string to a numpy array.
    """

    if with_indexes:
        word_to_index_dict = dict()
        index_to_embedding_array = []

    else:
        word_to_embedding_dict = dict()
```

```python
    with open(embeddings_filename, 'r', encoding='utf-8') as embeddings_file:
        for (i, line) in enumerate(embeddings_file):

            split = line.split(' ')

            word = split[0]

            representation = split[1:]
            representation = np.array(
                [float(val) for val in representation]
            )

            if with_indexes:
                word_to_index_dict[word] = i
                index_to_embedding_array.append(representation)
            else:
                word_to_embedding_dict[word] = representation

    # Empty representation for unknown words.
    _WORD_NOT_FOUND = [0.0] * len(representation)
    if with_indexes:
        _LAST_INDEX = i + 1
        word_to_index_dict = defaultdict(
            lambda: _LAST_INDEX, word_to_index_dict)
        index_to_embedding_array = np.array(
            index_to_embedding_array + [_WORD_NOT_FOUND])
        return word_to_index_dict, index_to_embedding_array
    else:
        word_to_embedding_dict = defaultdict(lambda: _WORD_NOT_FOUND)
        return word_to_embedding_dict

print('\nLoading embeddings from', embeddings_filename)
word_to_index, index_to_embedding = \
    load_embedding_from_disks(embeddings_filename, with_indexes=True)
print("Embedding loaded from disks.")

# Note: unknown words have representations with values [0, 0, ..., 0]
```

Loading embeddings from embeddings/gloVe.6B/glove.6B.50d.txt
Embedding loaded from disks.

```python
[4]: # Additional background code from
     # https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
     # shows the general structure of the data structures for word embeddings
     # This code is modified for our purposes in language modeling
```

```python
vocab_size, embedding_dim = index_to_embedding.shape
print("Embedding is of shape: {}".format(index_to_embedding.shape))
print("This means (number of words, number of dimensions per word)\n")
print("The first words are words that tend occur more often.")

print("Note: for unknown words, the representation is an empty vector,\n"
      "and the index is the last one. The dictionnary has a limit:")
print("    {} --> {} --> {}".format("A word", "Index in embedding",
      "Representation"))
word = "worsdfkljsdf"  # a word obviously not in the vocabulary
idx = word_to_index[word] # index for word obviously not in the vocabulary
complete_vocabulary_size = idx
embd = list(np.array(index_to_embedding[idx], dtype=int)) # "int" compact print
print("    {} --> {} --> {}".format(word, idx, embd))
word = "the"
idx = word_to_index[word]
embd = list(index_to_embedding[idx])  # "int" for compact print only.
print("    {} --> {} --> {}".format(word, idx, embd))

# Show how to use embeddings dictionaries with a test sentence
# This is a famous typing exercise with all letters of the alphabet
# https://en.wikipedia.org/wiki/The_quick_brown_fox_jumps_over_the_lazy_dog
a_typing_test_sentence = 'The quick brown fox jumps over the lazy dog'
print('\nTest sentence: ', a_typing_test_sentence, '\n')
words_in_test_sentence = a_typing_test_sentence.split()

print('Test sentence embeddings from complete vocabulary of',
      complete_vocabulary_size, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = index_to_embedding[word_to_index[word_]]
    print(word_ + ": ", embedding)
```

```
Embedding is of shape: (400001, 50)
This means (number of words, number of dimensions per word)

The first words are words that tend occur more often.
Note: for unknown words, the representation is an empty vector,
and the index is the last one. The dictionnary has a limit:
    A word --> Index in embedding --> Representation
    worsdfkljsdf --> 400000 --> [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0]
    the --> 0 --> [0.418, 0.24968, -0.41242, 0.1217, 0.34527, -0.044457,
-0.49688, -0.17862, -0.00066023, -0.6566, 0.27843, -0.14767, -0.55677, 0.14658,
-0.0095095, 0.011658, 0.10204, -0.12792, -0.8443, -0.12181, -0.016801, -0.33279,
-0.1552, -0.23131, -0.19181, -1.8823, -0.76746, 0.099051, -0.42125, -0.19526,
```

```
4.0071, -0.18594, -0.52287, -0.31681, 0.00059213, 0.0074449, 0.17778, -0.15897,
0.012041, -0.054223, -0.29871, -0.15749, -0.34758, -0.045637, -0.44251, 0.18785,
0.0027849, -0.18411, -0.11514, -0.78581]

Test sentence:  The quick brown fox jumps over the lazy dog

Test sentence embeddings from complete vocabulary of 400000 words:

the:  [ 4.1800e-01  2.4968e-01 -4.1242e-01  1.2170e-01  3.4527e-01 -4.4457e-02
 -4.9688e-01 -1.7862e-01 -6.6023e-04 -6.5660e-01  2.7843e-01 -1.4767e-01
 -5.5677e-01  1.4658e-01 -9.5095e-03  1.1658e-02  1.0204e-01 -1.2792e-01
 -8.4430e-01 -1.2181e-01 -1.6801e-02 -3.3279e-01 -1.5520e-01 -2.3131e-01
 -1.9181e-01 -1.8823e+00 -7.6746e-01  9.9051e-02 -4.2125e-01 -1.9526e-01
  4.0071e+00 -1.8594e-01 -5.2287e-01 -3.1681e-01  5.9213e-04  7.4449e-03
  1.7778e-01 -1.5897e-01  1.2041e-02 -5.4223e-02 -2.9871e-01 -1.5749e-01
 -3.4758e-01 -4.5637e-02 -4.4251e-01  1.8785e-01  2.7849e-03 -1.8411e-01
 -1.1514e-01 -7.8581e-01]
quick:  [ 0.13967   -0.53798   -0.18047   -0.25142    0.16203   -0.13868
 -0.24637    0.75111    0.27264    0.61035   -0.82548    0.038647
 -0.32361    0.30373   -0.14598   -0.23551    0.39267   -1.1287
 -0.23636   -1.0629     0.046277   0.29143   -0.25819   -0.094902
  0.79478   -1.2095    -0.01039   -0.092086   0.84322   -0.11061
  3.0096     0.51652   -0.76986    0.51074    0.37508    0.12156
  0.082794   0.43605   -0.1584    -0.61048    0.35006    0.52465
 -0.51747    0.0034705  0.73625    0.16252    0.85279    0.85268
  0.57892    0.64483  ]
brown:  [-0.88497    0.71685   -0.40379   -0.10698    0.81457    1.0258    -1.2698
 -0.49382   -0.27839   -0.92251   -0.49409    0.78942   -0.20066   -0.057371
  0.060682   0.30746    0.13441   -0.49376   -0.54788   -0.81912   -0.45394
  0.52098    1.0325    -0.8584    -0.65848   -1.2736     0.23616    1.0486
  0.18442   -0.3901     2.1385    -0.45301   -0.16911   -0.46737    0.15938
 -0.095071  -0.26512   -0.056479  0.63849   -1.0494     0.037507   0.76434
 -0.6412    -0.59594    0.46589    0.31494   -0.34072   -0.59167   -0.31057
  0.73274  ]
fox:  [ 0.44206    0.059552   0.15861    0.92777    0.1876     0.24256   -1.593
 -0.79847   -0.34099   -0.24021   -0.32756    0.43639   -0.11057    0.50472
  0.43853    0.19738   -0.1498    -0.046979 -0.83286    0.39878    0.062174
  0.28803    0.79134    0.31798   -0.21933   -1.1015    -0.080309   0.39122
  0.19503   -0.5936     1.7921     0.3826    -0.30509   -0.58686   -0.76935
 -0.61914   -0.61771   -0.68484   -0.67919   -0.74626   -0.036646   0.78251
 -1.0072    -0.59057   -0.7849    -0.39113   -0.49727   -0.4283    -0.15204
  1.5064  ]
jumps:  [-0.46105   -0.34219    0.71473   -0.29778    0.28839    0.6248
  0.36807   -0.072746   0.60476    0.31463   -0.052247  -0.62302
 -0.56332    0.7855     0.18116   -0.31698    0.38298   -0.081953
 -1.3658    -0.78263    0.39804   -0.17001   -0.11926   -0.40146
  1.1057    -0.51142   -0.36614    0.22177    0.34626   -0.30648
  1.3869     0.77328    0.5946     1.2577     0.23472   -0.46087
```

```
         -0.009223     0.44534      0.012732  -0.24749    -0.7142       0.02422
         0.083527      0.25088     -0.24259   -1.354       1.5481      -0.31728
         0.55305      -0.0028062]
over:  [ 0.12972      0.088073     0.24375    0.078102  -0.12783      0.27831
        -0.48693       0.19649     -0.39558   -0.28362   -0.47425     -0.59317
        -0.58804      -0.31702      0.49593    0.0087594  0.039613    -0.42495
        -0.97641      -0.46534      0.020675   0.086042   0.39317     -0.51255
        -0.17913      -1.8333       0.5622     0.41626    0.075127     0.02189
         3.784         0.71067     -0.073943   0.15373   -0.3853      -0.070163
        -0.35374       0.074501    -0.084228  -0.45548   -0.081068     0.39157
         0.173         0.2254      -0.12836    0.40951   -0.26079      0.090912
        -0.60515      -0.9827     ]
the:   [ 4.1800e-01  2.4968e-01 -4.1242e-01  1.2170e-01  3.4527e-01 -4.4457e-02
        -4.9688e-01 -1.7862e-01 -6.6023e-04 -6.5660e-01  2.7843e-01 -1.4767e-01
        -5.5677e-01  1.4658e-01 -9.5095e-03  1.1658e-02  1.0204e-01 -1.2792e-01
        -8.4430e-01 -1.2181e-01 -1.6801e-02 -3.3279e-01 -1.5520e-01 -2.3131e-01
        -1.9181e-01 -1.8823e+00 -7.6746e-01  9.9051e-02 -4.2125e-01 -1.9526e-01
         4.0071e+00 -1.8594e-01 -5.2287e-01 -3.1681e-01  5.9213e-04  7.4449e-03
         1.7778e-01 -1.5897e-01  1.2041e-02 -5.4223e-02 -2.9871e-01 -1.5749e-01
        -3.4758e-01 -4.5637e-02 -4.4251e-01  1.8785e-01  2.7849e-03 -1.8411e-01
        -1.1514e-01 -7.8581e-01]
lazy:  [-0.27611  -0.59712  -0.49227  -1.0372    -0.35878  -0.097425 -0.21014
        -0.092836 -0.054118  0.4542   -0.53296    0.37602   0.77087   0.79669
        -0.076608 -0.42515   0.42576   0.32791   -0.21996  -0.20261  -0.85139
         0.80547   0.97621   0.9792    1.1118    -0.36062  -0.2588    0.8596
         0.73631  -0.18601   1.2376   -0.038938   0.19246   0.52473  -0.04842
        -0.044149  0.064432  0.087822  0.42232   -0.55991  -0.44096   0.097736
        -0.17589   1.1799    0.13152  -1.0795     0.45685  -0.63312   1.2752
         1.1672  ]
dog:   [ 0.11008   -0.38781   -0.57615   -0.27714    0.70521    0.53994
        -1.0786    -0.40146    1.1504    -0.5678     0.0038977  0.52878
         0.64561    0.47262    0.48549   -0.18407    0.1801     0.91397
        -1.1979    -0.5778    -0.37985    0.33606    0.772      0.75555
         0.45506   -1.7671    -1.0503     0.42566    0.41893   -0.68327
         1.5673     0.27685   -0.61708    0.64638   -0.076996   0.37118
         0.1308    -0.45137    0.25398   -0.74392   -0.086199   0.24068
        -0.64819    0.83549    1.2502    -0.51379    0.04224   -0.88118
         0.7158     0.38519  ]
```

[5]:
```python
# ---------------------------------------------------------------
# Define vocabulary size for the language model
# To reduce the size of the vocabulary to the n most frequently used words

def default_factory():
    return EVOCABSIZE  # last/unknown-word row in limited_index_to_embedding
# dictionary has the items() function, returns list of (key, value) tuples
limited_word_to_index = defaultdict(default_factory, \
```

```
    {k: v for k, v in word_to_index.items() if v < EVOCABSIZE})

# Select the first EVOCABSIZE rows to the index_to_embedding
limited_index_to_embedding = index_to_embedding[0:EVOCABSIZE,:]
# Set the unknown-word row to be all zeros as previously
limited_index_to_embedding = np.append(limited_index_to_embedding,
    index_to_embedding[index_to_embedding.shape[0] - 1, :].\
        reshape(1,embedding_dim),
    axis = 0)

# Delete large numpy array to clear some CPU RAM
del index_to_embedding

# Verify the new vocabulary: should get same embeddings for test sentence
# Note that a small EVOCABSIZE may yield some zero vectors for embeddings
print('\nTest sentence embeddings from vocabulary of', EVOCABSIZE, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = limited_index_to_embedding[limited_word_to_index[word_]]
    print(word_ + ": ", embedding)
```

Test sentence embeddings from vocabulary of 10000 words:

the: [4.1800e-01 2.4968e-01 -4.1242e-01 1.2170e-01 3.4527e-01 -4.4457e-02
 -4.9688e-01 -1.7862e-01 -6.6023e-04 -6.5660e-01 2.7843e-01 -1.4767e-01
 -5.5677e-01 1.4658e-01 -9.5095e-03 1.1658e-02 1.0204e-01 -1.2792e-01
 -8.4430e-01 -1.2181e-01 -1.6801e-02 -3.3279e-01 -1.5520e-01 -2.3131e-01
 -1.9181e-01 -1.8823e+00 -7.6746e-01 9.9051e-02 -4.2125e-01 -1.9526e-01
  4.0071e+00 -1.8594e-01 -5.2287e-01 -3.1681e-01 5.9213e-04 7.4449e-03
  1.7778e-01 -1.5897e-01 1.2041e-02 -5.4223e-02 -2.9871e-01 -1.5749e-01
 -3.4758e-01 -4.5637e-02 -4.4251e-01 1.8785e-01 2.7849e-03 -1.8411e-01
 -1.1514e-01 -7.8581e-01]
quick: [0.13967   -0.53798   -0.18047   -0.25142   0.16203   -0.13868
 -0.24637   0.75111   0.27264   0.61035   -0.82548   0.038647
 -0.32361   0.30373   -0.14598   -0.23551   0.39267   -1.1287
 -0.23636   -1.0629   0.046277   0.29143   -0.25819   -0.094902
  0.79478   -1.2095   -0.01039   -0.092086   0.84322   -0.11061
  3.0096   0.51652   -0.76986   0.51074   0.37508   0.12156
  0.082794   0.43605   -0.1584   -0.61048   0.35006   0.52465
 -0.51747   0.0034705   0.73625   0.16252   0.85279   0.85268
  0.57892   0.64483   ]
brown: [-0.88497   0.71685   -0.40379   -0.10698   0.81457   1.0258   -1.2698
 -0.49382   -0.27839   -0.92251   -0.49409   0.78942   -0.20066   -0.057371
  0.060682   0.30746   0.13441   -0.49376   -0.54788   -0.81912   -0.45394
  0.52098   1.0325   -0.8584   -0.65848   -1.2736   0.23616   1.0486
  0.18442   -0.3901   2.1385   -0.45301   -0.16911   -0.46737   0.15938
```

```
    -0.095071 -0.26512   -0.056479  0.63849  -1.0494     0.037507  0.76434
    -0.6412   -0.59594    0.46589   0.31494  -0.34072  -0.59167  -0.31057
     0.73274 ]
fox:  [ 0.44206    0.059552  0.15861    0.92777   0.1876     0.24256  -1.593
 -0.79847  -0.34099  -0.24021  -0.32756   0.43639  -0.11057   0.50472
  0.43853   0.19738  -0.1498   -0.046979 -0.83286   0.39878   0.062174
  0.28803   0.79134   0.31798  -0.21933  -1.1015   -0.080309  0.39122
  0.19503  -0.5936    1.7921    0.3826   -0.30509  -0.58686  -0.76935
 -0.61914  -0.61771  -0.68484  -0.67919  -0.74626  -0.036646  0.78251
 -1.0072   -0.59057  -0.7849   -0.39113  -0.49727  -0.4283   -0.15204
  1.5064  ]
jumps:  [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0.]
over:  [ 0.12972    0.088073  0.24375    0.078102 -0.12783    0.27831
 -0.48693    0.19649   -0.39558   -0.28362   -0.47425   -0.59317
 -0.58804   -0.31702    0.49593    0.0087594  0.039613  -0.42495
 -0.97641   -0.46534    0.020675   0.086042   0.39317   -0.51255
 -0.17913   -1.8333     0.5622     0.41626    0.075127   0.02189
  3.784      0.71067   -0.073943   0.15373   -0.3853    -0.070163
 -0.35374    0.074501  -0.084228  -0.45548   -0.081068   0.39157
  0.173      0.2254    -0.12836    0.40951   -0.26079    0.090912
 -0.60515   -0.9827   ]
the:  [ 4.1800e-01  2.4968e-01 -4.1242e-01  1.2170e-01  3.4527e-01 -4.4457e-02
 -4.9688e-01 -1.7862e-01 -6.6023e-04 -6.5660e-01  2.7843e-01 -1.4767e-01
 -5.5677e-01  1.4658e-01 -9.5095e-03  1.1658e-02  1.0204e-01 -1.2792e-01
 -8.4430e-01 -1.2181e-01 -1.6801e-02 -3.3279e-01 -1.5520e-01 -2.3131e-01
 -1.9181e-01 -1.8823e+00 -7.6746e-01  9.9051e-02 -4.2125e-01 -1.9526e-01
  4.0071e+00 -1.8594e-01 -5.2287e-01 -3.1681e-01  5.9213e-04  7.4449e-03
  1.7778e-01 -1.5897e-01  1.2041e-02 -5.4223e-02 -2.9871e-01 -1.5749e-01
 -3.4758e-01 -4.5637e-02 -4.4251e-01  1.8785e-01  2.7849e-03 -1.8411e-01
 -1.1514e-01 -7.8581e-01]
lazy:  [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0.]
dog:  [ 0.11008   -0.38781   -0.57615   -0.27714    0.70521    0.53994
 -1.0786    -0.40146    1.1504    -0.5678     0.0038977  0.52878
  0.64561    0.47262    0.48549   -0.18407    0.1801     0.91397
 -1.1979    -0.5778    -0.37985    0.33606    0.772      0.75555
  0.45506   -1.7671    -1.0503     0.42566    0.41893   -0.68327
  1.5673     0.27685   -0.61708    0.64638   -0.076996   0.37118
  0.1308    -0.45137    0.25398   -0.74392   -0.086199   0.24068
 -0.64819    0.83549    1.2502    -0.51379    0.04224   -0.88118
  0.7158     0.38519  ]
```

[6]:
```
# ------------------------------------------------------------
# code for working with movie reviews data
```

```python
# Source: Miller, T. W. (2016). Web and Network Data Science.
#     Upper Saddle River, N.J.: Pearson Education.
#     ISBN-13: 978-0-13-388644-3
# This original study used a simple bag-of-words approach
# to sentiment analysis, along with pre-defined lists of
# negative and positive words.
# Code available at:  https://github.com/mtpa/wnds
# -----------------------------------------------------------
# Utility function to get file names within a directory
def listdir_no_hidden(path):
    start_list = os.listdir(path)
    end_list = []
    for file in start_list:
        if (not file.startswith('.')):
            end_list.append(file)
    return(end_list)

# define list of codes to be dropped from document
# carriage-returns, line-feeds, tabs
codelist = ['\r', '\n', '\t']

# We will not remove stopwords in this exercise because they are
# important to keeping sentences intact
if REMOVE_STOPWORDS:
    print(nltk.corpus.stopwords.words('english'))

# previous analysis of a list of top terms showed a number of words, along
# with contractions and other word strings to drop from further analysis, add
# these to the usual English stopwords to be dropped from a document collection
    more_stop_words = ['cant','didnt','doesnt','dont','goes','isnt','hes',\
        'shes','thats','theres','theyre','wont','youll','youre','youve', 'br'\
        've', 're', 'vs']

    some_proper_nouns_to_remove = ['dick','ginger','hollywood','jack',\
        'jill','john','karloff','kudrow','orson','peter','tcm','tom',\
        'toni','welles','william','wolheim','nikita']

    # start with the initial list and add to it for movie text work
    stoplist = nltk.corpus.stopwords.words('english') + more_stop_words +\
        some_proper_nouns_to_remove

# text parsing function for creating text documents
# there is more we could do for data preparation
# stemming... looking for contractions... possessives...
# but we will work with what we have in this parsing function
# if we want to do stemming at a later time, we can use
#     porter = nltk.PorterStemmer()
```

```python
# in a construction like this
#     words_stemmed = [porter.stem(word) for word in initial_words]
def text_parse(string):
    # replace non-alphanumeric with space
    temp_string = re.sub('[^a-zA-Z]', ' ', string)
    # replace codes with space
    for i in range(len(codelist)):
        stopstring = ' ' + codelist[i] + ' '
        temp_string = re.sub(stopstring, ' ', temp_string)
    # replace single-character words with space
    temp_string = re.sub('\s.\s', ' ', temp_string)
    # convert uppercase to lowercase
    temp_string = temp_string.lower()
    if REMOVE_STOPWORDS:
        # replace selected character strings/stop-words with space
        for i in range(len(stoplist)):
            stopstring = ' ' + str(stoplist[i]) + ' '
            temp_string = re.sub(stopstring, ' ', temp_string)
    # replace multiple blank characters with one blank character
    temp_string = re.sub('\s+', ' ', temp_string)
    return(temp_string)
```

```python
[7]: # ----------------------------------------------
     # gather data for 500 negative movie reviews
     # ----------------------------------------------
     dir_name = 'movie-reviews-negative'

     filenames = listdir_no_hidden(path=dir_name)
     num_files = len(filenames)

     for i in range(len(filenames)):
         file_exists = os.path.isfile(os.path.join(dir_name, filenames[i]))
         assert file_exists
     print('\nDirectory:',dir_name)
     print('%d files found' % len(filenames))
```

```
Directory: movie-reviews-negative
500 files found
```

```python
[8]: # Read data for negative movie reviews
     # Data will be stored in a list of lists where the each list represents
     # a document and document is a list of words.
     # We then break the text into words.

     def read_data(filename):

       with open(filename, encoding='utf-8') as f:
```

```python
        data = tf.compat.as_str(f.read())
        data = data.lower()
        data = text_parse(data)
        data = TreebankWordTokenizer().tokenize(data)   # The Penn Treebank

    return data

negative_documents = []

print('\nProcessing document files under', dir_name)
for i in range(num_files):
    ## print(' ', filenames[i])

    words = read_data(os.path.join(dir_name, filenames[i]))

    negative_documents.append(words)
    # print('Data size (Characters) (Document %d) %d' %(i,len(words)))
    # print('Sample string (Document %d) %s'%(i,words[:50]))
```

Processing document files under movie-reviews-negative

```python
[9]: # ------------------------------------------------
     # gather data for 500 positive movie reviews
     # ------------------------------------------------
     dir_name = 'movie-reviews-positive'
     filenames = listdir_no_hidden(path=dir_name)
     num_files = len(filenames)

     for i in range(len(filenames)):
         file_exists = os.path.isfile(os.path.join(dir_name, filenames[i]))
         assert file_exists
     print('\nDirectory:',dir_name)
     print('%d files found' % len(filenames))

     # Read data for positive movie reviews
     # Data will be stored in a list of lists where the each list
     # represents a document and document is a list of words.
     # We then break the text into words.

     def read_data(filename):

       with open(filename, encoding='utf-8') as f:
         data = tf.compat.as_str(f.read())
         data = data.lower()
         data = text_parse(data)
         data = TreebankWordTokenizer().tokenize(data)   # The Penn Treebank
```

```
    return data

positive_documents = []

print('\nProcessing document files under', dir_name)
for i in range(num_files):
    ## print(' ', filenames[i])

    words = read_data(os.path.join(dir_name, filenames[i]))

    positive_documents.append(words)
    # print('Data size (Characters) (Document %d) %d' %(i,len(words)))
    # print('Sample string (Document %d) %s'%(i,words[:50]))
```

Directory: movie-reviews-positive
500 files found

Processing document files under movie-reviews-positive

```
[10]: # -------------------------------------------------------
      # convert positive/negative documents into numpy array
      # note that reviews vary from 22 to 1052 words
      # so we use the first 20 and last 20 words of each review
      # as our word sequences for analysis
      # -------------------------------------------------------
      max_review_length = 0  # initialize
      for doc in negative_documents:
          max_review_length = max(max_review_length, len(doc))
      for doc in positive_documents:
          max_review_length = max(max_review_length, len(doc))
      print('max_review_length:', max_review_length)

      min_review_length = max_review_length  # initialize
      for doc in negative_documents:
          min_review_length = min(min_review_length, len(doc))
      for doc in positive_documents:
          min_review_length = min(min_review_length, len(doc))
      print('min_review_length:', min_review_length)

      # construct list of 1000 lists with 40 words in each list
      from itertools import chain
      documents = []
      for doc in negative_documents:
          doc_begin = doc[0:20]
          doc_end = doc[len(doc) - 20: len(doc)]
```

```
        documents.append(list(chain(*[doc_begin, doc_end])))
for doc in positive_documents:
    doc_begin = doc[0:20]
    doc_end = doc[len(doc) - 20: len(doc)]
    documents.append(list(chain(*[doc_begin, doc_end])))

    # create list of lists of lists for embeddings
    embeddings = []
    for doc in documents:
        embedding = []
        for word in doc:
            embedding.append(limited_index_to_embedding[limited_word_to_index[word]])
        embeddings.append(embedding)
```

```
max_review_length: 1052
min_review_length: 22
```

[11]:
```
# --------------------------------------------------------
# Check on the embeddings list of list of lists
# --------------------------------------------------------
# Show the first word in the first document
test_word = documents[0][0]
print('First word in first document:', test_word)
print('Embedding for this word:\n',
      limited_index_to_embedding[limited_word_to_index[test_word]])
print('Corresponding embedding from embeddings list of list of lists\n',
      embeddings[0][0][:])

# Show the seventh word in the tenth document
test_word = documents[6][9]
print('First word in first document:', test_word)
print('Embedding for this word:\n',
      limited_index_to_embedding[limited_word_to_index[test_word]])
print('Corresponding embedding from embeddings list of list of lists\n',
      embeddings[6][9][:])

# Show the last word in the last document
test_word = documents[999][39]
print('First word in first document:', test_word)
print('Embedding for this word:\n',
      limited_index_to_embedding[limited_word_to_index[test_word]])
print('Corresponding embedding from embeddings list of list of lists\n',
      embeddings[999][39][:])
```

```
First word in first document: while
Embedding for this word:
 [ 0.1011   -0.16566   0.22035  -0.10629   0.46929   0.37968  -0.62815
```

```
  -0.14385   -0.38333    0.055405   0.23511  -0.20999   -0.55395   -0.38271
   0.21008    0.02161   -0.23054  -0.13576  -0.61636   -0.4678     0.25716
   0.62309    0.3837    -0.25665   0.09041  -1.5184     0.4762    -0.089573
   0.025347  -0.25974    3.6121    0.62788   0.15387   -0.062747   0.28699
  -0.16471   -0.2079     0.4407    0.065441 -0.10303   -0.15489    0.27352
   0.38356   -0.098016   0.10705  -0.083071 -0.27168   -0.49441    0.043538
  -0.39141 ]
Corresponding embedding from embeddings list of list of lists
 [ 0.1011    -0.16566    0.22035  -0.10629   0.46929    0.37968   -0.62815
  -0.14385   -0.38333    0.055405   0.23511  -0.20999   -0.55395   -0.38271
   0.21008    0.02161   -0.23054  -0.13576  -0.61636   -0.4678     0.25716
   0.62309    0.3837    -0.25665   0.09041  -1.5184     0.4762    -0.089573
   0.025347  -0.25974    3.6121    0.62788   0.15387   -0.062747   0.28699
  -0.16471   -0.2079     0.4407    0.065441 -0.10303   -0.15489    0.27352
   0.38356   -0.098016   0.10705  -0.083071 -0.27168   -0.49441    0.043538
  -0.39141 ]
First word in first document: officially
Embedding for this word:
 [ 0.13682   -0.10324   -0.10126   -0.13996    0.080166 -0.18858   -0.96708
  -0.066722 -0.254     -0.61085    0.88298   -0.23186  -0.09482   -0.22099
   0.85226    0.47223   -0.73086    0.054607 -0.22859    0.6526     0.05519
  -0.47021    0.35769    0.18049   -0.23699  -1.3029     0.14341    0.044548
  -0.70229    0.022042   2.3984    -0.46118  -0.88351   -0.5511    -0.25662
  -0.56969    1.1733    -0.077844 -0.96175  -0.30038   -0.58143   -0.8909
  -0.34433   -0.53421   -0.84671    0.03971  -1.0485    -0.12547   -0.072426
  -0.19364 ]
Corresponding embedding from embeddings list of list of lists
 [ 0.13682   -0.10324   -0.10126   -0.13996    0.080166 -0.18858   -0.96708
  -0.066722 -0.254     -0.61085    0.88298   -0.23186  -0.09482   -0.22099
   0.85226    0.47223   -0.73086    0.054607 -0.22859    0.6526     0.05519
  -0.47021    0.35769    0.18049   -0.23699  -1.3029     0.14341    0.044548
  -0.70229    0.022042   2.3984    -0.46118  -0.88351   -0.5511    -0.25662
  -0.56969    1.1733    -0.077844 -0.96175  -0.30038   -0.58143   -0.8909
  -0.34433   -0.53421   -0.84671    0.03971  -1.0485    -0.12547   -0.072426
  -0.19364 ]
First word in first document: super
Embedding for this word:
 [-0.59147    0.16468    0.18271    1.4054    -0.23347   -0.2986
  -0.34696   -0.30997   -0.089015  -0.019025   0.28963    0.46779
  -0.85615    0.68968    0.52189    0.24809   -0.022432   1.009
  -2.2903    -0.33961   -0.83609   -0.75197    0.34107    0.31885
  -0.78405   -1.2021    -0.83693   -0.28469    0.41393    0.0074962
   1.7202     1.2959    -0.61426    0.4721     0.71448    0.55194
   0.43352    0.35058   -1.0558    -1.2248    -0.14596    0.11694
  -0.39677    0.13791   -0.03571    1.305     -0.14112   -0.18244
   0.22988    0.39888  ]
Corresponding embedding from embeddings list of list of lists
 [-0.59147    0.16468    0.18271    1.4054    -0.23347   -0.2986
```

```
 -0.34696    -0.30997    -0.089015   -0.019025    0.28963     0.46779
 -0.85615     0.68968     0.52189     0.24809    -0.022432    1.009
 -2.2903     -0.33961    -0.83609    -0.75197     0.34107     0.31885
 -0.78405    -1.2021     -0.83693    -0.28469     0.41393     0.0074962
  1.7202      1.2959     -0.61426     0.4721      0.71448     0.55194
  0.43352     0.35058    -1.0558     -1.2248     -0.14596     0.11694
 -0.39677     0.13791    -0.03571     1.305      -0.14112    -0.18244
  0.22988     0.39888    ]
```

0.1 Model 1: GloVe.6B, 50 Dimensions, vocabulary 10,000 words

```python
[12]:  # ----------------------------------------------------
       # Make embeddings a numpy array for use in an RNN
       # Create training and test sets with Scikit Learn
       # ----------------------------------------------------
       embeddings_array = np.array(embeddings)

       # Define the labels to be used 500 negative (0) and 500 positive (1)
       thumbs_down_up = np.concatenate((np.zeros((500), dtype = np.int32),
                           np.ones((500), dtype = np.int32)), axis = 0)

       # Scikit Learn for random splitting of the data
       from sklearn.model_selection import train_test_split

       RANDOM_SEED = 9999
       # Random splitting of the data in to training (80%) and test (20%)
       X_train, X_test, y_train, y_test = \
           train_test_split(embeddings_array, thumbs_down_up, test_size=0.20,
                            random_state = RANDOM_SEED)


       # ----------------------------------------------------------------------

       # We use a very simple Recurrent Neural Network for this assignment
       # Geron, A. 2017. Hands-On Machine Learning with Scikit-Learn & TensorFlow:
       #    Concepts, Tools, and Techniques to Build Intelligent Systems.
       #    Sebastopol, Calif.: O'Reilly. [ISBN-13 978-1-491-96229-9]
       #    Chapter 14 Recurrent Neural Networks, pages 390-391
       #    Source code available at https://github.com/ageron/handson-ml
       #    Jupyter notebook file 14_recurrent_neural_networks.ipynb
       #    See section on Training an sequence Classifier, # In [34]:
       #    which uses the MNIST case data...  we revise to accommodate
       #    the movie review data in this assignment
       # ----------------------------------------------------------------------
       reset_graph()

       n_steps = embeddings_array.shape[1]   # number of words per document
       n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
```

15

```python
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2    # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                           logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train1 = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test1 = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train1, 'Test accuracy:', acc_test1)
```

```
WARNING: The TensorFlow contrib module will not be included in TensorFlow 2.0.
For more information, please see:
  * https://github.com/tensorflow/community/blob/master/rfcs/20180907-contrib-
sunset.md
  * https://github.com/tensorflow/addons
If you depend on functionality not listed there, please file an issue.
```

```
WARNING:tensorflow:From <ipython-input-12-08ab4b6d54cf>:44:
BasicRNNCell.__init__ (from tensorflow.python.ops.rnn_cell_impl) is deprecated
and will be removed in a future version.
Instructions for updating:
This class is equivalent as tf.keras.layers.SimpleRNNCell, and will be replaced
by that in Tensorflow 2.0.
WARNING:tensorflow:From <ipython-input-12-08ab4b6d54cf>:45: dynamic_rnn (from
tensorflow.python.ops.rnn) is deprecated and will be removed in a future
version.
Instructions for updating:
Please use `keras.layers.RNN(cell)`, which is equivalent to this API
WARNING:tensorflow:From /Users/jmwanat/anaconda3/envs/tf/lib/python3.7/site-
packages/tensorflow/python/ops/tensor_array_ops.py:162: colocate_with (from
tensorflow.python.framework.ops) is deprecated and will be removed in a future
version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From <ipython-input-12-08ab4b6d54cf>:47: dense (from
tensorflow.python.layers.core) is deprecated and will be removed in a future
version.
Instructions for updating:
Use keras.layers.dense instead.

  ---- Epoch  0  ----

  Batch  0  training observations from  0  to  99
  Batch  1  training observations from  100  to  199
  Batch  2  training observations from  200  to  299
  Batch  3  training observations from  300  to  399
  Batch  4  training observations from  400  to  499
  Batch  5  training observations from  500  to  599
  Batch  6  training observations from  600  to  699
  Batch  7  training observations from  700  to  799

  Train accuracy: 0.5 Test accuracy: 0.51

  ---- Epoch  1  ----

  Batch  0  training observations from  0  to  99
  Batch  1  training observations from  100  to  199
  Batch  2  training observations from  200  to  299
  Batch  3  training observations from  300  to  399
  Batch  4  training observations from  400  to  499
  Batch  5  training observations from  500  to  599
  Batch  6  training observations from  600  to  699
  Batch  7  training observations from  700  to  799

  Train accuracy: 0.5 Test accuracy: 0.445
```

```
---- Epoch  2  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.5 Test accuracy: 0.495


---- Epoch  3  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.53 Test accuracy: 0.5


---- Epoch  4  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.56 Test accuracy: 0.495


---- Epoch  5  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.515


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.53


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.55


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.575


---- Epoch  9  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.585


---- Epoch  10  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.605


---- Epoch  11  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.64


---- Epoch  12  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.65
```

```
---- Epoch   13   ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100  to   199
Batch  2   training observations from  200  to   299
Batch  3   training observations from  300  to   399
Batch  4   training observations from  400  to   499
Batch  5   training observations from  500  to   599
Batch  6   training observations from  600  to   699
Batch  7   training observations from  700  to   799


Train accuracy: 0.74 Test accuracy: 0.655


---- Epoch   14   ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100  to   199
Batch  2   training observations from  200  to   299
Batch  3   training observations from  300  to   399
Batch  4   training observations from  400  to   499
Batch  5   training observations from  500  to   599
Batch  6   training observations from  600  to   699
Batch  7   training observations from  700  to   799


Train accuracy: 0.74 Test accuracy: 0.67


---- Epoch   15   ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100  to   199
Batch  2   training observations from  200  to   299
Batch  3   training observations from  300  to   399
Batch  4   training observations from  400  to   499
Batch  5   training observations from  500  to   599
Batch  6   training observations from  600  to   699
Batch  7   training observations from  700  to   799


Train accuracy: 0.76 Test accuracy: 0.66


---- Epoch   16   ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100  to   199
Batch  2   training observations from  200  to   299
Batch  3   training observations from  300  to   399
Batch  4   training observations from  400  to   499
Batch  5   training observations from  500  to   599
Batch  6   training observations from  600  to   699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.78 Test accuracy: 0.655


---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.65


---- Epoch  18  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.63


---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.62


---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.6


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.625


---- Epoch  22  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.635


---- Epoch  23  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.66


---- Epoch  24  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.8 Test accuracy: 0.66


---- Epoch  25  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.81 Test accuracy: 0.655


---- Epoch  26  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.8 Test accuracy: 0.665


---- Epoch  27  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799
```

```
Train accuracy: 0.82 Test accuracy: 0.66


---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.66


---- Epoch  29  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.655


---- Epoch  30  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.66


---- Epoch  31  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.66


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.65


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.65


---- Epoch  34  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.655


---- Epoch  35  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.85 Test accuracy: 0.66


---- Epoch  36  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.86 Test accuracy: 0.665


---- Epoch  37  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  38  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 0.86 Test accuracy: 0.665


---- Epoch  39  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.66


---- Epoch  40  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  41  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.665


---- Epoch  42  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.655


---- Epoch  43  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.65


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.65


---- Epoch  45  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.65


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.645


---- Epoch  47  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.67


---- Epoch  48  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.675


---- Epoch  49  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.675
```

```
[13]: RANDOM_SEED = 1234

      # To make output stable across runs
      def reset_graph(seed= RANDOM_SEED):
          tf.reset_default_graph()
          tf.set_random_seed(seed)
          np.random.seed(seed)

      reset_graph()

      n_steps = embeddings_array.shape[1]   # number of words per document
      n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
      n_neurons = 20   # analyst specified number of neurons
      n_outputs = 2   # thumbs-down or thumbs-up

      learning_rate = 0.001

      X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
      y = tf.placeholder(tf.int32, [None])

      basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
      outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

      logits = tf.layers.dense(states, n_outputs)
      xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
      loss = tf.reduce_mean(xentropy)
      optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
      training_op = optimizer.minimize(loss)
      correct = tf.nn.in_top_k(logits, y, 1)
      accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

      init = tf.global_variables_initializer()

      n_epochs = 50
      batch_size = 100

      with tf.Session() as sess:
          init.run()
          for epoch in range(n_epochs):
              print('\n  ---- Epoch ', epoch, ' ----\n')
              for iteration in range(y_train.shape[0] // batch_size):
                  X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
                  y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
                  print('  Batch ', iteration, ' training observations from ',
                        iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
                  sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
```

```
acc_train1b = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
acc_test1b = accuracy.eval(feed_dict={X: X_test, y: y_test})
print('\n  Train accuracy:', acc_train1b, 'Test accuracy:', acc_test1b)
```

---- Epoch 0 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.48 Test accuracy: 0.525

---- Epoch 1 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.48 Test accuracy: 0.56

---- Epoch 2 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.49 Test accuracy: 0.51

---- Epoch 3 ----

Batch 0 training observations from 0 to 99

```
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.48 Test accuracy: 0.505


---- Epoch  4  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.47 Test accuracy: 0.51


---- Epoch  5  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.49 Test accuracy: 0.515


---- Epoch  6  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.54 Test accuracy: 0.515
```

```
---- Epoch  7  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.53


---- Epoch  8  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.535


---- Epoch  9  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.54


---- Epoch  10  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.56 Test accuracy: 0.545


---- Epoch   11   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.57 Test accuracy: 0.56


---- Epoch   12   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.58 Test accuracy: 0.575


---- Epoch   13   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.6 Test accuracy: 0.575


---- Epoch   14   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.58


---- Epoch  15  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.61


---- Epoch  16  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.61


---- Epoch  17  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.615
```

```
---- Epoch  18  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.615


---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.61


---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.61


---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.66 Test accuracy: 0.595


---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.595


---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.59


---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.575


---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

Train accuracy: 0.68 Test accuracy: 0.58

---- Epoch 26 ----

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

Train accuracy: 0.68 Test accuracy: 0.595

---- Epoch 27 ----

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

Train accuracy: 0.68 Test accuracy: 0.6

---- Epoch 28 ----

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

Train accuracy: 0.69 Test accuracy: 0.6

---- Epoch 29 ----

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.61


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.6


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.615


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.75 Test accuracy: 0.615


---- Epoch  33  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.61


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.625


---- Epoch  35  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.625


---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.62


---- Epoch  37  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.625


---- Epoch  38  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.635


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.64


---- Epoch  40  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.65


---- Epoch  41  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.625


---- Epoch  42  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.64


---- Epoch  43  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.84 Test accuracy: 0.65


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.64


---- Epoch  45  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.645


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.645


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.86 Test accuracy: 0.645


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.64


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.645
```

[14]:
```python
RANDOM_SEED = 42

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up
```

```python
learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train1c = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test1c = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train1c, 'Test accuracy:', acc_test1c)
```

```
  ---- Epoch  0  ----

 Batch  0  training observations from   0  to   99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
 Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.52 Test accuracy: 0.545


---- Epoch  1  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.55 Test accuracy: 0.53


---- Epoch  2  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.49


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.58 Test accuracy: 0.53


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.6 Test accuracy: 0.53


---- Epoch  5  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.53


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.535


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.535


---- Epoch  8  ----
```

```
Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.555


---- Epoch  9  ----


Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.555


---- Epoch  10  ----


Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.565


---- Epoch  11  ----


Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.64 Test accuracy: 0.565


---- Epoch  12  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.555


---- Epoch  13  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.56


---- Epoch  14  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.565


---- Epoch  15  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.575


---- Epoch  16  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.575


---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.575


---- Epoch  18  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.58

---- Epoch  19  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.58


---- Epoch  20  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.6


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.6


---- Epoch  22  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.605
```

```
---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.595


---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.605


---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.62


---- Epoch  26  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.76 Test accuracy: 0.615


---- Epoch  27  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.77 Test accuracy: 0.615


---- Epoch  28  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.72 Test accuracy: 0.62


---- Epoch  29  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.71 Test accuracy: 0.62


---- Epoch  30  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.63


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.635


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.635


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.645
```

```
---- Epoch  34  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.64


---- Epoch  35  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.655


---- Epoch  36  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.655


---- Epoch  37  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.78 Test accuracy: 0.655


---- Epoch  38  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.66


---- Epoch  39  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.66


---- Epoch  40  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.665


---- Epoch  41  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.66


---- Epoch  42  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.65


---- Epoch  43  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.645


---- Epoch  44  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.645


---- Epoch  45  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.84 Test accuracy: 0.645


---- Epoch  46  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.84 Test accuracy: 0.645


---- Epoch  47  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.85 Test accuracy: 0.645


---- Epoch  48  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799
```

```
Train accuracy: 0.85 Test accuracy: 0.635


---- Epoch  49  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.635
```

0.2   Model 2: Glove.6B, 100 dimensions, vocabulary 10,000 words

```python
[15]: # ---------------------------------------------------------------
      # Select the pre-defined embeddings source
      # Define vocabulary size for the language model
      # Create a word_to_embedding_dict for GloVe.6B.50d
      embeddings_directory = 'embeddings/gloVe.6B'
      filename2 = 'glove.6B.100d.txt'
      embeddings_filename = os.path.join(embeddings_directory, filename2)
      # ---------------------------------------------------------------


      print('\nLoading embeddings from', embeddings_filename)
      word_to_index, index_to_embedding = \
          load_embedding_from_disks(embeddings_filename, with_indexes=True)
      print("Embedding loaded from disks.")


      # Additional background code from
      # https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
      # shows the general structure of the data structures for word embeddings
      # This code is modified for our purposes in language modeling
      vocab_size, embedding_dim = index_to_embedding.shape
      print("Embedding is of shape: {}".format(index_to_embedding.shape))
      print("This means (number of words, number of dimensions per word)\n")
      print("The first words are words that tend occur more often.")
```

```
Loading embeddings from embeddings/gloVe.6B/glove.6B.100d.txt
Embedding loaded from disks.
Embedding is of shape: (400001, 100)
```

This means (number of words, number of dimensions per word)

The first words are words that tend occur more often.

```
[16]: # Show how to use embeddings dictionaries with a test sentence
      # This is a famous typing exercise with all letters of the alphabet
      # https://en.wikipedia.org/wiki/The_quick_brown_fox_jumps_over_the_lazy_dog
      a_typing_test_sentence = 'The quick brown fox jumps over the lazy dog'
      print('\nTest sentence: ', a_typing_test_sentence, '\n')
      words_in_test_sentence = a_typing_test_sentence.split()

      print('Test sentence embeddings from complete vocabulary of',
            complete_vocabulary_size, 'words:\n')
      for word in words_in_test_sentence:
          word_ = word.lower()
          embedding = index_to_embedding[word_to_index[word_]]
          print(word_ + ": ", embedding)
```

Test sentence: The quick brown fox jumps over the lazy dog

Test sentence embeddings from complete vocabulary of 400000 words:

```
the:  [-0.038194 -0.24487   0.72812  -0.39961   0.083172  0.043953 -0.39141
  0.3344   -0.57545   0.087459  0.28787  -0.06731   0.30906  -0.26384
 -0.13231  -0.20757   0.33395  -0.33848  -0.31743  -0.48336   0.1464
 -0.37304   0.34577   0.052041  0.44946  -0.46971   0.02628  -0.54155
 -0.15518  -0.14107  -0.039722  0.28277   0.14393   0.23464  -0.31021
  0.086173  0.20397   0.52624   0.17164  -0.082378 -0.71787  -0.41531
  0.20335  -0.12763   0.41367   0.55187   0.57908  -0.33477  -0.36559
 -0.54857  -0.062892  0.26584   0.30205   0.99775  -0.80481  -3.0243
  0.01254  -0.36942   2.2167    0.72201  -0.24978   0.92136   0.034514
  0.46745   1.1079   -0.19358  -0.074575  0.23353  -0.052062 -0.22044
  0.057162 -0.15806  -0.30798  -0.41625   0.37972   0.15006  -0.53212
 -0.2055   -1.2526    0.071624  0.70565   0.49744  -0.42063   0.26148
 -1.538    -0.30223  -0.073438 -0.28312   0.37104  -0.25217   0.016215
 -0.017099 -0.38984   0.87424  -0.72569  -0.51058  -0.52028  -0.1459
  0.8278    0.27062 ]
quick:  [-0.43146  -0.22037   -0.22684   -0.10215   -0.31863   -0.11809
 -0.093402 -0.069789 -0.29029   -0.34006    0.099652  -0.059301
 -0.43764   0.19464    0.36997    0.73648   -0.53429   -0.3469
 -0.21415   0.62954    0.54868    0.29429   -0.32889   -0.61771
 -0.039648  0.91639   -0.64046    0.28725    0.095922  -0.38774
 -0.62958   0.33443   -0.4856    -0.2287     0.84277   -0.2204
 -0.13264  -0.18188    0.077686   0.080045  -0.018909  -0.26018
  0.29542  -0.89173   -0.39373   -0.35662    0.011656  -0.37658
  0.64576  -0.86503    0.12615    0.18984   -0.26936    0.56216
```

```
 0.38218     -2.1389     -0.0096116  0.15041     1.2586      -0.35475
-0.33285      0.07292    -0.077262   0.049068    0.90212     -0.27539
-0.20839      0.26349    -0.26515   -0.70593    -0.68474      0.38424
-0.21889     -0.88545     0.38583    0.26481    -0.7641      -0.037501
-0.020606    -0.71318     1.1045     0.0453     -0.41902     -0.47667
-1.4088      -0.50376     0.88062    0.0072194  -0.42083     -0.62586
 0.59608      0.30444    -0.40999   -0.28204    -0.52321     -0.44695
 0.21083     -0.010209    0.0086056  0.63263    ]
brown: [-4.3812e-01 -9.9389e-02 -2.6038e-01 -1.1084e+00  1.0550e-01 -5.4542e-02
 4.4868e-01  6.1750e-02 -5.8803e-01 -2.1738e-01 -3.6304e-01 -4.0887e-01
 3.7877e-02  8.4201e-01  1.0108e-01 -1.8530e-01  5.0486e-01 -3.4252e-01
 2.2516e-01 -2.6942e-02 -4.6399e-01  9.9140e-02  1.9596e-02 -6.7435e-01
 6.3123e-01  9.5930e-01  1.6215e-01 -4.3166e-01 -2.6642e-01  1.9136e-01
 4.5626e-01  6.8918e-01  3.6808e-01 -2.8273e-01 -4.6525e-01  5.9984e-01
 1.5369e-01  8.6585e-01  2.7917e-01  5.8380e-01 -4.6627e-01 -1.3590e+00
-1.0387e-01  6.0146e-02 -5.2733e-01  1.3135e-01 -3.3766e-01  1.7893e-01
 4.4812e-01 -7.0502e-01  6.3793e-01 -7.9508e-01  1.3176e-01  9.7769e-01
-2.3153e-01 -2.6450e+00 -1.1464e-01  2.7907e-01  4.9121e-01  5.1274e-01
 7.9559e-04  1.7932e-01 -2.9938e-01 -3.3465e-01  9.9161e-01 -6.0262e-01
 7.2080e-01  8.4681e-01 -2.3669e-01  1.3666e-01 -3.5330e-01  3.9442e-01
-7.2818e-01  9.1664e-02  3.0441e-01  4.8352e-02 -4.1140e-01  3.4362e-01
 1.2569e-01  4.2484e-01  4.5470e-01  1.6292e-01 -1.3630e-01 -2.1827e-01
-3.8261e-01 -9.2620e-01  5.1256e-01 -3.5184e-01  1.8316e-01  1.9807e-01
-1.9681e-02 -7.2242e-01 -4.3439e-01  1.3449e-01 -8.4339e-01  1.3815e-02
-1.1325e+00  1.8143e-01 -1.9537e-01 -3.6954e-01]
fox: [ 0.16917    -0.99783     0.24429    -0.79687     0.036447   -0.56127
 0.17305     0.29287    -0.43291    -0.82274    -0.11437    -0.28808
 0.20501    -0.4878      0.50534    -0.2117      0.48474     0.20959
 0.26642     0.6839     -0.2629      0.14794     0.087969   -0.17349
 0.61804     0.63733     0.41145     0.46401    -0.2165      0.5
 0.65265     1.0608      0.19275     0.141       0.51356     0.72558
-0.044848   -0.35761     0.49862     0.73592    -0.38307     0.12159
-0.75345     0.80579    -0.48075    -0.40283    -0.49931    -0.60309
 0.26126    -0.24109    -0.55885    -0.10622     0.11289     0.49708
 0.015915   -2.452      -0.32529     0.20437     0.55361     0.60879
-0.083061    0.60856     0.13958    -0.71847     1.1409      0.023752
 0.050995    0.29621    -0.16247     1.1456      0.16929    -0.0042113
-0.4026     -0.073144    0.096698   -0.15248    -0.69435     0.28032
-1.0238      0.58777    -0.34573    -0.60871     0.1842     -0.18736
-0.49948    -0.18095    -0.71161     0.69437     0.37298    -0.308
 0.2455     -0.94515     0.20393    -0.14885    -1.1153     -0.52266
-0.27841     0.027184    0.39712     0.17933    ]
jumps: [ 0.87831     0.76211     0.24562    -0.05516     0.10355    -0.6789     -0.36757
 0.52207    -0.37174    -0.10266     1.0164      0.97297     0.028706    0.22013
 0.36371     0.79072    -1.5199      0.72657     0.24994     0.07658     0.79373
 0.32268    -0.28497     0.30724     0.25493     0.049801   -0.68182     0.059687
 0.40362    -0.73308    -0.5968      0.2901      0.15876     0.070044    0.57204
 0.70252    -0.86423    -0.1618     -0.026244    0.19154    -0.14515     0.34694
```

```
 -0.62756    0.15429   -0.56114    0.15854   -0.56041   -0.39705    0.31183
 -0.19028   -0.53601    0.061462   0.12484    1.3302     0.34361   -1.1603
  0.10341    0.33138    0.74712    0.11517    0.17949    0.059578   0.22881
  0.52396   -0.43749    0.33677    0.028801  -0.67852    0.21443    0.038026
 -0.87474   -0.22532    0.020465   1.0772     0.71369   -0.14903   -0.53563
 -0.049547   0.23989   -0.19058    0.13683    0.29553   -0.20244   -0.40515
 -0.24246   -1.0324     0.32728   -0.46241    0.27757   -0.23512   -0.23432
  0.1031    -0.54905    0.21484   -0.16597   -0.34962   -0.16015   -0.2617
  0.41802   -0.055161]
over:  [-2.9574e-01  3.5345e-01  6.3326e-01  1.9576e-01 -3.0256e-02  5.4244e-01
 -2.1091e-01  3.2894e-01 -4.8888e-01  1.8379e-01  2.4242e-01  4.0346e-01
  1.1973e-01  1.3143e-02  2.4154e-01 -4.0184e-01  2.2176e-01 -2.7837e-01
 -4.6930e-01 -5.4899e-02  6.5148e-01  1.5958e-01  5.9556e-01  3.3167e-01
  7.2649e-01 -4.3182e-01  1.7208e-01 -1.1584e-02 -2.6389e-01 -2.2073e-01
 -2.8538e-01  3.5863e-01  2.4592e-01  2.2143e-01 -7.6221e-01  3.9352e-01
 -2.3915e-02  4.3028e-01 -4.7099e-01  2.5162e-01 -5.9507e-01 -1.0495e+00
  1.7973e-01 -3.1621e-01  2.3788e-01 -8.8560e-02  3.4751e-01 -5.5950e-01
  1.2997e-01 -7.0101e-01  2.8850e-01  1.8111e-01 -2.3004e-01  2.0682e+00
 -1.4925e-01 -2.8700e+00 -4.6722e-03 -2.2819e-01  1.6623e+00  6.5951e-01
  2.1892e-01  6.3600e-01  1.0332e-01  1.3176e-03  4.4414e-01  2.0222e-01
  5.2490e-01  6.4131e-01  2.7416e-01  1.0695e-01 -1.2030e-01  4.7109e-02
 -5.3503e-01 -4.6869e-01 -7.6050e-02  1.0654e-03 -3.8456e-01 -2.4067e-02
 -7.5877e-01  5.2622e-01  1.3285e+00 -3.9051e-01 -1.2174e-01  5.1886e-01
 -1.0374e+00 -3.3789e-01  7.4933e-02  2.0036e-01  2.4703e-02 -2.9090e-01
 -3.2043e-01  2.0445e-02 -9.9185e-01  1.6802e-02 -6.0819e-01 -2.6601e-01
 -1.9549e-01  2.3127e-01  9.4771e-01 -9.5560e-02]
the:  [-0.038194 -0.24487   0.72812  -0.39961   0.083172  0.043953 -0.39141
  0.3344   -0.57545   0.087459  0.28787  -0.06731   0.30906  -0.26384
 -0.13231  -0.20757   0.33395  -0.33848  -0.31743  -0.48336   0.1464
 -0.37304   0.34577   0.052041  0.44946  -0.46971   0.02628  -0.54155
 -0.15518  -0.14107  -0.039722  0.28277   0.14393   0.23464  -0.31021
  0.086173  0.20397   0.52624   0.17164  -0.082378 -0.71787  -0.41531
  0.20335  -0.12763   0.41367   0.55187   0.57908  -0.33477  -0.36559
 -0.54857  -0.062892  0.26584   0.30205   0.99775  -0.80481  -3.0243
  0.01254  -0.36942   2.2167    0.72201  -0.24978   0.92136   0.034514
  0.46745   1.1079   -0.19358  -0.074575  0.23353  -0.052062 -0.22044
  0.057162 -0.15806  -0.30798  -0.41625   0.37972   0.15006  -0.53212
 -0.2055   -1.2526    0.071624  0.70565   0.49744  -0.42063   0.26148
 -1.538    -0.30223  -0.073438 -0.28312   0.37104  -0.25217   0.016215
 -0.017099 -0.38984   0.87424  -0.72569  -0.51058  -0.52028  -0.1459
  0.8278    0.27062 ]
lazy:  [ 0.14481  -0.20397   0.3596   -0.59938  -0.93979   0.59784
 -0.21619   0.73051  -0.36588  -0.19962   0.14571   0.1642
  0.1086   -0.78575   0.53327   0.37127  -0.33013  -0.082276
  0.73923   0.86931   0.37934   1.2427   -0.19554  -0.53849
  0.20681   0.76727  -0.9714   -0.016255 -0.12529   0.36231
  0.13313   0.60993   0.44345  -0.3654    0.22531   0.72985
 -0.69992   0.14427   0.85324   0.21268  -0.46674   0.25746
```

```
  -0.88493     0.042164  -0.24125    -0.11241   -0.52837     0.38905
   0.35523     0.29078   -0.47363    -0.30561    0.072255    0.31778
  -0.64297    -0.3527     0.49651     0.29722    0.68888    -0.54184
   0.04863     0.26221   -0.61438    -0.2591     0.66305     0.25526
   0.42406    -0.22196   -0.053041   -0.80721   -0.89748    -0.1165
   0.45258     0.24817   -0.14874    -0.20952   -0.58499     0.5573
   0.47503    -0.6429    -0.11219     0.2627    -0.4951     -0.0085495
  -0.86135    -0.21422    0.0086754   0.35554   -0.48077    -0.39897
  -0.012746    0.13761   -0.20283     0.40565    0.056275   -0.35009
  -0.745      -0.42987   -0.56238    -0.13433   ]
dog:  [ 0.30817     0.30938     0.52803    -0.92543   -0.73671     0.63475
   0.44197     0.10262   -0.09142    -0.56607   -0.5327      0.2013
   0.7704     -0.13983    0.13727     1.1128     0.89301    -0.17869
  -0.0019722   0.57289    0.59479     0.50428   -0.28991    -1.3491
   0.42756     1.2748    -1.1613     -0.41084    0.042804    0.54866
   0.18897     0.3759     0.58035     0.66975    0.81156     0.93864
  -0.51005    -0.070079   0.82819    -0.35346    0.21086    -0.24412
  -0.16554    -0.78358   -0.48482     0.38968   -0.86356    -0.016391
   0.31984    -0.49246   -0.069363    0.018869  -0.098286    1.3126
  -0.12116    -1.2399    -0.091429    0.35294    0.64645     0.089642
   0.70294     1.1244     0.38639     0.52084    0.98787     0.79952
  -0.34625     0.14095    0.80167     0.20987   -0.86007    -0.15308
   0.074523    0.40816    0.019208    0.51587   -0.34428    -0.24525
  -0.77984     0.27425    0.22418     0.20164    0.017431   -0.014697
  -1.0235     -0.39695   -0.0056188   0.30569    0.31748     0.021404
   0.11837    -0.11319    0.42456     0.53405   -0.16717    -0.27185
  -0.6255      0.12883    0.62529    -0.52086   ]
```

```python
[17]: # --------------------------------------------------------------
      # Define vocabulary size for the language model
      # To reduce the size of the vocabulary to the n most frequently used words

      EVOCABSIZE = 10000   # specify desired size of pre-defined embedding vocabulary

      def default_factory():
          return EVOCABSIZE  # last/unknown-word row in limited_index_to_embedding
      # dictionary has the items() function, returns list of (key, value) tuples
      limited_word_to_index = defaultdict(default_factory, \
          {k: v for k, v in word_to_index.items() if v < EVOCABSIZE})

      # Select the first EVOCABSIZE rows to the index_to_embedding
      limited_index_to_embedding = index_to_embedding[0:EVOCABSIZE,:]
      # Set the unknown-word row to be all zeros as previously
      limited_index_to_embedding = np.append(limited_index_to_embedding,
          index_to_embedding[index_to_embedding.shape[0] - 1, :].\
              reshape(1,embedding_dim),
          axis = 0)
```

```python
# Delete large numpy array to clear some CPU RAM
del index_to_embedding

# Verify the new vocabulary: should get same embeddings for test sentence
# Note that a small EVOCABSIZE may yield some zero vectors for embeddings
print('\nTest sentence embeddings from vocabulary of', EVOCABSIZE, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = limited_index_to_embedding[limited_word_to_index[word_]]
    print(word_ + ": ", embedding)
```

Test sentence embeddings from vocabulary of 10000 words:

the: [-0.038194 -0.24487   0.72812 -0.39961   0.083172 0.043953 -0.39141
  0.3344   -0.57545   0.087459 0.28787 -0.06731   0.30906 -0.26384
 -0.13231 -0.20757   0.33395 -0.33848 -0.31743 -0.48336   0.1464
 -0.37304   0.34577   0.052041 0.44946 -0.46971   0.02628 -0.54155
 -0.15518 -0.14107 -0.039722 0.28277   0.14393   0.23464 -0.31021
  0.086173 0.20397   0.52624   0.17164 -0.082378 -0.71787 -0.41531
  0.20335 -0.12763   0.41367   0.55187   0.57908 -0.33477 -0.36559
 -0.54857 -0.062892 0.26584   0.30205   0.99775 -0.80481 -3.0243
  0.01254 -0.36942   2.2167   0.72201 -0.24978   0.92136   0.034514
  0.46745   1.1079   -0.19358 -0.074575 0.23353 -0.052062 -0.22044
  0.057162 -0.15806 -0.30798 -0.41625   0.37972   0.15006 -0.53212
 -0.2055   -1.2526   0.071624 0.70565   0.49744 -0.42063   0.26148
 -1.538   -0.30223 -0.073438 -0.28312   0.37104 -0.25217   0.016215
 -0.017099 -0.38984   0.87424 -0.72569 -0.51058 -0.52028 -0.1459
  0.8278   0.27062]
quick: [-0.43146   -0.22037   -0.22684   -0.10215   -0.31863   -0.11809
 -0.093402 -0.069789 -0.29029   -0.34006   0.099652 -0.059301
 -0.43764   0.19464   0.36997   0.73648   -0.53429   -0.3469
 -0.21415   0.62954   0.54868   0.29429   -0.32889   -0.61771
 -0.039648   0.91639   -0.64046   0.28725   0.095922 -0.38774
 -0.62958   0.33443   -0.4856   -0.2287   0.84277   -0.2204
 -0.13264   -0.18188   0.077686   0.080045 -0.018909 -0.26018
  0.29542   -0.89173   -0.39373   -0.35662   0.011656 -0.37658
  0.64576   -0.86503   0.12615   0.18984   -0.26936   0.56216
  0.38218   -2.1389   -0.0096116   0.15041   1.2586   -0.35475
 -0.33285   0.07292   -0.077262   0.049068   0.90212   -0.27539
 -0.20839   0.26349   -0.26515   -0.70593   -0.68474   0.38424
 -0.21889   -0.88545   0.38583   0.26481   -0.7641   -0.037501
 -0.020606 -0.71318   1.1045   0.0453   -0.41902   -0.47667
 -1.4088   -0.50376   0.88062   0.0072194 -0.42083   -0.62586
  0.59608   0.30444   -0.40999   -0.28204   -0.52321   -0.44695
  0.21083   -0.010209   0.0086056   0.63263   ]
```

```
brown:  [-4.3812e-01 -9.9389e-02 -2.6038e-01 -1.1084e+00  1.0550e-01 -5.4542e-02
   4.4868e-01  6.1750e-02 -5.8803e-01 -2.1738e-01 -3.6304e-01 -4.0887e-01
   3.7877e-02  8.4201e-01  1.0108e-01 -1.8530e-01  5.0486e-01 -3.4252e-01
   2.2516e-01 -2.6942e-02 -4.6399e-01  9.9140e-02  1.9596e-02 -6.7435e-01
   6.3123e-01  9.5930e-01  1.6215e-01 -4.3166e-01 -2.6642e-01  1.9136e-01
   4.5626e-01  6.8918e-01  3.6808e-01 -2.8273e-01 -4.6525e-01  5.9984e-01
   1.5369e-01  8.6585e-01  2.7917e-01  5.8380e-01 -4.6627e-01 -1.3590e+00
  -1.0387e-01  6.0146e-02 -5.2733e-01  1.3135e-01 -3.3766e-01  1.7893e-01
   4.4812e-01 -7.0502e-01  6.3793e-01 -7.9508e-01  1.3176e-01  9.7769e-01
  -2.3153e-01 -2.6450e+00 -1.1464e-01  2.7907e-01  4.9121e-01  5.1274e-01
   7.9559e-04  1.7932e-01 -2.9938e-01 -3.3465e-01  9.9161e-01 -6.0262e-01
   7.2080e-01  8.4681e-01 -2.3669e-01  1.3666e-01 -3.5330e-01  3.9442e-01
  -7.2818e-01  9.1664e-02  3.0441e-01  4.8352e-02 -4.1140e-01  3.4362e-01
   1.2569e-01  4.2484e-01  4.5470e-01  1.6292e-01 -1.3630e-01 -2.1827e-01
  -3.8261e-01 -9.2620e-01  5.1256e-01 -3.5184e-01  1.8316e-01  1.9807e-01
  -1.9681e-02 -7.2242e-01 -4.3439e-01  1.3449e-01 -8.4339e-01  1.3815e-02
  -1.1325e+00  1.8143e-01 -1.9537e-01 -3.6954e-01]
fox:  [ 0.16917  -0.99783   0.24429  -0.79687   0.036447 -0.56127
   0.17305   0.29287  -0.43291  -0.82274  -0.11437  -0.28808
   0.20501  -0.4878    0.50534  -0.2117    0.48474   0.20959
   0.26642   0.6839   -0.2629    0.14794   0.087969 -0.17349
   0.61804   0.63733   0.41145   0.46401  -0.2165    0.5
   0.65265   1.0608    0.19275   0.141     0.51356   0.72558
  -0.044848 -0.35761   0.49862   0.73592  -0.38307   0.12159
  -0.75345   0.80579  -0.48075  -0.40283  -0.49931  -0.60309
   0.26126  -0.24109  -0.55885  -0.10622   0.11289   0.49708
   0.015915 -2.452    -0.32529   0.20437   0.55361   0.60879
  -0.083061  0.60856   0.13958  -0.71847   1.1409    0.023752
   0.050995  0.29621  -0.16247   1.1456    0.16929  -0.0042113
  -0.4026   -0.073144  0.096698 -0.15248  -0.69435   0.28032
  -1.0238    0.58777  -0.34573  -0.60871   0.1842   -0.18736
  -0.49948  -0.18095  -0.71161   0.69437   0.37298  -0.308
   0.2455   -0.94515   0.20393  -0.14885  -1.1153   -0.52266
  -0.27841   0.027184  0.39712   0.17933  ]
jumps:  [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
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 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0.]
over:  [-2.9574e-01  3.5345e-01  6.3326e-01  1.9576e-01 -3.0256e-02  5.4244e-01
  -2.1091e-01  3.2894e-01 -4.8888e-01  1.8379e-01  2.4242e-01  4.0346e-01
   1.1973e-01  1.3143e-02  2.4154e-01 -4.0184e-01  2.2176e-01 -2.7837e-01
  -4.6930e-01 -5.4899e-02  6.5148e-01  1.5958e-01  5.9556e-01  3.3167e-01
   7.2649e-01 -4.3182e-01  1.7208e-01 -1.1584e-02 -2.6389e-01 -2.2073e-01
  -2.8538e-01  3.5863e-01  2.4592e-01  2.2143e-01 -7.6221e-01  3.9352e-01
  -2.3915e-02  4.3028e-01 -4.7099e-01  2.5162e-01 -5.9507e-01 -1.0495e+00
   1.7973e-01 -3.1621e-01  2.3788e-01 -8.8560e-02  3.4751e-01 -5.5950e-01
   1.2997e-01 -7.0101e-01  2.8850e-01  1.8111e-01 -2.3004e-01  2.0682e+00
```

```
 -1.4925e-01 -2.8700e+00 -4.6722e-03 -2.2819e-01  1.6623e+00  6.5951e-01
  2.1892e-01  6.3600e-01  1.0332e-01  1.3176e-03  4.4414e-01  2.0222e-01
  5.2490e-01  6.4131e-01  2.7416e-01  1.0695e-01 -1.2030e-01  4.7109e-02
 -5.3503e-01 -4.6869e-01 -7.6050e-02  1.0654e-03 -3.8456e-01 -2.4067e-02
 -7.5877e-01  5.2622e-01  1.3285e+00 -3.9051e-01 -1.2174e-01  5.1886e-01
 -1.0374e+00 -3.3789e-01  7.4933e-02  2.0036e-01  2.4703e-02 -2.9090e-01
 -3.2043e-01  2.0445e-02 -9.9185e-01  1.6802e-02 -6.0819e-01 -2.6601e-01
 -1.9549e-01  2.3127e-01  9.4771e-01 -9.5560e-02]
the: [-0.038194 -0.24487   0.72812  -0.39961   0.083172  0.043953 -0.39141
  0.3344   -0.57545   0.087459  0.28787  -0.06731   0.30906  -0.26384
 -0.13231  -0.20757   0.33395  -0.33848  -0.31743  -0.48336   0.1464
 -0.37304   0.34577   0.052041  0.44946  -0.46971   0.02628  -0.54155
 -0.15518  -0.14107  -0.039722  0.28277   0.14393   0.23464  -0.31021
  0.086173  0.20397   0.52624   0.17164  -0.082378 -0.71787  -0.41531
  0.20335  -0.12763   0.41367   0.55187   0.57908  -0.33477  -0.36559
 -0.54857  -0.062892  0.26584   0.30205   0.99775  -0.80481  -3.0243
  0.01254  -0.36942   2.2167    0.72201  -0.24978   0.92136   0.034514
  0.46745   1.1079   -0.19358  -0.074575  0.23353  -0.052062 -0.22044
  0.057162 -0.15806  -0.30798  -0.41625   0.37972   0.15006  -0.53212
 -0.2055   -1.2526    0.071624  0.70565   0.49744  -0.42063   0.26148
 -1.538    -0.30223  -0.073438 -0.28312   0.37104  -0.25217   0.016215
 -0.017099 -0.38984   0.87424  -0.72569  -0.51058  -0.52028  -0.1459
  0.8278    0.27062 ]
lazy: [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0.]
dog: [ 0.30817   0.30938   0.52803  -0.92543  -0.73671   0.63475
  0.44197   0.10262  -0.09142  -0.56607  -0.5327    0.2013
  0.7704   -0.13983   0.13727   1.1128    0.89301  -0.17869
 -0.0019722 0.57289   0.59479   0.50428  -0.28991  -1.3491
  0.42756   1.2748   -1.1613   -0.41084   0.042804  0.54866
  0.18897   0.3759    0.58035   0.66975   0.81156   0.93864
 -0.51005  -0.070079  0.82819  -0.35346   0.21086  -0.24412
 -0.16554  -0.78358  -0.48482   0.38968  -0.86356  -0.016391
  0.31984  -0.49246  -0.069363  0.018869 -0.098286  1.3126
 -0.12116  -1.2399   -0.091429  0.35294   0.64645   0.089642
  0.70294   1.1244    0.38639   0.52084   0.98787   0.79952
 -0.34625   0.14095   0.80167   0.20987  -0.86007  -0.15308
  0.074523  0.40816   0.019208  0.51587  -0.34428  -0.24525
 -0.77984   0.27425   0.22418   0.20164   0.017431 -0.014697
 -1.0235   -0.39695  -0.0056188 0.30569   0.31748   0.021404
  0.11837  -0.11319   0.42456   0.53405  -0.16717  -0.27185
 -0.6255    0.12883   0.62529  -0.52086  ]
```

```
[18]: # create list of lists of lists for embeddings
      embeddings = []
      for doc in documents:
          embedding = []
          for word in doc:
              embedding.append(limited_index_to_embedding[limited_word_to_index[word]])
          embeddings.append(embedding)



      # ----------------------------------------------------
      # Check on the embeddings list of list of lists
      # ----------------------------------------------------
      # Show the first word in the first document
      test_word = documents[0][0]
      print('First word in first document:', test_word)
      print('Embedding for this word:\n',
            limited_index_to_embedding[limited_word_to_index[test_word]])
      print('Corresponding embedding from embeddings list of list of lists\n',
            embeddings[0][0][:])
```

```
First word in first document: while
Embedding for this word:
 [ 0.094157    0.46457     0.4535     -0.15074     0.27223     0.4545
  -0.14906     0.15345    -0.061775   -0.080787    0.53914    -0.39179
   0.083668   -0.10328     0.27425    -0.80995    -0.11588    -0.32288
  -0.23434     0.19782     0.47749     0.027463    0.49629     0.41455
   0.55198     0.13814    -0.14193    -0.65181    -0.055301   -0.026074
  -0.26557     0.16076    -0.32292    -0.10203     0.08234     0.13615
   0.27754     0.19405    -0.2348     -0.12201    -0.39889    -0.6782
   0.42633     0.21963    -0.20309     0.16836     0.013425   -0.35281
  -0.069011   -0.93563     0.16361    -0.13117     0.099808    1.8998
  -0.26605    -2.4321     -0.34386    -0.46084     1.3691      0.72702
  -0.18504     0.18016     0.085648    0.46807     0.12802     0.28034
   0.68951     0.36221     0.66845     0.32295    -0.58005    -0.27069
   0.15057    -0.46084    -0.21336     0.36952    -0.23539     0.075712
  -0.71302    -0.27551     0.64845     0.10345    -0.64706     0.29101
  -1.4154     -0.31586    -0.26086     0.24959    -0.20852    -0.28688
  -0.075658   -0.63833    -0.0040848   0.21971    -0.91796     0.271
  -0.30677    -0.23741     0.69147    -0.16581   ]
Corresponding embedding from embeddings list of list of lists
 [ 0.094157    0.46457     0.4535     -0.15074     0.27223     0.4545
  -0.14906     0.15345    -0.061775   -0.080787    0.53914    -0.39179
   0.083668   -0.10328     0.27425    -0.80995    -0.11588    -0.32288
  -0.23434     0.19782     0.47749     0.027463    0.49629     0.41455
   0.55198     0.13814    -0.14193    -0.65181    -0.055301   -0.026074
  -0.26557     0.16076    -0.32292    -0.10203     0.08234     0.13615
   0.27754     0.19405    -0.2348     -0.12201    -0.39889    -0.6782
```

```
    0.42633      0.21963     -0.20309      0.16836      0.013425   -0.35281
   -0.069011    -0.93563      0.16361     -0.13117      0.099808    1.8998
   -0.26605     -2.4321      -0.34386     -0.46084      1.3691      0.72702
   -0.18504      0.18016      0.085648     0.46807      0.12802     0.28034
    0.68951      0.36221      0.66845      0.32295     -0.58005    -0.27069
    0.15057     -0.46084     -0.21336      0.36952     -0.23539     0.075712
   -0.71302     -0.27551      0.64845      0.10345     -0.64706     0.29101
   -1.4154      -0.31586     -0.26086      0.24959     -0.20852    -0.28688
   -0.075658    -0.63833     -0.0040848    0.21971     -0.91796     0.271
   -0.30677     -0.23741      0.69147     -0.16581    ]
```

[19]:
```python
# ------------------------------------------------------
# Make embeddings a numpy array for use in an RNN
# Create training and test sets with Scikit Learn
# ------------------------------------------------------
embeddings_array = np.array(embeddings)

# Define the labels to be used 500 negative (0) and 500 positive (1)
thumbs_down_up = np.concatenate((np.zeros((500), dtype = np.int32),
                    np.ones((500), dtype = np.int32)), axis = 0)

# Scikit Learn for random splitting of the data
from sklearn.model_selection import train_test_split

RANDOM_SEED = 9999
# Random splitting of the data in to training (80%) and test (20%)
X_train, X_test, y_train, y_test = \
    train_test_split(embeddings_array, thumbs_down_up, test_size=0.20,
                    random_state = RANDOM_SEED)


# -------------------------------------------------------------------------------
# We use a very simple Recurrent Neural Network for this assignment
# Geron, A. 2017. Hands-On Machine Learning with Scikit-Learn & TensorFlow:
#     Concepts, Tools, and Techniques to Build Intelligent Systems.
#     Sebastopol, Calif.: O'Reilly. [ISBN-13 978-1-491-96229-9]
#     Chapter 14 Recurrent Neural Networks, pages 390-391
#     Source code available at https://github.com/ageron/handson-ml
#     Jupyter notebook file 14_recurrent_neural_networks.ipynb
#     See section on Training an sequence Classifier, # In [34]:
#     which uses the MNIST case data...  we revise to accommodate
#     the movie review data in this assignment
# -------------------------------------------------------------------------------
reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
```

```python
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                           logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                  iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train2 = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test2 = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train2, 'Test accuracy:', acc_test2)
```

```
  ---- Epoch  0  ----

 Batch  0  training observations from  0  to   99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.55 Test accuracy: 0.505


---- Epoch  1  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.53 Test accuracy: 0.545


---- Epoch  2  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.55 Test accuracy: 0.555


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.525


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.53


---- Epoch  5  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.54


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.57


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.56
```

```
---- Epoch  8  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.585


---- Epoch  9  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.595


---- Epoch  10  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.6


---- Epoch  11  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.68 Test accuracy: 0.6


---- Epoch  12  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.66 Test accuracy: 0.59


---- Epoch  13  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.68 Test accuracy: 0.595


---- Epoch  14  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.7 Test accuracy: 0.62


---- Epoch  15  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.62


---- Epoch  16  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.63


---- Epoch  17  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.65


---- Epoch  18  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.635
```

```
---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.62


---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.625


---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.635


---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.79 Test accuracy: 0.645


---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.65


---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.645


---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.66


---- Epoch  26  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.66


---- Epoch  27  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.655


---- Epoch  28  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655


---- Epoch  30  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.645


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.65


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.66


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.83 Test accuracy: 0.655


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.66


---- Epoch  35  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.66


---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.655


---- Epoch  37  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.66


---- Epoch  38  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.665


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.67


---- Epoch  40  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.655


---- Epoch  41  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.615


---- Epoch  42  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.64


---- Epoch  43  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.665


---- Epoch  44  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.88 Test accuracy: 0.67

---- Epoch  45  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.88 Test accuracy: 0.64

---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.9 Test accuracy: 0.63

---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.91 Test accuracy: 0.635

---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.9 Test accuracy: 0.63


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.9 Test accuracy: 0.635
```

[20]:
```python
RANDOM_SEED = 1234

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()


n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                   logits=logits)
loss = tf.reduce_mean(xentropy)
```

```python
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train2b = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test2b = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train2b, 'Test accuracy:', acc_test2b)
```

```
  ---- Epoch  0  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
 Batch  7  training observations from  700  to  799

 Train accuracy: 0.56 Test accuracy: 0.52

  ---- Epoch  1  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.59 Test accuracy: 0.565


---- Epoch  2  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.55


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.555


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.535


---- Epoch  5  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.55


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.56


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.55


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.555


---- Epoch  9  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.575


---- Epoch  10  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.57


---- Epoch  11  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.595


---- Epoch  12  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.68 Test accuracy: 0.615


---- Epoch  13  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.62


---- Epoch  14  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.62


---- Epoch  15  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.615


---- Epoch  16  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.61


---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.6


---- Epoch  18  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.6


---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.59


---- Epoch  20  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.58


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.575


---- Epoch  22  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.58


---- Epoch  23  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.76 Test accuracy: 0.585


---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.58


---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.59


---- Epoch  26  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.59


---- Epoch  27  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.59


---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.6


---- Epoch  29  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.595


---- Epoch  30  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.595


---- Epoch  31  ----

Batch  0  training observations from  0  to  99
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.59


---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.6


---- Epoch  29  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.595


---- Epoch  30  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.595


---- Epoch  31  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.6


---- Epoch  32  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.6


---- Epoch  33  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.605


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.615
```

```
---- Epoch  35  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.85 Test accuracy: 0.605


---- Epoch  36  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.85 Test accuracy: 0.6


---- Epoch  37  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.85 Test accuracy: 0.6


---- Epoch  38  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.6


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.595


---- Epoch  40  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.59


---- Epoch  41  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.59


---- Epoch  42  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.58


---- Epoch  43  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.575


---- Epoch  44  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.58


---- Epoch  45  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.585
```

```
---- Epoch  46  ----

Batch  0  training observations from  0   to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.59


---- Epoch  47  ----

Batch  0  training observations from  0   to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.59


---- Epoch  48  ----

Batch  0  training observations from  0   to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.585


---- Epoch  49  ----

Batch  0  training observations from  0   to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
        Batch  7  training observations from  700  to  799

        Train accuracy: 0.9 Test accuracy: 0.59
```

[21]:
```python
RANDOM_SEED = 42

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()


n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                    logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
```

```
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train2c = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test2c = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train2c, 'Test accuracy:', acc_test2c)
```

---- Epoch 0 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.55 Test accuracy: 0.505

---- Epoch 1 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.53 Test accuracy: 0.545

---- Epoch 2 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

```
Train accuracy: 0.55 Test accuracy: 0.555


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.525


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.53


---- Epoch  5  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.54


---- Epoch  6  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.57


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.56


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.585


---- Epoch  9  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.595


---- Epoch  10  ----


Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.6


---- Epoch  11  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.6


---- Epoch  12  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.59


---- Epoch  13  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.595
```

```
---- Epoch  14  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.62


---- Epoch  15  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.62


---- Epoch  16  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.63


---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.65


---- Epoch  18  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.635


---- Epoch  19  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.62


---- Epoch  20  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.625


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.635


---- Epoch  22  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.645


---- Epoch  23  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.65


---- Epoch  24  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.645
```

```
---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.66


---- Epoch  26  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.66


---- Epoch  27  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.655


---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.82 Test accuracy: 0.655

---- Epoch  29  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.82 Test accuracy: 0.655

---- Epoch  30  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.84 Test accuracy: 0.645

---- Epoch  31  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.84 Test accuracy: 0.65

---- Epoch  32  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.84 Test accuracy: 0.66


---- Epoch  33  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.83 Test accuracy: 0.655


---- Epoch  34  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.83 Test accuracy: 0.66


---- Epoch  35  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.84 Test accuracy: 0.66


---- Epoch  36  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.655


---- Epoch  37  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.66


---- Epoch  38  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.665


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

Train accuracy: 0.89 Test accuracy: 0.67

---- Epoch 40 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.87 Test accuracy: 0.655

---- Epoch 41 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.84 Test accuracy: 0.615

---- Epoch 42 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.88 Test accuracy: 0.64

---- Epoch 43 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.665


---- Epoch  44  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.67


---- Epoch  45  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.64


---- Epoch  46  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.63


---- Epoch  47  ----
```

```
Batch  0   training observations from   0  to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.91 Test accuracy: 0.635


---- Epoch  48  ----


Batch  0   training observations from   0  to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.9 Test accuracy: 0.63


---- Epoch  49  ----


Batch  0   training observations from   0  to   99
Batch  1   training observations from   100  to   199
Batch  2   training observations from   200  to   299
Batch  3   training observations from   300  to   399
Batch  4   training observations from   400  to   499
Batch  5   training observations from   500  to   599
Batch  6   training observations from   600  to   699
Batch  7   training observations from   700  to   799


Train accuracy: 0.9 Test accuracy: 0.635
```

0.3 Model 3: Glove.twitter 50 dimensions, vocabulary 10,000 words

```python
[22]: # -------------------------------------------------------------
      # Select the pre-defined embeddings source
      # Define vocabulary size for the language model
      # Create a word_to_embedding_dict for GloVe.6B.50d
      embeddings_directory = 'embeddings/glove.twitter.27B'
      filename3 = 'glove.twitter.27B.50d.txt'
      embeddings_filename = os.path.join(embeddings_directory, filename3)
      # -------------------------------------------------------------
```

```python
print('\nLoading embeddings from', embeddings_filename)
word_to_index, index_to_embedding = \
    load_embedding_from_disks(embeddings_filename, with_indexes=True)
print("Embedding loaded from disks.")

# Additional background code from
# https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
# shows the general structure of the data structures for word embeddings
# This code is modified for our purposes in language modeling
vocab_size, embedding_dim = index_to_embedding.shape
print("Embedding is of shape: {}".format(index_to_embedding.shape))
print("This means (number of words, number of dimensions per word)\n")
print("The first words are words that tend occur more often.")
```

```
Loading embeddings from embeddings/glove.twitter.27B/glove.twitter.27B.50d.txt
Embedding loaded from disks.
Embedding is of shape: (1193515, 50)
This means (number of words, number of dimensions per word)

The first words are words that tend occur more often.
```

[23]:
```python
# Show how to use embeddings dictionaries with a test sentence
# This is a famous typing exercise with all letters of the alphabet
# https://en.wikipedia.org/wiki/The_quick_brown_fox_jumps_over_the_lazy_dog
a_typing_test_sentence = 'The quick brown fox jumps over the lazy dog'
print('\nTest sentence: ', a_typing_test_sentence, '\n')
words_in_test_sentence = a_typing_test_sentence.split()

print('Test sentence embeddings from complete vocabulary of',
      complete_vocabulary_size, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = index_to_embedding[word_to_index[word_]]
    print(word_ + ": ", embedding)
```

```
Test sentence:  The quick brown fox jumps over the lazy dog

Test sentence embeddings from complete vocabulary of 400000 words:

the:  [ 2.5320e-01 -1.4884e-02  5.9371e-01  1.5902e-01  1.2754e-01  2.2428e-01
  8.9421e-01  3.6396e-01 -3.1339e-01 -5.1857e-01  2.9637e-01 -4.1098e-02
 -6.4555e+00  3.2260e-01  3.7280e-01 -6.1690e-01  4.6744e-01  5.0600e-01
  3.1950e-02  1.0155e-01 -1.9615e-01  1.3364e-01 -2.7140e-01 -4.1728e-01
```

```
 7.7940e-03  1.3573e-01 -7.2992e-02  2.5208e-01  5.1148e-01  1.5120e-01
 8.4398e-02 -2.4791e-01 -1.5913e-01  1.5005e-01  7.7243e-01  3.6632e-01
-9.8310e-02 -6.4317e-02 -7.1983e-04 -1.5231e-01 -1.4604e+00 -3.1696e-01
-4.1762e-01  7.3363e-02  3.2043e-01  3.4324e-01  1.0895e-02 -2.8932e-01
 4.5493e-01  1.8659e-01]
quick: [ 0.12993    0.017304  -0.67992   -0.68787    0.90278    0.19785
 0.8508    -0.64082   -0.042651   0.40325   -0.27191   -0.0051179
-3.6292    -0.88436   -0.48239    0.47148   -0.13498   -0.27328
-0.71906   -0.53527   -0.84605   -0.28626    0.45777   -0.31809
-0.42931    0.5375     0.33676    0.45397   -0.58573    0.1359
-0.14093    0.31584   -0.044451   0.16463    0.32599    1.033
 0.23227   -0.40527    0.531      0.28329   -0.60584    0.55059
 0.63242   -0.043776   0.97157   -0.48357   -0.16058    0.21731
-0.081218   0.96826  ]
brown: [-6.4007e-01 -1.7615e+00  6.4874e-01  3.7342e-02 -1.4549e-01 -1.5672e-01
 8.4636e-01  4.6387e-01 -1.6172e-01 -2.5805e-01 -6.8369e-02  2.5422e-01
-3.5850e+00 -7.2949e-01  2.3258e-01 -1.9458e-01 -4.2143e-01  8.0162e-04
 2.5699e-01  7.5122e-02 -3.4076e-01  1.2274e-01  2.7698e-01 -1.3465e+00
 6.1301e-01 -2.5346e-01  6.6083e-02  4.9287e-01 -3.7427e-01 -6.0144e-01
 1.5865e-01  8.7051e-01 -1.0704e+00 -3.2066e-01 -4.2425e-01  3.3071e-01
-8.8770e-02 -2.2529e-01  2.5774e-01  1.1681e-01 -1.2520e+00 -2.9067e-01
-1.7117e-01  2.7823e-01 -2.8013e-01 -5.9460e-01  3.4445e-01 -8.0539e-02
-1.1274e-01 -4.6464e-01]
fox:   [ 2.7783e-01  2.2203e-02  4.4302e-01 -5.2157e-01 -3.1011e-01 -1.5692e-01
 2.1954e-01  6.6322e-01  2.7156e-01 -8.0996e-01  5.3198e-01 -4.1933e-01
-3.0320e+00  3.9679e-01  4.2704e-01 -9.4355e-01 -3.3419e-01  2.4981e-01
 9.2074e-01  4.9750e-01 -9.8847e-02 -5.9936e-01 -2.4662e-01 -6.9806e-01
-7.1866e-02 -5.7444e-01 -1.9589e-01  6.9227e-01 -6.3946e-01 -7.7689e-02
-1.5605e-01  1.6552e-01 -1.5322e-01 -8.4405e-01 -2.3729e-01  5.4035e-01
 3.9505e-01 -4.6509e-01 -6.3955e-01 -5.8067e-01 -1.2615e+00 -1.2464e-01
 1.7502e-01  6.6657e-01  6.1855e-01  4.5100e-01  1.2583e-03 -3.3447e-01
-2.8782e-01 -3.8150e-01]
jumps: [-0.14442 -0.12975   1.0448   -0.33292   0.19768   0.69413   0.51918
-0.24851 -0.037997 -1.319     0.49032   0.35393  -2.0517   -0.52521
 0.30637  0.30789  -0.32436  -0.20925   0.2389   -1.3992    0.756
-0.74176  1.2795    0.46474  -0.43089   0.80793  -1.0938   -0.13291
-0.35417  0.90423  -0.59747   0.53428   0.6505   -0.25233  -0.27441
 0.85977  1.3324    0.15238   1.0832   -0.77706  -0.012607  0.16236
-0.88413  0.097072  0.62249  -0.085237 -0.15263  -0.28406   0.58478
 1.3047  ]
over:  [ 0.65718    0.48357    0.79396    0.0061244 -0.79137    0.43614
 0.11402   -0.54439   -0.47266   -0.25204    0.9146     0.12985
-5.0918    -0.056972  -0.38673   -0.0191    -0.071072  -0.12098
-0.74613   -0.41611    0.13207   -0.21725    0.066948   0.1893
 0.83169    0.50931    0.19545   -0.29529   -1.3769    -0.25262
-0.28541    0.63398   -0.52167   -0.15683    1.0083    -0.70692
-0.067646   0.48093   -0.073803  -0.7121    -0.99231    0.053425
 0.0079127 -0.19086    0.50033   -0.32102    0.11986    0.1885
```

```
       0.11279     1.0351   ]
the: [ 2.5320e-01 -1.4884e-02  5.9371e-01  1.5902e-01  1.2754e-01  2.2428e-01
  8.9421e-01  3.6396e-01 -3.1339e-01 -5.1857e-01  2.9637e-01 -4.1098e-02
 -6.4555e+00  3.2260e-01  3.7280e-01 -6.1690e-01  4.6744e-01  5.0600e-01
  3.1950e-02  1.0155e-01 -1.9615e-01  1.3364e-01 -2.7140e-01 -4.1728e-01
  7.7940e-03  1.3573e-01 -7.2992e-02  2.5208e-01  5.1148e-01  1.5120e-01
  8.4398e-02 -2.4791e-01 -1.5913e-01  1.5005e-01  7.7243e-01  3.6632e-01
 -9.8310e-02 -6.4317e-02 -7.1983e-04 -1.5231e-01 -1.4604e+00 -3.1696e-01
 -4.1762e-01  7.3363e-02  3.2043e-01  3.4324e-01  1.0895e-02 -2.8932e-01
  4.5493e-01  1.8659e-01]
lazy: [ 0.29308    -0.26061    -0.37649    -0.030178   -0.4979       0.60142
  1.0672     -0.19923    -0.25602     0.78305    -0.84569    -0.4397
 -3.6832     -0.38996    -0.40995    -0.11761    -0.20017    -0.66875
 -1.0319      0.3054     -0.76448    -0.0059399  0.11207     0.30618
  0.23115     1.2014      0.089656    0.043695   -0.20261    -0.010501
 -0.13685     0.16524     0.8081      0.097575   -0.67664     0.48361
 -0.28666    -0.47856     0.23563     0.32544    -0.5195      1.0511
  0.21663     0.33345     1.018       0.064562    0.51507     1.3312
 -0.93497     0.14716   ]
dog: [-0.32538 -0.32445 -0.49074 -0.70731 -0.61267 -0.53143    0.49369
  0.25313 -0.19132 -0.4573  -0.38428   0.97144 -4.2376    -0.39954
  0.46864  0.61591  0.14492 -1.2449    0.14534 -0.5073    -0.42109
  0.58748  0.49906 -0.20719  0.26784   0.59813 -0.59354    0.45339
  0.49441  0.08239 -0.44238  0.26892  -0.023738 -0.17423  -0.74823
  0.18656  0.078524 -0.24285 -0.19756  -0.49863  -1.0753    0.18612
 -0.87087  0.44196  0.815    1.0486    1.2306    0.32016  -0.28743
 -0.10879 ]
```

```python
# ----------------------------------------------------------------
# Define vocabulary size for the language model
# To reduce the size of the vocabulary to the n most frequently used words

EVOCABSIZE = 10000   # specify desired size of pre-defined embedding vocabulary

def default_factory():
    return EVOCABSIZE  # last/unknown-word row in limited_index_to_embedding
# dictionary has the items() function, returns list of (key, value) tuples
limited_word_to_index = defaultdict(default_factory, \
    {k: v for k, v in word_to_index.items() if v < EVOCABSIZE})

# Select the first EVOCABSIZE rows to the index_to_embedding
limited_index_to_embedding = index_to_embedding[0:EVOCABSIZE,:]
# Set the unknown-word row to be all zeros as previously
limited_index_to_embedding = np.append(limited_index_to_embedding,
    index_to_embedding[index_to_embedding.shape[0] - 1, :].\
        reshape(1,embedding_dim),
    axis = 0)
```

```python
# Delete large numpy array to clear some CPU RAM
del index_to_embedding

# Verify the new vocabulary: should get same embeddings for test sentence
# Note that a small EVOCABSIZE may yield some zero vectors for embeddings
print('\nTest sentence embeddings from vocabulary of', EVOCABSIZE, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = limited_index_to_embedding[limited_word_to_index[word_]]
    print(word_ + ": ", embedding)
```

Test sentence embeddings from vocabulary of 10000 words:

the: [2.5320e-01 -1.4884e-02 5.9371e-01 1.5902e-01 1.2754e-01 2.2428e-01
  8.9421e-01 3.6396e-01 -3.1339e-01 -5.1857e-01 2.9637e-01 -4.1098e-02
 -6.4555e+00 3.2260e-01 3.7280e-01 -6.1690e-01 4.6744e-01 5.0600e-01
  3.1950e-02 1.0155e-01 -1.9615e-01 1.3364e-01 -2.7140e-01 -4.1728e-01
  7.7940e-03 1.3573e-01 -7.2992e-02 2.5208e-01 5.1148e-01 1.5120e-01
  8.4398e-02 -2.4791e-01 -1.5913e-01 1.5005e-01 7.7243e-01 3.6632e-01
 -9.8310e-02 -6.4317e-02 -7.1983e-04 -1.5231e-01 -1.4604e+00 -3.1696e-01
 -4.1762e-01 7.3363e-02 3.2043e-01 3.4324e-01 1.0895e-02 -2.8932e-01
  4.5493e-01 1.8659e-01]
quick: [0.12993   0.017304 -0.67992   -0.68787   0.90278   0.19785
  0.8508   -0.64082   -0.042651   0.40325   -0.27191   -0.0051179
 -3.6292   -0.88436   -0.48239   0.47148   -0.13498   -0.27328
 -0.71906   -0.53527   -0.84605   -0.28626   0.45777   -0.31809
 -0.42931   0.5375   0.33676   0.45397   -0.58573   0.1359
 -0.14093   0.31584   -0.044451   0.16463   0.32599   1.033
  0.23227   -0.40527   0.531   0.28329   -0.60584   0.55059
  0.63242   -0.043776   0.97157   -0.48357   -0.16058   0.21731
 -0.081218   0.96826   ]
brown: [-6.4007e-01 -1.7615e+00 6.4874e-01 3.7342e-02 -1.4549e-01 -1.5672e-01
  8.4636e-01 4.6387e-01 -1.6172e-01 -2.5805e-01 -6.8369e-02 2.5422e-01
 -3.5850e+00 -7.2949e-01 2.3258e-01 -1.9458e-01 -4.2143e-01 8.0162e-04
  2.5699e-01 7.5122e-02 -3.4076e-01 1.2274e-01 2.7698e-01 -1.3465e+00
  6.1301e-01 -2.5346e-01 6.6083e-02 4.9287e-01 -3.7427e-01 -6.0144e-01
  1.5865e-01 8.7051e-01 -1.0704e+00 -3.2066e-01 -4.2425e-01 3.3071e-01
 -8.8770e-02 -2.2529e-01 2.5774e-01 1.1681e-01 -1.2520e+00 -2.9067e-01
 -1.7117e-01 2.7823e-01 -2.8013e-01 -5.9460e-01 3.4445e-01 -8.0539e-02
 -1.1274e-01 -4.6464e-01]
fox: [2.7783e-01 2.2203e-02 4.4302e-01 -5.2157e-01 -3.1011e-01 -1.5692e-01
  2.1954e-01 6.6322e-01 2.7156e-01 -8.0996e-01 5.3198e-01 -4.1933e-01
 -3.0320e+00 3.9679e-01 4.2704e-01 -9.4355e-01 -3.3419e-01 2.4981e-01
  9.2074e-01 4.9750e-01 -9.8847e-02 -5.9936e-01 -2.4662e-01 -6.9806e-01
 -7.1866e-02 -5.7444e-01 -1.9589e-01 6.9227e-01 -6.3946e-01 -7.7689e-02

```
 -1.5605e-01  1.6552e-01 -1.5322e-01 -8.4405e-01 -2.3729e-01  5.4035e-01
  3.9505e-01 -4.6509e-01 -6.3955e-01 -5.8067e-01 -1.2615e+00 -1.2464e-01
  1.7502e-01  6.6657e-01  6.1855e-01  4.5100e-01  1.2583e-03 -3.3447e-01
 -2.8782e-01 -3.8150e-01]
jumps:  [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0.]
over:  [ 0.65718     0.48357     0.79396     0.0061244 -0.79137     0.43614
  0.11402    -0.54439    -0.47266    -0.25204     0.9146      0.12985
 -5.0918     -0.056972   -0.38673    -0.0191     -0.071072   -0.12098
 -0.74613    -0.41611     0.13207    -0.21725     0.066948    0.1893
  0.83169     0.50931     0.19545    -0.29529    -1.3769     -0.25262
 -0.28541     0.63398    -0.52167    -0.15683     1.0083     -0.70692
 -0.067646    0.48093    -0.073803   -0.7121     -0.99231     0.053425
  0.0079127  -0.19086     0.50033    -0.32102     0.11986     0.1885
  0.11279     1.0351    ]
the:  [ 2.5320e-01 -1.4884e-02  5.9371e-01  1.5902e-01  1.2754e-01  2.2428e-01
  8.9421e-01  3.6396e-01 -3.1339e-01 -5.1857e-01  2.9637e-01 -4.1098e-02
 -6.4555e+00  3.2260e-01  3.7280e-01 -6.1690e-01  4.6744e-01  5.0600e-01
  3.1950e-02  1.0155e-01 -1.9615e-01  1.3364e-01 -2.7140e-01 -4.1728e-01
  7.7940e-03  1.3573e-01 -7.2992e-02  2.5208e-01  5.1148e-01  1.5120e-01
  8.4398e-02 -2.4791e-01 -1.5913e-01  1.5005e-01  7.7243e-01  3.6632e-01
 -9.8310e-02 -6.4317e-02 -7.1983e-04 -1.5231e-01 -1.4604e+00 -3.1696e-01
 -4.1762e-01  7.3363e-02  3.2043e-01  3.4324e-01  1.0895e-02 -2.8932e-01
  4.5493e-01  1.8659e-01]
lazy:  [ 0.29308    -0.26061    -0.37649    -0.030178  -0.4979      0.60142
  1.0672     -0.19923    -0.25602     0.78305    -0.84569    -0.4397
 -3.6832     -0.38996    -0.40995    -0.11761    -0.20017    -0.66875
 -1.0319      0.3054     -0.76448    -0.0059399  0.11207     0.30618
  0.23115     1.2014      0.089656    0.043695   -0.20261    -0.010501
 -0.13685     0.16524     0.8081      0.097575   -0.67664     0.48361
 -0.28666    -0.47856     0.23563     0.32544    -0.5195      1.0511
  0.21663     0.33345     1.018       0.064562    0.51507     1.3312
 -0.93497     0.14716   ]
dog:  [-0.32538    -0.32445    -0.49074    -0.70731    -0.61267    -0.53143     0.49369
  0.25313    -0.19132    -0.4573     -0.38428     0.97144    -4.2376     -0.39954
  0.46864     0.61591     0.14492    -1.2449      0.14534    -0.5073     -0.42109
  0.58748     0.49906    -0.20719     0.26784     0.59813    -0.59354     0.45339
  0.49441     0.08239    -0.44238     0.26892    -0.023738  -0.17423    -0.74823
  0.18656     0.078524   -0.24285    -0.19756    -0.49863    -1.0753      0.18612
 -0.87087     0.44196     0.815       1.0486      1.2306      0.32016    -0.28743
 -0.10879  ]
```

[25]:
```python
# create list of lists of lists for embeddings
embeddings = []
for doc in documents:
    embedding = []
```

```python
    for word in doc:
        embedding.append(limited_index_to_embedding[limited_word_to_index[word]])
    embeddings.append(embedding)


# -------------------------------------------------------
# Check on the embeddings list of list of lists
# -------------------------------------------------------
# Show the first word in the first document
test_word = documents[0][0]
print('First word in first document:', test_word)
print('Embedding for this word:\n',
      limited_index_to_embedding[limited_word_to_index[test_word]])
print('Corresponding embedding from embeddings list of list of lists\n',
      embeddings[0][0][:])
```

```
First word in first document: while
Embedding for this word:
 [-0.50128    0.40962    0.64312   -0.26067   -0.27818    0.59036    0.90437
  0.25659   -0.11475   -0.58194   -0.079421  -0.2883    -5.1047     0.10286
 -0.76867   -0.12699   -0.16268   -1.002     -0.29238   -0.68732    0.06251
 -0.36165    0.29152    0.24277    0.24353    0.79343   -0.55596   -0.1399
 -0.21129    0.28897   -0.44656    0.15926   -0.64158    0.019389   0.18832
  0.10346    0.17686    0.38195    0.42093   -0.017792  -0.15155    0.72622
 -0.083218   0.081371   0.76465    0.23819   -0.26818    0.69448   -0.14709
  0.060293]
Corresponding embedding from embeddings list of list of lists
 [-0.50128    0.40962    0.64312   -0.26067   -0.27818    0.59036    0.90437
  0.25659   -0.11475   -0.58194   -0.079421  -0.2883    -5.1047     0.10286
 -0.76867   -0.12699   -0.16268   -1.002     -0.29238   -0.68732    0.06251
 -0.36165    0.29152    0.24277    0.24353    0.79343   -0.55596   -0.1399
 -0.21129    0.28897   -0.44656    0.15926   -0.64158    0.019389   0.18832
  0.10346    0.17686    0.38195    0.42093   -0.017792  -0.15155    0.72622
 -0.083218   0.081371   0.76465    0.23819   -0.26818    0.69448   -0.14709
  0.060293]
```

[26]:
```python
# -------------------------------------------------------
# Make embeddings a numpy array for use in an RNN
# Create training and test sets with Scikit Learn
# -------------------------------------------------------
embeddings_array = np.array(embeddings)

# Define the labels to be used 500 negative (0) and 500 positive (1)
thumbs_down_up = np.concatenate((np.zeros((500), dtype = np.int32),
                    np.ones((500), dtype = np.int32)), axis = 0)

# Scikit Learn for random splitting of the data
```

```python
from sklearn.model_selection import train_test_split

RANDOM_SEED = 9999
# Random splitting of the data in to training (80%) and test (20%)
X_train, X_test, y_train, y_test = \
    train_test_split(embeddings_array, thumbs_down_up, test_size=0.20,
                     random_state = RANDOM_SEED)


# -----------------------------------------------------------------------------    ⌴
 ↪
# We use a very simple Recurrent Neural Network for this assignment
# Geron, A. 2017. Hands-On Machine Learning with Scikit-Learn & TensorFlow:
#     Concepts, Tools, and Techniques to Build Intelligent Systems.
#     Sebastopol, Calif.: O'Reilly. [ISBN-13 978-1-491-96229-9]
#     Chapter 14 Recurrent Neural Networks, pages 390-391
#     Source code available at https://github.com/ageron/handson-ml
#     Jupyter notebook file 14_recurrent_neural_networks.ipynb
#     See section on Training an sequence Classifier, # In [34]:
#     which uses the MNIST case data...  we revise to accommodate
#     the movie review data in this assignment
# ----------------------------------------------------------------------------
reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()
```

```
n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                  iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train3 = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test3 = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train3, 'Test accuracy:', acc_test3)
```

```
 ---- Epoch  0  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.51 Test accuracy: 0.515

 ---- Epoch  1  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.54 Test accuracy: 0.53

 ---- Epoch  2  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.53


---- Epoch  3  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.55


---- Epoch  4  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.555


---- Epoch  5  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.58
```

```
---- Epoch  6  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.58


---- Epoch  7  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.6 Test accuracy: 0.56


---- Epoch  8  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.6 Test accuracy: 0.57


---- Epoch  9  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.63 Test accuracy: 0.58


---- Epoch  10   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.62 Test accuracy: 0.575


---- Epoch  11   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.63 Test accuracy: 0.57


---- Epoch  12   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.65 Test accuracy: 0.57


---- Epoch  13   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.575


---- Epoch  14  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.57


---- Epoch  15  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.565


---- Epoch  16  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.58
```

```
---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.58


---- Epoch  18  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.57


---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.58


---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.69 Test accuracy: 0.59


---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.61


---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.62


---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.63


---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.625


---- Epoch  25  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.625


---- Epoch  26  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.625


---- Epoch  27  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.615


---- Epoch  28  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.62


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.62


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.62


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.77 Test accuracy: 0.63


---- Epoch  32  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.63


---- Epoch  33  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.64


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.635


---- Epoch  35  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.63


---- Epoch  36  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.62


---- Epoch  37  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.645


---- Epoch  38  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.645


---- Epoch  39  ----
```

```
Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.655


---- Epoch  40  ----


Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.65


---- Epoch  41  ----


Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.645


---- Epoch  42  ----


Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.82 Test accuracy: 0.655


---- Epoch  43  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.655


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.66


---- Epoch  45  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.66


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.83 Test accuracy: 0.655


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.655


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.655


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655
```

```
[27]: RANDOM_SEED = 1234
```

```python
# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()


n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up


learning_rate = 0.001


X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])


basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)


logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                        logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))


init = tf.global_variables_initializer()


n_epochs = 50
batch_size = 100


with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train3b = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test3b = accuracy.eval(feed_dict={X: X_test, y: y_test})
```

```
        print('\n  Train accuracy:', acc_train3b, 'Test accuracy:', acc_test3b)
```

---- Epoch 0 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.54 Test accuracy: 0.5

---- Epoch 1 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.54 Test accuracy: 0.51

---- Epoch 2 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.58 Test accuracy: 0.53

---- Epoch 3 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.59


---- Epoch  4  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.605


---- Epoch  5  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.6


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.62


---- Epoch  7  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.6


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.605


---- Epoch  9  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.6


---- Epoch  10  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.69 Test accuracy: 0.595


---- Epoch  11  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.6


---- Epoch  12  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.585


---- Epoch  13  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.575


---- Epoch  14  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.58


---- Epoch  15  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.57


---- Epoch  16  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.58


---- Epoch  17  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.58


---- Epoch  18  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.58


---- Epoch  19  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.59


---- Epoch  20  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.585


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.7 Test accuracy: 0.585


---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.595


---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.595


---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.59


---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.6


---- Epoch  26  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.6


---- Epoch  27  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.6


---- Epoch  28  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.59


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.61


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.605


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.605


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.605
```

```
---- Epoch  33  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.605


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.605


---- Epoch  35  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.63


---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.73 Test accuracy: 0.635


---- Epoch  37  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.75 Test accuracy: 0.625


---- Epoch  38  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.75 Test accuracy: 0.655


---- Epoch  39  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.76 Test accuracy: 0.665


---- Epoch  40  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.655


---- Epoch  41  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.65


---- Epoch  42  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.655


---- Epoch  43  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.65
```

```
---- Epoch  44  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.66


---- Epoch  45  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.65


---- Epoch  46  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.65


---- Epoch  47  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.8 Test accuracy: 0.64

---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.81 Test accuracy: 0.63

---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.81 Test accuracy: 0.64
```

```python
[28]: RANDOM_SEED = 42

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.001
```

```python
X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train3c = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test3c = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train3c, 'Test accuracy:', acc_test3c)
```

```
  ---- Epoch  0  ----

 Batch  0  training observations from  0  to   99
 Batch  1  training observations from  100  to   199
 Batch  2  training observations from  200  to   299
 Batch  3  training observations from  300  to   399
 Batch  4  training observations from  400  to   499
 Batch  5  training observations from  500  to   599
 Batch  6  training observations from  600  to   699
 Batch  7  training observations from  700  to   799

 Train accuracy: 0.51 Test accuracy: 0.515
```

```
---- Epoch  1  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.53


---- Epoch  2  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.53


---- Epoch  3  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.55


---- Epoch  4  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.555


---- Epoch  5  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.58


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.58


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.6 Test accuracy: 0.56


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.6 Test accuracy: 0.57


---- Epoch  9  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.58


---- Epoch  10  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.575


---- Epoch  11  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.57
```

```
---- Epoch  12  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.57


---- Epoch  13  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.575


---- Epoch  14  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.57


---- Epoch  15  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.67 Test accuracy: 0.565

---- Epoch  16  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.69 Test accuracy: 0.58

---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.69 Test accuracy: 0.58

---- Epoch  18  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.67 Test accuracy: 0.57

---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.58


---- Epoch  20  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.59


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.61


---- Epoch  22  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.62


---- Epoch  23  ----
```

```
Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.63


---- Epoch  24  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.625


---- Epoch  25  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.625


---- Epoch  26  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.74 Test accuracy: 0.625


---- Epoch  27  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.615


---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.62


---- Epoch  29  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.62


---- Epoch  30  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.62


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.63


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.63


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.64


---- Epoch  34  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.635


---- Epoch  35  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.63


---- Epoch  36  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.62


---- Epoch  37  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

Train accuracy: 0.78 Test accuracy: 0.645

---- Epoch 38 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.79 Test accuracy: 0.645

---- Epoch 39 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.79 Test accuracy: 0.655

---- Epoch 40 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.79 Test accuracy: 0.65

---- Epoch 41 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.645


---- Epoch  42  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655


---- Epoch  43  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.655


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.66


---- Epoch  45  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.66


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.655


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.655


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.655
```

```
---- Epoch  49  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655
```

0.4   Model 4: Glove.twitter 100 dimensions, vocabulary 10,000

```python
[29]: # ------------------------------------------------------------
      # Select the pre-defined embeddings source
      # Define vocabulary size for the language model
      # Create a word_to_embedding_dict for GloVe.6B.50d
      embeddings_directory = 'embeddings/glove.twitter.27B'
      filename3 = 'glove.twitter.27B.100d.txt'
      embeddings_filename = os.path.join(embeddings_directory, filename3)
      # ------------------------------------------------------------


      print('\nLoading embeddings from', embeddings_filename)
      word_to_index, index_to_embedding = \
          load_embedding_from_disks(embeddings_filename, with_indexes=True)
      print("Embedding loaded from disks.")

      # Additional background code from
      # https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
      # shows the general structure of the data structures for word embeddings
      # This code is modified for our purposes in language modeling
      vocab_size, embedding_dim = index_to_embedding.shape
      print("Embedding is of shape: {}".format(index_to_embedding.shape))
      print("This means (number of words, number of dimensions per word)\n")
      print("The first words are words that tend occur more often.")
```

```
Loading embeddings from embeddings/glove.twitter.27B/glove.twitter.27B.100d.txt
Embedding loaded from disks.
Embedding is of shape: (1193515, 100)
This means (number of words, number of dimensions per word)


The first words are words that tend occur more often.
```

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```
[30]: # Show how to use embeddings dictionaries with a test sentence
      # This is a famous typing exercise with all letters of the alphabet
      # https://en.wikipedia.org/wiki/The_quick_brown_fox_jumps_over_the_lazy_dog
      a_typing_test_sentence = 'The quick brown fox jumps over the lazy dog'
      print('\nTest sentence: ', a_typing_test_sentence, '\n')
      words_in_test_sentence = a_typing_test_sentence.split()

      print('Test sentence embeddings from complete vocabulary of',
            complete_vocabulary_size, 'words:\n')
      for word in words_in_test_sentence:
          word_ = word.lower()
          embedding = index_to_embedding[word_to_index[word_]]
          print(word_ + ": ", embedding)
```

```
Test sentence:  The quick brown fox jumps over the lazy dog

Test sentence embeddings from complete vocabulary of 400000 words:

the:  [ 9.5152e-02  3.7024e-01  5.4291e-01  1.9621e-01  4.8205e-02  3.2033e-01
 -5.9638e-01  1.5868e-02 -1.2989e-01 -6.3028e-01  8.1944e-02  2.4164e-01
 -6.0990e+00 -6.8557e-01  5.0354e-01 -3.4089e-02  1.1705e-01 -7.7403e-03
 -8.6512e-02  4.3617e-01 -4.3982e-01  2.6125e-01 -4.0348e-02 -1.9194e-01
  8.3204e-02 -5.8246e-01 -3.1923e-02  1.2630e-01  4.0120e-01  6.8906e-02
 -1.0517e-01 -2.0804e-01 -4.2554e-01  4.7799e-01  3.4651e-01  2.4057e-01
  5.0244e-02 -7.2587e-02 -2.4347e-03 -5.0342e-01 -1.0601e+00 -3.1586e-01
 -3.2457e-02 -7.6317e-02  7.9045e-01  8.6367e-02 -1.9632e-01  5.7566e-02
  8.4129e-01 -4.2020e-01 -1.1335e-03 -8.5632e-02  6.1910e-02  2.1423e-01
 -1.0356e-01 -3.6946e-02 -2.6005e-01 -3.5657e-01  5.4321e-02  3.0875e-02
  1.4092e-01 -9.1998e-02 -4.1841e-01 -3.1135e-01 -1.4937e-01 -2.2699e-04
 -3.3454e-01 -1.4848e-01 -1.1944e-01 -2.7174e-01  3.1320e-01 -1.0998e-01
 -4.7524e-01  1.4056e-01  3.9641e-01 -4.9413e-02 -4.2601e-01 -2.3576e-01
  6.1482e-02 -3.5313e-02  2.4161e+00  2.8979e-01  3.8882e-01  3.6779e-01
  2.0685e-01  1.3992e-01 -4.2459e-01  4.4590e-01  2.6234e-01 -4.4834e-01
  3.7196e-03 -2.2521e-01  1.4764e-01 -3.6417e-01 -1.8493e-01  2.2282e-01
  4.7626e-01 -5.1083e-01  4.6877e-01  3.4882e-01]
quick:  [ 0.50111    0.37708   -0.19973   -0.55111    0.17148    0.019936
  0.50052    0.017863  -0.43901    0.4485    -0.22766   -0.087691
 -3.5079    -0.62763   -0.75083   -0.19767   -0.39356    0.3996
 -0.081026  -0.53157   -0.38539   -0.61069    0.10148   -0.10846
 -0.29013    0.61234    0.027151  -0.044352  -0.40846    0.42045
 -0.22149    0.018245  -0.25989   -0.049784   0.28018    0.26186
 -0.22841   -0.28096    0.046061   0.26917   -0.41851    0.25948
  0.10509    0.75517    0.43909    0.07024    0.053149   0.59465
 -0.23239    0.37033   -0.29459   -0.040892  -0.37618    0.015432
  0.056196  -0.25702   -0.16717    0.2405     0.29895   -0.64143
  0.91313   -0.057541   0.20291    1.0468     0.65415   -0.94901
```

```
   0.49342      0.014261    0.14139     0.17338    -0.76048     0.53518
   0.26007      0.34376     0.057837   -0.55036     0.66677    -0.31764
   0.41491     -0.025773    1.5507      0.394      -0.31088    -0.53684
   0.15205      0.70041    -0.1879     -0.24963    -0.16778    -0.34475
  -0.51597      0.010533   -0.59016    -0.44993     0.80113     0.051259
  -0.49647      0.59636     0.0075998   0.28048    ]
brown:  [-0.26106    -0.75489    -0.022668    0.055802   -0.77145     0.05871
   0.3852       0.40926    -0.97445    -0.33838     0.47742    -0.01054
  -3.1085      -0.55482     0.35536     0.44814     0.29137     0.16997
   0.66486      0.22324     0.32805    -0.40968    -0.19862     0.3546
   0.30566     -0.55413    -0.54773     0.25429    -0.72556    -0.22337
   0.16802      0.14168    -1.0443     -0.57601    -0.21027     0.18212
  -0.81012     -0.71126    -0.39691    -0.13592    -0.37764    -0.52612
  -0.80185      0.31638    -0.073107   -0.74961     0.44858    -0.0039955
  -0.22895     -0.95689    -0.70048    -0.15495     0.30279     0.51368
  -0.51663      0.053121   -0.23784     0.49018     0.47278     0.29428
  -0.42305      0.39041    -0.051611   -0.30997     0.12854    -0.67797
  -0.23172      0.13328     0.43269    -0.28219     0.56389    -0.52302
   0.52544      0.20713    -0.4926      0.2071     -0.012374    0.62647
   0.38548      0.5472      1.5739      0.38571    -0.095062   -0.70715
  -0.37873     -0.065873    0.34776     0.80396    -0.34771     0.43994
  -0.23445     -0.36284    -0.11516    -0.68272    -0.027322    0.24447
  -0.088484     0.34491    -0.55879     0.343      ]
fox:   [ 0.64344     0.0086088   0.50145    -0.70381    -0.36289    -0.51602
   0.3751      -0.0078184   0.10752    -0.29124     0.61808    -0.036332
  -2.4467      -0.0050135   0.18236    -0.18152    -0.19349    -0.19442
   0.3793       0.46691     0.03579    -0.48468    -0.45103    -0.045509
   0.6732      -1.4904     -0.23975    -0.26736    -0.058426    0.11573
   0.79477      0.09746    -0.36717    -0.20758     0.099006   -0.51114
  -0.023912     0.14275    -0.87894     0.13728    -0.26524    -0.33326
   0.25857     -0.27703     0.5022      0.7164     -0.26708     0.018559
   0.39153     -0.42015    -0.55746    -0.2797     -0.36874     0.090716
  -0.29017      0.25543    -0.016203    0.014775   -0.45174    -0.48211
  -0.18746      0.59934    -0.20146    -0.3756     -0.11143     0.26213
   0.15496      0.53471     0.43618    -0.7356      0.34366    -0.036715
  -0.2377      -0.3525     -0.5546      0.44059    -0.17759     0.50194
  -0.59675     -0.0427      1.5432      0.22326     0.40868     0.70572
  -0.17751      0.071547    0.84483     0.3794     -0.67034    -0.54685
  -0.55382     -0.88651    -0.25728    -0.1996     -0.15984     0.37977
   0.62406      0.037116   -0.427       0.029686   ]
jumps: [-0.28348     0.1648      1.4019     -0.85675     0.027551    0.5412
   0.88782      0.046905   -0.45316    -0.60368     0.55262     1.205
  -2.0585       0.51703    -0.32351    -0.30435     0.45369     0.31998
  -0.96374     -0.60021     0.47335    -0.74688     0.47179    -0.2158
  -0.09306      0.83334    -0.74749    -0.089607   -0.17782     1.2692
   0.6947       0.043769    0.52786    -0.010808   -0.16553    -0.074203
  -0.49438      0.39217     0.16966    -0.73894     0.57277     0.55778
  -0.30532     -0.24023     0.96471     0.19401     0.40399     0.1934
```

```
    0.084298    0.66986   -0.19846    0.29749    0.3546   -0.23385
   -0.14053    0.29882    0.69889    0.19321    0.95773   -0.18805
   -0.22225   -0.23144    0.38776    0.0037293  0.24487   -0.33569
   -0.17885    0.73331    0.26516   -0.098724   0.31112   -0.33525
   -0.63795   -0.97048   -0.63374    0.25719    0.23121   -1.4143
    1.011     -0.014403   0.8709     0.57321    0.40159    0.302
   -0.43126   -0.16309    0.81327    0.45568   -0.14238   -0.69614
   -0.21193   -0.13398   -0.20042    0.14101    0.47543   -0.36219
    0.71711   -0.47106    0.35576    0.46552  ]
over:  [-1.3037e-01  2.0490e-01  4.2575e-01 -3.1239e-01 -5.4739e-01  2.1011e-01
 -7.2276e-03 -6.3219e-02 -1.2984e-02 -8.2143e-02  2.5385e-01  3.2791e-01
 -4.9173e+00  3.1567e-01 -2.0232e-01 -2.5671e-01 -1.8498e-03  4.3715e-01
 -1.0066e+00  2.5198e-02 -3.9015e-02 -3.4754e-01 -2.8745e-02  6.5716e-01
  1.0906e+00  2.3102e-01  5.5719e-01 -4.6840e-01 -5.8515e-01 -2.9006e-01
 -2.6508e-01  3.9253e-01 -5.1165e-01  2.4492e-02  8.1263e-01 -4.2014e-01
 -3.4857e-01  3.5984e-01  1.5941e-01 -6.9736e-01 -1.4426e+00 -9.9337e-03
 -2.3335e-01 -4.6266e-01  2.6243e-01 -2.9373e-01  4.8860e-01  7.2830e-01
 -3.2475e-02  6.2540e-01 -4.3399e-01 -1.0553e-01  3.1752e-01 -1.5631e-01
 -2.4268e-01 -3.9298e-01 -3.7478e-01 -6.6699e-02  1.5477e-01  7.4870e-01
 -2.3318e-01  9.7446e-02 -4.4590e-01 -6.1845e-02  1.7504e-01  7.3357e-01
  8.8520e-01 -1.9843e-01  2.5146e-01 -3.8909e-01 -3.0322e-01  4.3190e-01
  5.9478e-02 -2.7233e-01 -3.8758e-01  5.1850e-01 -1.6175e-01 -7.5551e-01
  5.5890e-01  1.0797e-01  1.4943e+00  1.6329e-01  6.6365e-01  1.2885e-01
 -9.8670e-02 -4.8738e-02  1.3253e-01 -1.6620e-01 -4.2653e-01 -1.7694e-01
 -2.6400e-01  1.0666e-01 -1.9857e-02  1.2652e-01  1.5045e-01 -7.6070e-02
 -3.4198e-01 -1.4165e-01  4.8806e-01  5.2860e-01]
the:  [ 9.5152e-02  3.7024e-01  5.4291e-01  1.9621e-01  4.8205e-02  3.2033e-01
 -5.9638e-01  1.5868e-02 -1.2989e-01 -6.3028e-01  8.1944e-02  2.4164e-01
 -6.0990e+00 -6.8557e-01  5.0354e-01 -3.4089e-02  1.1705e-01 -7.7403e-03
 -8.6512e-02  4.3617e-01 -4.3982e-01  2.6125e-01 -4.0348e-02 -1.9194e-01
  8.3204e-02 -5.8246e-01 -3.1923e-02  1.2630e-01  4.0120e-01  6.8906e-02
 -1.0517e-01 -2.0804e-01 -4.2554e-01  4.7799e-01  3.4651e-01  2.4057e-01
  5.0244e-02 -7.2587e-02 -2.4347e-03 -5.0342e-01 -1.0601e+00 -3.1586e-01
 -3.2457e-02 -7.6317e-02  7.9045e-01  8.6367e-02 -1.9632e-01  5.7566e-02
  8.4129e-01 -4.2020e-01 -1.1335e-03 -8.5632e-02  6.1910e-02  2.1423e-01
 -1.0356e-01 -3.6946e-02 -2.6005e-01 -3.5657e-01  5.4321e-02  3.0875e-02
  1.4092e-01 -9.1998e-02 -4.1841e-01 -3.1135e-01 -1.4937e-01 -2.2699e-04
 -3.3454e-01 -1.4848e-01 -1.1944e-01 -2.7174e-01  3.1320e-01 -1.0998e-01
 -4.7524e-01  1.4056e-01  3.9641e-01 -4.9413e-02 -4.2601e-01 -2.3576e-01
  6.1482e-02 -3.5313e-02  2.4161e+00  2.8979e-01  3.8882e-01  3.6779e-01
  2.0685e-01  1.3992e-01 -4.2459e-01  4.4590e-01  2.6234e-01 -4.4834e-01
  3.7196e-03 -2.2521e-01  1.4764e-01 -3.6417e-01 -1.8493e-01  2.2282e-01
  4.7626e-01 -5.1083e-01  4.6877e-01  3.4882e-01]
lazy:  [ 1.4021e-01 -6.1686e-01  6.6047e-01  4.5844e-01 -4.7073e-02  5.6833e-01
  4.7711e-01 -3.0135e-01  2.5490e-01  2.7677e-01 -7.2243e-01 -4.7596e-01
 -3.1877e+00 -3.0520e-01 -1.1225e+00  1.1409e-01 -1.6397e-01 -6.2531e-01
 -6.4549e-01 -7.0767e-01 -1.3721e-01  1.6656e-01 -1.5643e-01 -5.8997e-01
  5.3493e-01  4.2989e-01 -1.6078e-01  3.1838e-01 -1.7478e-01 -6.6117e-02
```

```
        -9.1278e-02 -2.2732e-01 -6.2848e-01  3.7686e-01 -6.0958e-01  3.7723e-02
         1.3443e-01  5.8768e-01  1.0611e-01  1.0578e+00 -7.9843e-01  1.5644e-02
         5.1333e-01 -2.6829e-01  8.6280e-02 -4.8820e-01 -7.8925e-02  5.7910e-01
        -8.3873e-01  7.4992e-01 -4.7451e-01  5.3792e-01  2.5934e-01 -2.5577e-01
        -7.2746e-01  7.2324e-01 -3.5029e-01  2.3883e-01  2.2178e-01  2.3307e-01
        -2.4567e-01  2.3833e-01  6.6281e-01 -1.1956e-01 -2.3183e-02 -7.2004e-01
        -4.5729e-02  6.8426e-01  3.5203e-01  5.6147e-01 -6.6437e-01  4.0224e-01
        -3.9397e-01 -1.1179e-01  1.5747e-01 -1.4167e-03  1.0760e+00  6.7952e-01
        -3.5587e-01 -7.7132e-02  2.0712e+00  4.2989e-01 -3.2253e-01  1.9375e-02
         6.2629e-01  3.2018e-01  3.3936e-01 -9.2320e-02  2.8323e-01  1.4915e-01
         2.3714e-01  4.1720e-01 -1.6513e-01  1.8810e-01  7.0461e-01  2.5950e-01
        -1.0690e-01  9.0640e-01  2.2023e-01 -1.9887e-01]
 dog: [ 5.0779e-01 -1.0274e+00  4.8136e-01 -9.4170e-02  4.4837e-01 -5.2291e-01
         5.1498e-01 -3.8927e-02  3.5867e-01 -6.5994e-02 -8.2882e-01  7.6179e-01
        -3.8030e+00 -1.0576e-02  2.1654e-01  5.9712e-01  3.7424e-01 -2.2629e-02
        -1.0331e-02 -3.3966e-01  9.4336e-02  2.6253e-01 -4.0161e-01 -7.9532e-03
         1.0206e+00 -3.5793e-01 -5.6500e-01  5.8815e-01 -8.1847e-01  3.0293e-01
         4.7199e-01 -9.7429e-02 -6.1226e-01 -1.7797e-01 -1.1616e-01  3.2586e-01
         1.1498e-01 -1.9030e-01  1.1591e-02  4.6478e-01 -1.6805e-01  2.1972e-01
        -2.5938e-01 -1.3541e-02  7.0714e-01  7.8106e-01  7.9917e-01  1.0389e+00
         5.2792e-01 -1.1160e-01 -6.2275e-01  3.0692e-02  3.3847e-01 -5.3092e-01
        -9.9688e-02  2.1596e-01  6.0522e-01  1.2356e+00 -3.4528e-03 -9.7514e-02
        -2.4938e-01  2.1539e-01  4.4643e-01  9.5375e-02 -2.7366e-01 -2.8537e-01
        -4.0894e-01  4.8223e-01  3.0318e-01  1.9440e-01  8.3242e-01 -5.0378e-01
         3.0090e-01 -4.9792e-01  5.0297e-01  3.2685e-02 -5.1790e-01 -2.3541e-01
         2.2960e-01 -6.3588e-01  1.6270e+00  6.2832e-01 -7.4846e-01  6.0073e-01
        -1.1215e-02 -3.2113e-01  1.4339e-01 -6.0809e-02  8.8218e-02  6.5936e-01
        -4.6127e-01 -3.7644e-01 -1.1330e-01  1.5875e-01  3.9119e-01  6.7659e-01
        -7.1224e-02  1.7458e-01 -3.3406e-02  7.3152e-01]
```

[31]:
```python
# ---------------------------------------------------------------
# Define vocabulary size for the language model
# To reduce the size of the vocabulary to the n most frequently used words

EVOCABSIZE = 10000  # specify desired size of pre-defined embedding vocabulary

def default_factory():
    return EVOCABSIZE  # last/unknown-word row in limited_index_to_embedding
# dictionary has the items() function, returns list of (key, value) tuples
limited_word_to_index = defaultdict(default_factory, \
    {k: v for k, v in word_to_index.items() if v < EVOCABSIZE})

# Select the first EVOCABSIZE rows to the index_to_embedding
limited_index_to_embedding = index_to_embedding[0:EVOCABSIZE,:]
# Set the unknown-word row to be all zeros as previously
limited_index_to_embedding = np.append(limited_index_to_embedding,
    index_to_embedding[index_to_embedding.shape[0] - 1, :].\
```

```
        reshape(1,embedding_dim),
    axis = 0)

# Delete large numpy array to clear some CPU RAM
del index_to_embedding

# Verify the new vocabulary: should get same embeddings for test sentence
# Note that a small EVOCABSIZE may yield some zero vectors for embeddings
print('\nTest sentence embeddings from vocabulary of', EVOCABSIZE, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = limited_index_to_embedding[limited_word_to_index[word_]]
    print(word_ + ": ", embedding)
```

```
Test sentence embeddings from vocabulary of 10000 words:

the:  [ 9.5152e-02  3.7024e-01  5.4291e-01  1.9621e-01  4.8205e-02  3.2033e-01
 -5.9638e-01  1.5868e-02 -1.2989e-01 -6.3028e-01  8.1944e-02  2.4164e-01
 -6.0990e+00 -6.8557e-01  5.0354e-01 -3.4089e-02  1.1705e-01 -7.7403e-03
 -8.6512e-02  4.3617e-01 -4.3982e-01  2.6125e-01 -4.0348e-02 -1.9194e-01
  8.3204e-02 -5.8246e-01 -3.1923e-02  1.2630e-01  4.0120e-01  6.8906e-02
 -1.0517e-01 -2.0804e-01 -4.2554e-01  4.7799e-01  3.4651e-01  2.4057e-01
  5.0244e-02 -7.2587e-02 -2.4347e-03 -5.0342e-01 -1.0601e+00 -3.1586e-01
 -3.2457e-02 -7.6317e-02  7.9045e-01  8.6367e-02 -1.9632e-01  5.7566e-02
  8.4129e-01 -4.2020e-01 -1.1335e-03 -8.5632e-02  6.1910e-02  2.1423e-01
 -1.0356e-01 -3.6946e-02 -2.6005e-01 -3.5657e-01  5.4321e-02  3.0875e-02
  1.4092e-01 -9.1998e-02 -4.1841e-01 -3.1135e-01 -1.4937e-01 -2.2699e-04
 -3.3454e-01 -1.4848e-01 -1.1944e-01 -2.7174e-01  3.1320e-01 -1.0998e-01
 -4.7524e-01  1.4056e-01  3.9641e-01 -4.9413e-02 -4.2601e-01 -2.3576e-01
  6.1482e-02 -3.5313e-02  2.4161e+00  2.8979e-01  3.8882e-01  3.6779e-01
  2.0685e-01  1.3992e-01 -4.2459e-01  4.4590e-01  2.6234e-01 -4.4834e-01
  3.7196e-03 -2.2521e-01  1.4764e-01 -3.6417e-01 -1.8493e-01  2.2282e-01
  4.7626e-01 -5.1083e-01  4.6877e-01  3.4882e-01]
quick:  [ 0.50111    0.37708   -0.19973   -0.55111    0.17148    0.019936
  0.50052    0.017863  -0.43901    0.4485    -0.22766   -0.087691
 -3.5079    -0.62763   -0.75083   -0.19767   -0.39356    0.3996
 -0.081026  -0.53157   -0.38539   -0.61069    0.10148   -0.10846
 -0.29013    0.61234    0.027151  -0.044352  -0.40846    0.42045
 -0.22149    0.018245  -0.25989   -0.049784   0.28018    0.26186
 -0.22841   -0.28096    0.046061   0.26917   -0.41851    0.25948
  0.10509    0.75517    0.43909    0.07024    0.053149   0.59465
 -0.23239    0.37033   -0.29459   -0.040892  -0.37618    0.015432
  0.056196  -0.25702   -0.16717    0.2405     0.29895   -0.64143
  0.91313   -0.057541   0.20291    1.0468     0.65415   -0.94901
  0.49342    0.014261   0.14139    0.17338   -0.76048    0.53518
  0.26007    0.34376    0.057837  -0.55036    0.66677   -0.31764
```

```
  0.41491   -0.025773   1.5507       0.394      -0.31088   -0.53684
  0.15205    0.70041   -0.1879      -0.24963   -0.16778   -0.34475
 -0.51597    0.010533  -0.59016     -0.44993    0.80113    0.051259
 -0.49647    0.59636    0.0075998    0.28048  ]
brown: [-0.26106   -0.75489   -0.022668   0.055802  -0.77145    0.05871
  0.3852     0.40926   -0.97445    -0.33838    0.47742   -0.01054
 -3.1085    -0.55482    0.35536     0.44814    0.29137    0.16997
  0.66486    0.22324    0.32805    -0.40968   -0.19862    0.3546
  0.30566   -0.55413   -0.54773     0.25429   -0.72556   -0.22337
  0.16802    0.14168   -1.0443     -0.57601   -0.21027    0.18212
 -0.81012   -0.71126   -0.39691    -0.13592   -0.37764   -0.52612
 -0.80185    0.31638   -0.073107   -0.74961    0.44858   -0.0039955
 -0.22895   -0.95689   -0.70048    -0.15495    0.30279    0.51368
 -0.51663    0.053121  -0.23784     0.49018    0.47278    0.29428
 -0.42305    0.39041   -0.051611   -0.30997    0.12854   -0.67797
 -0.23172    0.13328    0.43269    -0.28219    0.56389   -0.52302
  0.52544    0.20713   -0.4926      0.2071    -0.012374   0.62647
  0.38548    0.5472     1.5739      0.38571   -0.095062  -0.70715
 -0.37873   -0.065873   0.34776     0.80396   -0.34771    0.43994
 -0.23445   -0.36284   -0.11516    -0.68272   -0.027322   0.24447
 -0.088484   0.34491   -0.55879     0.343    ]
fox: [ 0.64344    0.0086088  0.50145    -0.70381   -0.36289   -0.51602
  0.3751    -0.0078184  0.10752    -0.29124    0.61808   -0.036332
 -2.4467    -0.0050135  0.18236    -0.18152   -0.19349   -0.19442
  0.3793     0.46691    0.03579    -0.48468   -0.45103   -0.045509
  0.6732    -1.4904    -0.23975    -0.26736   -0.058426   0.11573
  0.79477    0.09746   -0.36717    -0.20758    0.099006  -0.51114
 -0.023912   0.14275   -0.87894     0.13728   -0.26524   -0.33326
  0.25857   -0.27703    0.5022      0.7164    -0.26708    0.018559
  0.39153   -0.42015   -0.55746    -0.2797    -0.36874    0.090716
 -0.29017    0.25543   -0.016203    0.014775  -0.45174   -0.48211
 -0.18746    0.59934   -0.20146    -0.3756    -0.11143    0.26213
  0.15496    0.53471    0.43618    -0.7356     0.34366   -0.036715
 -0.2377    -0.3525    -0.5546      0.44059   -0.17759    0.50194
 -0.59675   -0.0427     1.5432      0.22326    0.40868    0.70572
 -0.17751    0.071547   0.84483     0.3794    -0.67034   -0.54685
 -0.55382   -0.88651   -0.25728    -0.1996    -0.15984    0.37977
  0.62406    0.037116  -0.427       0.029686 ]
jumps: [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0.]
over: [-1.3037e-01  2.0490e-01  4.2575e-01 -3.1239e-01 -5.4739e-01  2.1011e-01
 -7.2276e-03 -6.3219e-02 -1.2984e-02 -8.2143e-02  2.5385e-01  3.2791e-01
 -4.9173e+00  3.1567e-01 -2.0232e-01 -2.5671e-01 -1.8498e-03  4.3715e-01
 -1.0066e+00  2.5198e-02 -3.9015e-02 -3.4754e-01 -2.8745e-02  6.5716e-01
  1.0906e+00  2.3102e-01  5.5719e-01 -4.6840e-01 -5.8515e-01 -2.9006e-01
```

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```
 -2.6508e-01  3.9253e-01 -5.1165e-01  2.4492e-02  8.1263e-01 -4.2014e-01
 -3.4857e-01  3.5984e-01  1.5941e-01 -6.9736e-01 -1.4426e+00 -9.9337e-03
 -2.3335e-01 -4.6266e-01  2.6243e-01 -2.9373e-01  4.8860e-01  7.2830e-01
 -3.2475e-02  6.2540e-01 -4.3399e-01 -1.0553e-01  3.1752e-01 -1.5631e-01
 -2.4268e-01 -3.9298e-01 -3.7478e-01 -6.6699e-02  1.5477e-01  7.4870e-01
 -2.3318e-01  9.7446e-02 -4.4590e-01 -6.1845e-02  1.7504e-01  7.3357e-01
  8.8520e-01 -1.9843e-01  2.5146e-01 -3.8909e-01 -3.0322e-01  4.3190e-01
  5.9478e-02 -2.7233e-01 -3.8758e-01  5.1850e-01 -1.6175e-01 -7.5551e-01
  5.5890e-01  1.0797e-01  1.4943e+00  1.6329e-01  6.6365e-01  1.2885e-01
 -9.8670e-02 -4.8738e-02  1.3253e-01 -1.6620e-01 -4.2653e-01 -1.7694e-01
 -2.6400e-01  1.0666e-01 -1.9857e-02  1.2652e-01  1.5045e-01 -7.6070e-02
 -3.4198e-01 -1.4165e-01  4.8806e-01  5.2860e-01]
the: [ 9.5152e-02  3.7024e-01  5.4291e-01  1.9621e-01  4.8205e-02  3.2033e-01
 -5.9638e-01  1.5868e-02 -1.2989e-01 -6.3028e-01  8.1944e-02  2.4164e-01
 -6.0990e+00 -6.8557e-01  5.0354e-01 -3.4089e-02  1.1705e-01 -7.7403e-03
 -8.6512e-02  4.3617e-01 -4.3982e-01  2.6125e-01 -4.0348e-02 -1.9194e-01
  8.3204e-02 -5.8246e-01 -3.1923e-02  1.2630e-01  4.0120e-01  6.8906e-02
 -1.0517e-01 -2.0804e-01 -4.2554e-01  4.7799e-01  3.4651e-01  2.4057e-01
  5.0244e-02 -7.2587e-02 -2.4347e-03 -5.0342e-01 -1.0601e+00 -3.1586e-01
 -3.2457e-02 -7.6317e-02  7.9045e-01  8.6367e-02 -1.9632e-01  5.7566e-02
  8.4129e-01 -4.2020e-01 -1.1335e-03 -8.5632e-02  6.1910e-02  2.1423e-01
 -1.0356e-01 -3.6946e-02 -2.6005e-01 -3.5657e-01  5.4321e-02  3.0875e-02
  1.4092e-01 -9.1998e-02 -4.1841e-01 -3.1135e-01 -1.4937e-01 -2.2699e-04
 -3.3454e-01 -1.4848e-01 -1.1944e-01 -2.7174e-01  3.1320e-01 -1.0998e-01
 -4.7524e-01  1.4056e-01  3.9641e-01 -4.9413e-02 -4.2601e-01 -2.3576e-01
  6.1482e-02 -3.5313e-02  2.4161e+00  2.8979e-01  3.8882e-01  3.6779e-01
  2.0685e-01  1.3992e-01 -4.2459e-01  4.4590e-01  2.6234e-01 -4.4834e-01
  3.7196e-03 -2.2521e-01  1.4764e-01 -3.6417e-01 -1.8493e-01  2.2282e-01
  4.7626e-01 -5.1083e-01  4.6877e-01  3.4882e-01]
lazy: [ 1.4021e-01 -6.1686e-01  6.6047e-01  4.5844e-01 -4.7073e-02  5.6833e-01
  4.7711e-01 -3.0135e-01  2.5490e-01  2.7677e-01 -7.2243e-01 -4.7596e-01
 -3.1877e+00 -3.0520e-01 -1.1225e+00  1.1409e-01 -1.6397e-01 -6.2531e-01
 -6.4549e-01 -7.0767e-01 -1.3721e-01  1.6656e-01 -1.5643e-01 -5.8997e-01
  5.3493e-01  4.2989e-01 -1.6078e-01  3.1838e-01 -1.7478e-01 -6.6117e-02
 -9.1278e-02 -2.2732e-01 -6.2848e-01  3.7686e-01 -6.0958e-01  3.7723e-02
  1.3443e-01  5.8768e-01  1.0611e-01  1.0578e+00 -7.9843e-01  1.5644e-02
  5.1333e-01 -2.6829e-01  8.6280e-02 -4.8820e-01 -7.8925e-02  5.7910e-01
 -8.3873e-01  7.4992e-01 -4.7451e-01  5.3792e-01  2.5934e-01 -2.5577e-01
 -7.2746e-01  7.2324e-01 -3.5029e-01  2.3883e-01  2.2178e-01  2.3307e-01
 -2.4567e-01  2.3833e-01  6.6281e-01 -1.1956e-01 -2.3183e-02 -7.2004e-01
 -4.5729e-02  6.8426e-01  3.5203e-01  5.6147e-01 -6.6437e-01  4.0224e-01
 -3.9397e-01 -1.1179e-01  1.5747e-01 -1.4167e-03  1.0760e+00  6.7952e-01
 -3.5587e-01 -7.7132e-02  2.0712e+00  4.2989e-01 -3.2253e-01  1.9375e-02
  6.2629e-01  3.2018e-01  3.3936e-01 -9.2320e-02  2.8323e-01  1.4915e-01
  2.3714e-01  4.1720e-01 -1.6513e-01  1.8810e-01  7.0461e-01  2.5950e-01
 -1.0690e-01  9.0640e-01  2.2023e-01 -1.9887e-01]
dog: [ 5.0779e-01 -1.0274e+00  4.8136e-01 -9.4170e-02  4.4837e-01 -5.2291e-01
  5.1498e-01 -3.8927e-02  3.5867e-01 -6.5994e-02 -8.2882e-01  7.6179e-01
```

```
 -3.8030e+00 -1.0576e-02  2.1654e-01  5.9712e-01  3.7424e-01 -2.2629e-02
 -1.0331e-02 -3.3966e-01  9.4336e-02  2.6253e-01 -4.0161e-01 -7.9532e-03
  1.0206e+00 -3.5793e-01 -5.6500e-01  5.8815e-01 -8.1847e-01  3.0293e-01
  4.7199e-01 -9.7429e-02 -6.1226e-01 -1.7797e-01 -1.1616e-01  3.2586e-01
  1.1498e-01 -1.9030e-01  1.1591e-02  4.6478e-01 -1.6805e-01  2.1972e-01
 -2.5938e-01 -1.3541e-02  7.0714e-01  7.8106e-01  7.9917e-01  1.0389e+00
  5.2792e-01 -1.1160e-01 -6.2275e-01  3.0692e-02  3.3847e-01 -5.3092e-01
 -9.9688e-02  2.1596e-01  6.0522e-01  1.2356e+00 -3.4528e-03 -9.7514e-02
 -2.4938e-01  2.1539e-01  4.4643e-01  9.5375e-02 -2.7366e-01 -2.8537e-01
 -4.0894e-01  4.8223e-01  3.0318e-01  1.9440e-01  8.3242e-01 -5.0378e-01
  3.0090e-01 -4.9792e-01  5.0297e-01  3.2685e-02 -5.1790e-01 -2.3541e-01
  2.2960e-01 -6.3588e-01  1.6270e+00  6.2832e-01 -7.4846e-01  6.0073e-01
 -1.1215e-02 -3.2113e-01  1.4339e-01 -6.0809e-02  8.8218e-02  6.5936e-01
 -4.6127e-01 -3.7644e-01 -1.1330e-01  1.5875e-01  3.9119e-01  6.7659e-01
 -7.1224e-02  1.7458e-01 -3.3406e-02  7.3152e-01]
```

[32]:
```python
# create list of lists of lists for embeddings
embeddings = []
for doc in documents:
    embedding = []
    for word in doc:
        embedding.append(limited_index_to_embedding[limited_word_to_index[word]])
    embeddings.append(embedding)



# ------------------------------------------------------
# Check on the embeddings list of list of lists
# ------------------------------------------------------
# Show the first word in the first document
test_word = documents[0][0]
print('First word in first document:', test_word)
print('Embedding for this word:\n',
      limited_index_to_embedding[limited_word_to_index[test_word]])
print('Corresponding embedding from embeddings list of list of lists\n',
      embeddings[0][0][:])
```

```
First word in first document: while
Embedding for this word:
 [-4.7197e-02 -2.4357e-01  1.0880e-01 -5.6693e-01 -3.8555e-02  1.5236e-01
 -4.4097e-02 -3.5602e-02  2.5351e-01 -6.9209e-01 -5.5410e-04  1.8290e-03
 -5.1479e+00  3.6846e-01 -3.4871e-01 -9.0599e-02 -2.9809e-01 -1.1419e-01
 -8.5266e-01 -1.8206e-01 -7.7734e-01 -1.2525e-02  2.4790e-01 -4.6548e-04
  1.9668e-01  6.5513e-01 -4.8212e-01 -1.7646e-01  2.6732e-01  2.8195e-01
  4.1784e-01  2.3964e-02 -2.9772e-01  3.6287e-01 -7.5949e-03  1.8756e-01
 -8.4115e-02 -1.3346e-01  1.1355e-01  4.3278e-01 -7.8362e-02  1.9060e-01
  3.5403e-01  1.4928e-01  7.2068e-01 -3.5885e-01  1.1589e-01  5.2705e-01
 -4.1823e-01  2.0411e-01 -5.0177e-01 -2.2404e-01  5.5086e-01 -2.2030e-01
```

```
   -5.2023e-02  5.7555e-02 -1.8871e-01  3.0119e-02  6.2221e-01  1.0051e-01
    1.5656e-01 -2.9829e-02  2.8033e-01 -4.5078e-01  5.2535e-01 -8.6973e-03
    1.4169e-01  2.4950e-01  2.9821e-01  1.5145e-01 -1.7910e-01  1.4797e-01
    7.3218e-02 -8.1712e-01 -6.1936e-02  1.8336e-01 -1.0639e-01 -2.1006e-01
    1.4606e-01  2.3040e-01  1.2416e+00  8.3053e-02 -4.7140e-01  4.7603e-01
    1.3378e-01 -5.0239e-01  1.3375e-01  1.4129e-01  2.0460e-01  1.4739e-01
    5.0854e-01 -1.6517e-01 -3.5384e-01  2.1834e-02 -5.1504e-01  9.7128e-02
    1.3943e-01 -1.3130e-01  1.1166e-01  3.2966e-02]
 Corresponding embedding from embeddings list of list of lists
  [-4.7197e-02 -2.4357e-01  1.0880e-01 -5.6693e-01 -3.8555e-02  1.5236e-01
 -4.4097e-02 -3.5602e-02  2.5351e-01 -6.9209e-01 -5.5410e-04  1.8290e-03
 -5.1479e+00  3.6846e-01 -3.4871e-01 -9.0599e-02 -2.9809e-01 -1.1419e-01
 -8.5266e-01 -1.8206e-01 -7.7734e-01 -1.2525e-02  2.4790e-01 -4.6548e-04
  1.9668e-01  6.5513e-01 -4.8212e-01 -1.7646e-01  2.6732e-01  2.8195e-01
  4.1784e-01  2.3964e-02 -2.9772e-01  3.6287e-01 -7.5949e-03  1.8756e-01
 -8.4115e-02 -1.3346e-01  1.1355e-01  4.3278e-01 -7.8362e-02  1.9060e-01
  3.5403e-01  1.4928e-01  7.2068e-01 -3.5885e-01  1.1589e-01  5.2705e-01
 -4.1823e-01  2.0411e-01 -5.0177e-01 -2.2404e-01  5.5086e-01 -2.2030e-01
 -5.2023e-02  5.7555e-02 -1.8871e-01  3.0119e-02  6.2221e-01  1.0051e-01
  1.5656e-01 -2.9829e-02  2.8033e-01 -4.5078e-01  5.2535e-01 -8.6973e-03
  1.4169e-01  2.4950e-01  2.9821e-01  1.5145e-01 -1.7910e-01  1.4797e-01
  7.3218e-02 -8.1712e-01 -6.1936e-02  1.8336e-01 -1.0639e-01 -2.1006e-01
  1.4606e-01  2.3040e-01  1.2416e+00  8.3053e-02 -4.7140e-01  4.7603e-01
  1.3378e-01 -5.0239e-01  1.3375e-01  1.4129e-01  2.0460e-01  1.4739e-01
  5.0854e-01 -1.6517e-01 -3.5384e-01  2.1834e-02 -5.1504e-01  9.7128e-02
  1.3943e-01 -1.3130e-01  1.1166e-01  3.2966e-02]
```

[33]:
```python
# -------------------------------------------------------
# Make embeddings a numpy array for use in an RNN
# Create training and test sets with Scikit Learn
# -------------------------------------------------------
embeddings_array = np.array(embeddings)

# Define the labels to be used 500 negative (0) and 500 positive (1)
thumbs_down_up = np.concatenate((np.zeros((500), dtype = np.int32),
                    np.ones((500), dtype = np.int32)), axis = 0)

# Scikit Learn for random splitting of the data
from sklearn.model_selection import train_test_split

RANDOM_SEED = 9999
# Random splitting of the data in to training (80%) and test (20%)
X_train, X_test, y_train, y_test = \
    train_test_split(embeddings_array, thumbs_down_up, test_size=0.20,
                    random_state = RANDOM_SEED)
```

```python
# ----------------------------------------------------------------------------
# We use a very simple Recurrent Neural Network for this assignment
# Geron, A. 2017. Hands-On Machine Learning with Scikit-Learn & TensorFlow:
#     Concepts, Tools, and Techniques to Build Intelligent Systems.
#     Sebastopol, Calif.: O'Reilly. [ISBN-13 978-1-491-96229-9]
#     Chapter 14 Recurrent Neural Networks, pages 390-391
#     Source code available at https://github.com/ageron/handson-ml
#     Jupyter notebook file 14_recurrent_neural_networks.ipynb
#     See section on Training an sequence Classifier, # In [34]:
#     which uses the MNIST case data...  we revise to accommodate
#     the movie review data in this assignment
# ----------------------------------------------------------------------------
reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up


learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                  logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
```

```
        X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
        y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
        print('  Batch ', iteration, ' training observations from ',
                iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
        sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
    acc_train4 = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
    acc_test4 = accuracy.eval(feed_dict={X: X_test, y: y_test})
    print('\n  Train accuracy:', acc_train4, 'Test accuracy:', acc_test4)
```

---- Epoch 0 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.53 Test accuracy: 0.55

---- Epoch 1 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.57 Test accuracy: 0.545

---- Epoch 2 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

```
Train accuracy: 0.59 Test accuracy: 0.535


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.58 Test accuracy: 0.565


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.58 Test accuracy: 0.565


---- Epoch  5  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.565


---- Epoch  6  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.6 Test accuracy: 0.575


---- Epoch  7   ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.63 Test accuracy: 0.575


---- Epoch  8   ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.64 Test accuracy: 0.565


---- Epoch  9   ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.62 Test accuracy: 0.57


---- Epoch  10   ----


Batch  0   training observations from  0   to   99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.575


---- Epoch  11  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.55


---- Epoch  12  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.555


---- Epoch  13  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.54
```

```
---- Epoch  14  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.545


---- Epoch  15  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.545


---- Epoch  16  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.555


---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.565


---- Epoch  18  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.58


---- Epoch  19  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.595


---- Epoch  20  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.59


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.635


---- Epoch  22  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.64


---- Epoch  23  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.67


---- Epoch  24  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.675
```

```
---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.67


---- Epoch  26  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.665


---- Epoch  27  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.69


---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.89 Test accuracy: 0.68


---- Epoch  29  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.67


---- Epoch  30  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.67


---- Epoch  31  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.67


---- Epoch  32  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.69


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.675


---- Epoch  34  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.68


---- Epoch  35  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.665


---- Epoch  36  ----
```

```
Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.665


---- Epoch  37  ----


Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.655


---- Epoch  38  ----


Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.65


---- Epoch  39  ----


Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.88 Test accuracy: 0.675


---- Epoch  40  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.66


---- Epoch  41  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.655


---- Epoch  42  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.92 Test accuracy: 0.65


---- Epoch  43  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.89 Test accuracy: 0.645


---- Epoch   44   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.88 Test accuracy: 0.65


---- Epoch   45   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.9 Test accuracy: 0.655


---- Epoch   46   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.9 Test accuracy: 0.655


---- Epoch   47   ----
```

```
Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799

Train accuracy: 0.91 Test accuracy: 0.645


---- Epoch  48  ----

Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799

Train accuracy: 0.91 Test accuracy: 0.65


---- Epoch  49  ----

Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799

Train accuracy: 0.91 Test accuracy: 0.64
```

```python
RANDOM_SEED = 1234

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)


reset_graph()
```

```python
n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
n_neurons = 20  # analyst specified number of neurons
n_outputs = 2  # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train4b = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test4b = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train4b, 'Test accuracy:', acc_test4b)
```

```
  ---- Epoch  0  ----

  Batch  0  training observations from  0  to  99
  Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.46 Test accuracy: 0.555


---- Epoch  1  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.5


---- Epoch  2  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.51 Test accuracy: 0.52


---- Epoch  3  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.57
```

```
---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.575


---- Epoch  5  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.54 Test accuracy: 0.575


---- Epoch  6  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.575


---- Epoch  7  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.55 Test accuracy: 0.57


---- Epoch  8  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.565


---- Epoch  9  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.56


---- Epoch  10  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.58 Test accuracy: 0.545


---- Epoch  11  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.545


---- Epoch  12  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.54


---- Epoch  13  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.565


---- Epoch  14  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.565


---- Epoch  15  ----
```

```
Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.575


---- Epoch  16  ----


Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.57


---- Epoch  17  ----


Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.57


---- Epoch  18  ----


Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.65 Test accuracy: 0.58

---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.68 Test accuracy: 0.58

---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.71 Test accuracy: 0.565

---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.71 Test accuracy: 0.555

---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.73 Test accuracy: 0.555


---- Epoch  23  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.75 Test accuracy: 0.57


---- Epoch  24  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.74 Test accuracy: 0.57


---- Epoch  25  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.74 Test accuracy: 0.595


---- Epoch  26  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.76 Test accuracy: 0.62


---- Epoch  27   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.75 Test accuracy: 0.65


---- Epoch  28   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.77 Test accuracy: 0.665


---- Epoch  29   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 0.81 Test accuracy: 0.675


---- Epoch  30  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.705


---- Epoch  31  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.695


---- Epoch  32  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.675


---- Epoch  33  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.695


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.685


---- Epoch  35  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.68


---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.685


---- Epoch  37  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.7


---- Epoch  38  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.695


---- Epoch  39  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.705


---- Epoch  40  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.69
```

```
---- Epoch  41  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.69


---- Epoch  42  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.69


---- Epoch  43  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.705


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.65


---- Epoch  45  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.7


---- Epoch  46  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.705


---- Epoch  47  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.7


---- Epoch  48  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.705


---- Epoch  49  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.68
```

[35]:
```python
RANDOM_SEED = 42

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
n_neurons = 20  # analyst specified number of neurons
n_outputs = 2  # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
```

```
                                                    logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))


init = tf.global_variables_initializer()


n_epochs = 50
batch_size = 100


with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                  iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train4c = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test4c = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train4c, 'Test accuracy:', acc_test4c)
```

```
  ---- Epoch  0  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
 Batch  7  training observations from  700  to  799

 Train accuracy: 0.53 Test accuracy: 0.55

  ---- Epoch  1  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.545


---- Epoch  2  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.535


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.58 Test accuracy: 0.565


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.58 Test accuracy: 0.565


---- Epoch  5  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.565


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.6 Test accuracy: 0.575


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.575


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.565
```

```
---- Epoch  9  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.62 Test accuracy: 0.57


---- Epoch  10  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.62 Test accuracy: 0.575


---- Epoch  11  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.64 Test accuracy: 0.55


---- Epoch  12  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
```

```
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.63 Test accuracy: 0.555


---- Epoch  13  ----


Batch  0   training observations from   0  to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.65 Test accuracy: 0.54


---- Epoch  14  ----


Batch  0   training observations from   0  to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.67 Test accuracy: 0.545


---- Epoch  15  ----


Batch  0   training observations from   0  to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.66 Test accuracy: 0.545


---- Epoch  16  ----


Batch  0   training observations from   0  to   99
Batch  1   training observations from   100   to   199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.555


---- Epoch  17  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.565


---- Epoch  18  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.58


---- Epoch  19  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.595
```

```
---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.59


---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.635


---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.64


---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.81 Test accuracy: 0.67


---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.675


---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.67


---- Epoch  26  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.665


---- Epoch  27  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.69


---- Epoch  28  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.68


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.67


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.67


---- Epoch  31  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.67


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.69


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.675


---- Epoch  34  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.89 Test accuracy: 0.68


---- Epoch  35  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.665


---- Epoch  36  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.665


---- Epoch  37  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.655


---- Epoch  38  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.65


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.675


---- Epoch  40  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.66


---- Epoch  41  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.655


---- Epoch  42  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.92 Test accuracy: 0.65


---- Epoch  43  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.89 Test accuracy: 0.645


---- Epoch  44  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.88 Test accuracy: 0.65


---- Epoch  45  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 0.9 Test accuracy: 0.655


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.9 Test accuracy: 0.655


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.645


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.65


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.91 Test accuracy: 0.64
```

0.5   Model 5: Glove.6B, 50 dimensions, vocabulary 30,000 words

```python
[36]: # ---------------------------------------------------------------
      # Select the pre-defined embeddings source
      # Define vocabulary size for the language model
      # Create a word_to_embedding_dict for GloVe.6B.50d
      embeddings_directory = 'embeddings/gloVe.6B'
      filename = 'glove.6B.50d.txt'
      embeddings_filename = os.path.join(embeddings_directory, filename)
      # ---------------------------------------------------------------


      print('\nLoading embeddings from', embeddings_filename)
      word_to_index, index_to_embedding = \
          load_embedding_from_disks(embeddings_filename, with_indexes=True)
      print("Embedding loaded from disks.")

      # Additional background code from
      # https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
      # shows the general structure of the data structures for word embeddings
      # This code is modified for our purposes in language modeling
      vocab_size, embedding_dim = index_to_embedding.shape
      print("Embedding is of shape: {}".format(index_to_embedding.shape))
      print("This means (number of words, number of dimensions per word)\n")
      print("The first words are words that tend occur more often.")
```

```
Loading embeddings from embeddings/gloVe.6B/glove.6B.50d.txt
Embedding loaded from disks.
Embedding is of shape: (400001, 50)
This means (number of words, number of dimensions per word)

The first words are words that tend occur more often.
```

```python
[37]: # Show how to use embeddings dictionaries with a test sentence
      # This is a famous typing exercise with all letters of the alphabet
      # https://en.wikipedia.org/wiki/The_quick_brown_fox_jumps_over_the_lazy_dog
      a_typing_test_sentence = 'The quick brown fox jumps over the lazy dog'
      print('\nTest sentence: ', a_typing_test_sentence, '\n')
      words_in_test_sentence = a_typing_test_sentence.split()
```

```python
print('Test sentence embeddings from complete vocabulary of',
      complete_vocabulary_size, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = index_to_embedding[word_to_index[word_]]
    print(word_ + ": ", embedding)
```

Test sentence: The quick brown fox jumps over the lazy dog

Test sentence embeddings from complete vocabulary of 400000 words:

the: [4.1800e-01 2.4968e-01 -4.1242e-01 1.2170e-01 3.4527e-01 -4.4457e-02
 -4.9688e-01 -1.7862e-01 -6.6023e-04 -6.5660e-01 2.7843e-01 -1.4767e-01
 -5.5677e-01 1.4658e-01 -9.5095e-03 1.1658e-02 1.0204e-01 -1.2792e-01
 -8.4430e-01 -1.2181e-01 -1.6801e-02 -3.3279e-01 -1.5520e-01 -2.3131e-01
 -1.9181e-01 -1.8823e+00 -7.6746e-01 9.9051e-02 -4.2125e-01 -1.9526e-01
  4.0071e+00 -1.8594e-01 -5.2287e-01 -3.1681e-01 5.9213e-04 7.4449e-03
  1.7778e-01 -1.5897e-01 1.2041e-02 -5.4223e-02 -2.9871e-01 -1.5749e-01
 -3.4758e-01 -4.5637e-02 -4.4251e-01 1.8785e-01 2.7849e-03 -1.8411e-01
 -1.1514e-01 -7.8581e-01]
quick: [0.13967   -0.53798   -0.18047   -0.25142   0.16203   -0.13868
 -0.24637   0.75111   0.27264   0.61035   -0.82548   0.038647
 -0.32361   0.30373   -0.14598   -0.23551   0.39267   -1.1287
 -0.23636   -1.0629   0.046277   0.29143   -0.25819   -0.094902
  0.79478   -1.2095   -0.01039   -0.092086   0.84322   -0.11061
  3.0096   0.51652   -0.76986   0.51074   0.37508   0.12156
  0.082794   0.43605   -0.1584   -0.61048   0.35006   0.52465
 -0.51747   0.0034705 0.73625   0.16252   0.85279   0.85268
  0.57892   0.64483]
brown: [-0.88497   0.71685   -0.40379   -0.10698   0.81457   1.0258   -1.2698
 -0.49382   -0.27839   -0.92251   -0.49409   0.78942   -0.20066   -0.057371
  0.060682   0.30746   0.13441   -0.49376   -0.54788   -0.81912   -0.45394
  0.52098   1.0325   -0.8584   -0.65848   -1.2736   0.23616   1.0486
  0.18442   -0.3901   2.1385   -0.45301   -0.16911   -0.46737   0.15938
 -0.095071 -0.26512   -0.056479   0.63849   -1.0494   0.037507   0.76434
 -0.6412   -0.59594   0.46589   0.31494   -0.34072   -0.59167   -0.31057
  0.73274]
fox: [0.44206   0.059552   0.15861   0.92777   0.1876   0.24256   -1.593
 -0.79847   -0.34099   -0.24021   -0.32756   0.43639   -0.11057   0.50472
  0.43853   0.19738   -0.1498   -0.046979 -0.83286   0.39878   0.062174
  0.28803   0.79134   0.31798   -0.21933   -1.1015   -0.080309   0.39122
  0.19503   -0.5936   1.7921   0.3826   -0.30509   -0.58686   -0.76935
 -0.61914   -0.61771   -0.68484   -0.67919   -0.74626   -0.036646   0.78251
 -1.0072   -0.59057   -0.7849   -0.39113   -0.49727   -0.4283   -0.15204
  1.5064   ]
jumps: [-0.46105   -0.34219   0.71473   -0.29778   0.28839   0.6248

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```

```
      0.36807    -0.072746     0.60476     0.31463    -0.052247  -0.62302
     -0.56332      0.7855      0.18116    -0.31698      0.38298   -0.081953
     -1.3658      -0.78263     0.39804    -0.17001     -0.11926   -0.40146
      1.1057      -0.51142    -0.36614     0.22177      0.34626   -0.30648
      1.3869       0.77328     0.5946      1.2577       0.23472   -0.46087
     -0.009223     0.44534     0.012732   -0.24749     -0.7142     0.02422
      0.083527     0.25088    -0.24259    -1.354        1.5481    -0.31728
      0.55305     -0.0028062]
over:  [ 0.12972     0.088073    0.24375     0.078102  -0.12783      0.27831
     -0.48693      0.19649    -0.39558    -0.28362     -0.47425   -0.59317
     -0.58804     -0.31702     0.49593     0.0087594   0.039613  -0.42495
     -0.97641     -0.46534     0.020675    0.086042     0.39317   -0.51255
     -0.17913     -1.8333      0.5622      0.41626      0.075127    0.02189
      3.784        0.71067    -0.073943    0.15373     -0.3853    -0.070163
     -0.35374      0.074501   -0.084228   -0.45548     -0.081068    0.39157
      0.173        0.2254     -0.12836     0.40951     -0.26079     0.090912
     -0.60515     -0.9827    ]
the:  [ 4.1800e-01  2.4968e-01 -4.1242e-01  1.2170e-01  3.4527e-01 -4.4457e-02
     -4.9688e-01 -1.7862e-01 -6.6023e-04 -6.5660e-01  2.7843e-01 -1.4767e-01
     -5.5677e-01  1.4658e-01 -9.5095e-03  1.1658e-02  1.0204e-01 -1.2792e-01
     -8.4430e-01 -1.2181e-01 -1.6801e-02 -3.3279e-01 -1.5520e-01 -2.3131e-01
     -1.9181e-01 -1.8823e+00 -7.6746e-01  9.9051e-02 -4.2125e-01 -1.9526e-01
      4.0071e+00 -1.8594e-01 -5.2287e-01 -3.1681e-01  5.9213e-04  7.4449e-03
      1.7778e-01 -1.5897e-01  1.2041e-02 -5.4223e-02 -2.9871e-01 -1.5749e-01
     -3.4758e-01 -4.5637e-02 -4.4251e-01  1.8785e-01  2.7849e-03 -1.8411e-01
     -1.1514e-01 -7.8581e-01]
lazy:  [-0.27611  -0.59712  -0.49227  -1.0372    -0.35878  -0.097425 -0.21014
     -0.092836 -0.054118  0.4542    -0.53296    0.37602    0.77087    0.79669
     -0.076608 -0.42515   0.42576    0.32791   -0.21996   -0.20261   -0.85139
      0.80547   0.97621   0.9792     1.1118    -0.36062   -0.2588     0.8596
      0.73631  -0.18601   1.2376    -0.038938   0.19246    0.52473   -0.04842
     -0.044149  0.064432  0.087822   0.42232   -0.55991   -0.44096    0.097736
     -0.17589   1.1799    0.13152   -1.0795     0.45685   -0.63312    1.2752
      1.1672  ]
dog:  [ 0.11008    -0.38781    -0.57615    -0.27714     0.70521     0.53994
     -1.0786     -0.40146     1.1504     -0.5678       0.0038977  0.52878
      0.64561     0.47262     0.48549    -0.18407      0.1801     0.91397
     -1.1979     -0.5778     -0.37985     0.33606      0.772      0.75555
      0.45506    -1.7671     -1.0503      0.42566      0.41893   -0.68327
      1.5673      0.27685    -0.61708     0.64638     -0.076996   0.37118
      0.1308     -0.45137     0.25398    -0.74392     -0.086199   0.24068
     -0.64819     0.83549     1.2502     -0.51379      0.04224   -0.88118
      0.7158      0.38519   ]
```

[38]:
```
# -----------------------------------------------------------------
# Define vocabulary size for the language model
# To reduce the size of the vocabulary to the n most frequently used words
```

```python
EVOCABSIZE = 30000   # specify desired size of pre-defined embedding vocabulary

def default_factory():
    return EVOCABSIZE  # last/unknown-word row in limited_index_to_embedding
# dictionary has the items() function, returns list of (key, value) tuples
limited_word_to_index = defaultdict(default_factory, \
    {k: v for k, v in word_to_index.items() if v < EVOCABSIZE})

# Select the first EVOCABSIZE rows to the index_to_embedding
limited_index_to_embedding = index_to_embedding[0:EVOCABSIZE,:]
# Set the unknown-word row to be all zeros as previously
limited_index_to_embedding = np.append(limited_index_to_embedding,
    index_to_embedding[index_to_embedding.shape[0] - 1, :].\
        reshape(1,embedding_dim),
    axis = 0)

# Delete large numpy array to clear some CPU RAM
del index_to_embedding

# Verify the new vocabulary: should get same embeddings for test sentence
# Note that a small EVOCABSIZE may yield some zero vectors for embeddings
print('\nTest sentence embeddings from vocabulary of', EVOCABSIZE, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = limited_index_to_embedding[limited_word_to_index[word_]]
    print(word_ + ": ", embedding)
```

```
Test sentence embeddings from vocabulary of 30000 words:

the:  [ 4.1800e-01  2.4968e-01 -4.1242e-01  1.2170e-01  3.4527e-01 -4.4457e-02
 -4.9688e-01 -1.7862e-01 -6.6023e-04 -6.5660e-01  2.7843e-01 -1.4767e-01
 -5.5677e-01  1.4658e-01 -9.5095e-03  1.1658e-02  1.0204e-01 -1.2792e-01
 -8.4430e-01 -1.2181e-01 -1.6801e-02 -3.3279e-01 -1.5520e-01 -2.3131e-01
 -1.9181e-01 -1.8823e+00 -7.6746e-01  9.9051e-02 -4.2125e-01 -1.9526e-01
  4.0071e+00 -1.8594e-01 -5.2287e-01 -3.1681e-01  5.9213e-04  7.4449e-03
  1.7778e-01 -1.5897e-01  1.2041e-02 -5.4223e-02 -2.9871e-01 -1.5749e-01
 -3.4758e-01 -4.5637e-02 -4.4251e-01  1.8785e-01  2.7849e-03 -1.8411e-01
 -1.1514e-01 -7.8581e-01]
quick:  [ 0.13967   -0.53798   -0.18047   -0.25142    0.16203   -0.13868
 -0.24637    0.75111    0.27264    0.61035   -0.82548    0.038647
 -0.32361    0.30373   -0.14598   -0.23551    0.39267   -1.1287
 -0.23636   -1.0629     0.046277   0.29143   -0.25819   -0.094902
  0.79478   -1.2095    -0.01039   -0.092086   0.84322   -0.11061
  3.0096     0.51652   -0.76986    0.51074    0.37508    0.12156
  0.082794   0.43605   -0.1584    -0.61048    0.35006    0.52465
```

```
-0.51747     0.0034705  0.73625      0.16252      0.85279      0.85268
 0.57892     0.64483   ]
brown:  [-0.88497    0.71685   -0.40379  -0.10698     0.81457     1.0258    -1.2698
 -0.49382  -0.27839   -0.92251  -0.49409    0.78942   -0.20066   -0.057371
  0.060682  0.30746    0.13441  -0.49376   -0.54788   -0.81912   -0.45394
  0.52098   1.0325    -0.8584   -0.65848   -1.2736     0.23616    1.0486
  0.18442  -0.3901     2.1385   -0.45301   -0.16911   -0.46737    0.15938
 -0.095071 -0.26512   -0.056479  0.63849   -1.0494     0.037507   0.76434
 -0.6412   -0.59594    0.46589   0.31494   -0.34072   -0.59167   -0.31057
  0.73274 ]
fox:  [ 0.44206    0.059552   0.15861    0.92777    0.1876     0.24256  -1.593
 -0.79847  -0.34099   -0.24021  -0.32756    0.43639   -0.11057    0.50472
  0.43853   0.19738   -0.1498   -0.046979 -0.83286    0.39878    0.062174
  0.28803   0.79134    0.31798  -0.21933   -1.1015    -0.080309   0.39122
  0.19503  -0.5936     1.7921    0.3826    -0.30509   -0.58686   -0.76935
 -0.61914  -0.61771   -0.68484  -0.67919   -0.74626   -0.036646   0.78251
 -1.0072   -0.59057   -0.7849   -0.39113   -0.49727   -0.4283    -0.15204
  1.5064  ]
jumps:  [-0.46105   -0.34219    0.71473   -0.29778    0.28839     0.6248
  0.36807   -0.072746   0.60476    0.31463   -0.052247  -0.62302
 -0.56332    0.7855     0.18116   -0.31698    0.38298   -0.081953
 -1.3658    -0.78263    0.39804   -0.17001   -0.11926   -0.40146
  1.1057    -0.51142   -0.36614    0.22177    0.34626   -0.30648
  1.3869     0.77328    0.5946     1.2577     0.23472   -0.46087
 -0.009223   0.44534    0.012732  -0.24749   -0.7142     0.02422
  0.083527   0.25088   -0.24259   -1.354      1.5481    -0.31728
  0.55305   -0.0028062]
over:  [ 0.12972    0.088073   0.24375    0.078102  -0.12783     0.27831
 -0.48693    0.19649   -0.39558   -0.28362   -0.47425   -0.59317
 -0.58804   -0.31702    0.49593    0.0087594  0.039613  -0.42495
 -0.97641   -0.46534    0.020675   0.086042   0.39317   -0.51255
 -0.17913   -1.8333     0.5622     0.41626    0.075127   0.02189
  3.784      0.71067   -0.073943   0.15373   -0.3853    -0.070163
 -0.35374    0.074501  -0.084228  -0.45548   -0.081068   0.39157
  0.173      0.2254    -0.12836    0.40951   -0.26079    0.090912
 -0.60515   -0.9827    ]
the:  [ 4.1800e-01  2.4968e-01 -4.1242e-01  1.2170e-01  3.4527e-01 -4.4457e-02
 -4.9688e-01 -1.7862e-01 -6.6023e-04 -6.5660e-01  2.7843e-01 -1.4767e-01
 -5.5677e-01  1.4658e-01 -9.5095e-03  1.1658e-02  1.0204e-01 -1.2792e-01
 -8.4430e-01 -1.2181e-01 -1.6801e-02 -3.3279e-01 -1.5520e-01 -2.3131e-01
 -1.9181e-01 -1.8823e+00 -7.6746e-01  9.9051e-02 -4.2125e-01 -1.9526e-01
  4.0071e+00 -1.8594e-01 -5.2287e-01 -3.1681e-01  5.9213e-04  7.4449e-03
  1.7778e-01 -1.5897e-01  1.2041e-02 -5.4223e-02 -2.9871e-01 -1.5749e-01
 -3.4758e-01 -4.5637e-02 -4.4251e-01  1.8785e-01  2.7849e-03 -1.8411e-01
 -1.1514e-01 -7.8581e-01]
lazy:  [-0.27611  -0.59712  -0.49227  -1.0372   -0.35878  -0.097425 -0.21014
 -0.092836 -0.054118  0.4542   -0.53296    0.37602    0.77087    0.79669
 -0.076608 -0.42515    0.42576    0.32791   -0.21996   -0.20261   -0.85139
```

```
     0.80547    0.97621    0.9792     1.1118    -0.36062   -0.2588      0.8596
     0.73631   -0.18601    1.2376    -0.038938  0.19246    0.52473   -0.04842
    -0.044149   0.064432   0.087822   0.42232   -0.55991   -0.44096    0.097736
    -0.17589    1.1799     0.13152   -1.0795     0.45685   -0.63312    1.2752
     1.1672   ]
dog: [ 0.11008   -0.38781   -0.57615   -0.27714    0.70521    0.53994
    -1.0786    -0.40146    1.1504    -0.5678     0.0038977  0.52878
     0.64561    0.47262    0.48549   -0.18407    0.1801     0.91397
    -1.1979    -0.5778    -0.37985    0.33606    0.772      0.75555
     0.45506   -1.7671    -1.0503     0.42566    0.41893   -0.68327
     1.5673     0.27685   -0.61708    0.64638   -0.076996   0.37118
     0.1308    -0.45137    0.25398   -0.74392   -0.086199   0.24068
    -0.64819    0.83549    1.2502    -0.51379    0.04224   -0.88118
     0.7158     0.38519  ]
```

```python
# create list of lists of lists for embeddings
embeddings = []
for doc in documents:
    embedding = []
    for word in doc:
        embedding.append(limited_index_to_embedding[limited_word_to_index[word]])
    embeddings.append(embedding)


# --------------------------------------------------------
# Check on the embeddings list of list of lists
# --------------------------------------------------------
# Show the first word in the first document
test_word = documents[0][0]
print('First word in first document:', test_word)
print('Embedding for this word:\n',
      limited_index_to_embedding[limited_word_to_index[test_word]])
print('Corresponding embedding from embeddings list of list of lists\n',
      embeddings[0][0][:])
```

```
First word in first document: while
Embedding for this word:
 [ 0.1011    -0.16566    0.22035   -0.10629    0.46929    0.37968   -0.62815
  -0.14385   -0.38333    0.055405   0.23511   -0.20999   -0.55395   -0.38271
   0.21008    0.02161   -0.23054   -0.13576   -0.61636   -0.4678     0.25716
   0.62309    0.3837    -0.25665    0.09041   -1.5184     0.4762    -0.089573
   0.025347  -0.25974    3.6121     0.62788    0.15387   -0.062747   0.28699
  -0.16471   -0.2079     0.4407     0.065441  -0.10303   -0.15489    0.27352
   0.38356   -0.098016   0.10705   -0.083071  -0.27168   -0.49441    0.043538
  -0.39141 ]
Corresponding embedding from embeddings list of list of lists
 [ 0.1011    -0.16566    0.22035   -0.10629    0.46929    0.37968   -0.62815
```

```
 -0.14385  -0.38333   0.055405  0.23511  -0.20999  -0.55395  -0.38271
  0.21008   0.02161  -0.23054  -0.13576  -0.61636  -0.4678    0.25716
  0.62309   0.3837   -0.25665   0.09041  -1.5184    0.4762   -0.089573
  0.025347 -0.25974   3.6121    0.62788   0.15387  -0.062747  0.28699
 -0.16471  -0.2079    0.4407    0.065441 -0.10303  -0.15489   0.27352
  0.38356  -0.098016  0.10705  -0.083071 -0.27168  -0.49441   0.043538
 -0.39141 ]
```

[40]:
```python
# --------------------------------------------------------
# Make embeddings a numpy array for use in an RNN
# Create training and test sets with Scikit Learn
# --------------------------------------------------------
embeddings_array = np.array(embeddings)

# Define the labels to be used 500 negative (0) and 500 positive (1)
thumbs_down_up = np.concatenate((np.zeros((500), dtype = np.int32),
                    np.ones((500), dtype = np.int32)), axis = 0)

# Scikit Learn for random splitting of the data
from sklearn.model_selection import train_test_split

RANDOM_SEED = 9999
# Random splitting of the data in to training (80%) and test (20%)
X_train, X_test, y_train, y_test = \
    train_test_split(embeddings_array, thumbs_down_up, test_size=0.20,
                    random_state = RANDOM_SEED)

# ------------------------------------------------------------------------     ⊔
  ↪
# We use a very simple Recurrent Neural Network for this assignment
# Geron, A. 2017. Hands-On Machine Learning with Scikit-Learn & TensorFlow:
#    Concepts, Tools, and Techniques to Build Intelligent Systems.
#    Sebastopol, Calif.: O'Reilly. [ISBN-13 978-1-491-96229-9]
#    Chapter 14 Recurrent Neural Networks, pages 390-391
#    Source code available at https://github.com/ageron/handson-ml
#    Jupyter notebook file 14_recurrent_neural_networks.ipynb
#    See section on Training an sequence Classifier, # In [34]:
#    which uses the MNIST case data...  we revise to accommodate
#    the movie review data in this assignment
# ------------------------------------------------------------------------
reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up
```

```python
learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train5 = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test5 = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train5, 'Test accuracy:', acc_test5)
```

```
 ---- Epoch  0  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
 Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.52 Test accuracy: 0.54


---- Epoch  1  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.515


---- Epoch  2  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.55 Test accuracy: 0.505


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.485


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.53


---- Epoch  5  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.525


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.55


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.57


---- Epoch  8  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.63 Test accuracy: 0.56


---- Epoch  9  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.63 Test accuracy: 0.585


---- Epoch  10  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.66 Test accuracy: 0.585


---- Epoch  11  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 0.65 Test accuracy: 0.595


---- Epoch  12  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.595


---- Epoch  13  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.605


---- Epoch  14  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.61


---- Epoch  15  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.69 Test accuracy: 0.615


---- Epoch  16  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.69 Test accuracy: 0.62


---- Epoch  17  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.69 Test accuracy: 0.62


---- Epoch  18  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.69 Test accuracy: 0.62


---- Epoch  19  ----

Batch  0   training observations from   0   to   99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.64


---- Epoch  20  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.645


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.645


---- Epoch  22  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.64
```

```
---- Epoch   23  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.625


---- Epoch   24  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.62


---- Epoch   25  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.63


---- Epoch   26  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.62


---- Epoch  27  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.62


---- Epoch  28  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.63


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.635


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.635


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.64


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.645


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.645
```

```
---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.64


---- Epoch  35  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.64


---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.635


---- Epoch  37  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.83 Test accuracy: 0.63

---- Epoch  38  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.83 Test accuracy: 0.63

---- Epoch  39  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.84 Test accuracy: 0.625

---- Epoch  40  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.83 Test accuracy: 0.625

---- Epoch  41  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.83 Test accuracy: 0.63


---- Epoch  42   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.85 Test accuracy: 0.64


---- Epoch  43   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.85 Test accuracy: 0.64


---- Epoch  44   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  45   ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  46  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.655


---- Epoch  47  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  48  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
    Train accuracy: 0.85 Test accuracy: 0.64

    ---- Epoch   49   ----

    Batch   0   training observations from   0  to   99
    Batch   1   training observations from   100   to   199
    Batch   2   training observations from   200   to   299
    Batch   3   training observations from   300   to   399
    Batch   4   training observations from   400   to   499
    Batch   5   training observations from   500   to   599
    Batch   6   training observations from   600   to   699
    Batch   7   training observations from   700   to   799

    Train accuracy: 0.84 Test accuracy: 0.635
```

```python
[41]: RANDOM_SEED = 1234

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)


reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
n_neurons = 20  # analyst specified number of neurons
n_outputs = 2  # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
```

```python
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train5b = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test5b = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train5b, 'Test accuracy:', acc_test5b)
```

```
 ---- Epoch  0  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
 Batch  7  training observations from  700  to  799

 Train accuracy: 0.5 Test accuracy: 0.535


 ---- Epoch  1  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
 Batch  7  training observations from  700  to  799

 Train accuracy: 0.47 Test accuracy: 0.565
```

```
---- Epoch  2  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.51 Test accuracy: 0.505


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.46 Test accuracy: 0.495


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.48 Test accuracy: 0.485


---- Epoch  5  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.52 Test accuracy: 0.505


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.5 Test accuracy: 0.555


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.52 Test accuracy: 0.56


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.53 Test accuracy: 0.57


---- Epoch  9  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.55 Test accuracy: 0.57


---- Epoch  10  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.575


---- Epoch  11  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.56 Test accuracy: 0.575


---- Epoch  12  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.595
```

```
---- Epoch  13  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799


Train accuracy: 0.6 Test accuracy: 0.59


---- Epoch  14  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799


Train accuracy: 0.62 Test accuracy: 0.6


---- Epoch  15  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799


Train accuracy: 0.62 Test accuracy: 0.61


---- Epoch  16  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.63 Test accuracy: 0.605


---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.59


---- Epoch  18  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.59


---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.585


---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.585


---- Epoch  21  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.58


---- Epoch  22  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.585


---- Epoch  23  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.585


---- Epoch  24  ----
```

```
Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.59


---- Epoch  25  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.6


---- Epoch  26  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.6


---- Epoch  27  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.66 Test accuracy: 0.6


---- Epoch  28  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.66 Test accuracy: 0.585


---- Epoch  29  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.68 Test accuracy: 0.59


---- Epoch  30  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.71 Test accuracy: 0.595


---- Epoch  31  ----

Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.605


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.61


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.6


---- Epoch  34  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.62


---- Epoch  35  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.64


---- Epoch  36  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.64


---- Epoch  37  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.64


---- Epoch  38  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.74 Test accuracy: 0.64


---- Epoch  39  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.66


---- Epoch  40  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.66


---- Epoch  41  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.76 Test accuracy: 0.665


---- Epoch  42  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.655


---- Epoch  43  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.65


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.65


---- Epoch  45  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.635


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.63


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.645


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.64


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.655
```

```
[42]:  RANDOM_SEED = 42

       # To make output stable across runs
       def reset_graph(seed= RANDOM_SEED):
           tf.reset_default_graph()
           tf.set_random_seed(seed)
           np.random.seed(seed)

       reset_graph()

       n_steps = embeddings_array.shape[1]   # number of words per document
       n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
       n_neurons = 20   # analyst specified number of neurons
       n_outputs = 2   # thumbs-down or thumbs-up

       learning_rate = 0.001

       X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
       y = tf.placeholder(tf.int32, [None])

       basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
       outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

       logits = tf.layers.dense(states, n_outputs)
       xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                              logits=logits)
       loss = tf.reduce_mean(xentropy)
       optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
       training_op = optimizer.minimize(loss)
       correct = tf.nn.in_top_k(logits, y, 1)
       accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

       init = tf.global_variables_initializer()

       n_epochs = 50
       batch_size = 100

       with tf.Session() as sess:
           init.run()
           for epoch in range(n_epochs):
               print('\n  ---- Epoch ', epoch, ' ----\n')
               for iteration in range(y_train.shape[0] // batch_size):
                   X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
                   y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
                   print('  Batch ', iteration, ' training observations from ',
                         iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
                   sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
```

```
        acc_train5c = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test5c = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train5c, 'Test accuracy:', acc_test5c)
```

---- Epoch 0 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.52 Test accuracy: 0.54

---- Epoch 1 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.57 Test accuracy: 0.515

---- Epoch 2 ----

Batch 0 training observations from 0 to 99
Batch 1 training observations from 100 to 199
Batch 2 training observations from 200 to 299
Batch 3 training observations from 300 to 399
Batch 4 training observations from 400 to 499
Batch 5 training observations from 500 to 599
Batch 6 training observations from 600 to 699
Batch 7 training observations from 700 to 799

Train accuracy: 0.55 Test accuracy: 0.505

---- Epoch 3 ----

Batch 0 training observations from 0 to 99

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.57 Test accuracy: 0.485


---- Epoch  4  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.53


---- Epoch  5  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.525


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.55
```

```
---- Epoch  7  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799


Train accuracy: 0.63 Test accuracy: 0.57


---- Epoch  8  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799


Train accuracy: 0.63 Test accuracy: 0.56


---- Epoch  9  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
Batch  6  training observations from  600  to   699
Batch  7  training observations from  700  to   799


Train accuracy: 0.63 Test accuracy: 0.585


---- Epoch  10  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to   199
Batch  2  training observations from  200  to   299
Batch  3  training observations from  300  to   399
Batch  4  training observations from  400  to   499
Batch  5  training observations from  500  to   599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.585


---- Epoch  11  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.595


---- Epoch  12  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.595


---- Epoch  13  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.605


---- Epoch  14  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.61


---- Epoch  15  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.615


---- Epoch  16  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.62


---- Epoch  17  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.62
```

```
---- Epoch  18  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.62


---- Epoch  19  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.64


---- Epoch  20  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.645


---- Epoch  21  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.73 Test accuracy: 0.645

---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.74 Test accuracy: 0.64

---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.75 Test accuracy: 0.625

---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.75 Test accuracy: 0.62

---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.63


---- Epoch  26  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.62


---- Epoch  27  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.72 Test accuracy: 0.62


---- Epoch  28  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.75 Test accuracy: 0.63


---- Epoch  29  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.75 Test accuracy: 0.635


---- Epoch  30  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.74 Test accuracy: 0.635


---- Epoch  31  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.76 Test accuracy: 0.64


---- Epoch  32  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 0.78 Test accuracy: 0.645


---- Epoch  33  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.645


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.64


---- Epoch  35  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.64

---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.635


---- Epoch  37  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.63


---- Epoch  38  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.63


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.625


---- Epoch  40  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.83 Test accuracy: 0.625


---- Epoch   41   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.83 Test accuracy: 0.63


---- Epoch   42   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.85 Test accuracy: 0.64


---- Epoch   43   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 0.85 Test accuracy: 0.64


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  45  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.655


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.85 Test accuracy: 0.64


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.84 Test accuracy: 0.635
```

0.6 Model 6: Glove.6B, 100 dimensions, vocabulary 30,000 words

```python
[43]: # ------------------------------------------------------------
      # Select the pre-defined embeddings source
      # Define vocabulary size for the language model
      # Create a word_to_embedding_dict for GloVe.6B.50d
      embeddings_directory = 'embeddings/gloVe.6B'
      filename = 'glove.6B.100d.txt'
      embeddings_filename = os.path.join(embeddings_directory, filename)
      # ------------------------------------------------------------


      print('\nLoading embeddings from', embeddings_filename)
      word_to_index, index_to_embedding = \
          load_embedding_from_disks(embeddings_filename, with_indexes=True)
```

```
print("Embedding loaded from disks.")

# Additional background code from
# https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
# shows the general structure of the data structures for word embeddings
# This code is modified for our purposes in language modeling
vocab_size, embedding_dim = index_to_embedding.shape
print("Embedding is of shape: {}".format(index_to_embedding.shape))
print("This means (number of words, number of dimensions per word)\n")
print("The first words are words that tend occur more often.")
```

Loading embeddings from embeddings/gloVe.6B/glove.6B.100d.txt
Embedding loaded from disks.
Embedding is of shape: (400001, 100)
This means (number of words, number of dimensions per word)

The first words are words that tend occur more often.

[44]:
```
# Show how to use embeddings dictionaries with a test sentence
# This is a famous typing exercise with all letters of the alphabet
# https://en.wikipedia.org/wiki/The_quick_brown_fox_jumps_over_the_lazy_dog
a_typing_test_sentence = 'The quick brown fox jumps over the lazy dog'
print('\nTest sentence: ', a_typing_test_sentence, '\n')
words_in_test_sentence = a_typing_test_sentence.split()

print('Test sentence embeddings from complete vocabulary of',
      complete_vocabulary_size, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = index_to_embedding[word_to_index[word_]]
    print(word_ + ": ", embedding)
```

Test sentence: The quick brown fox jumps over the lazy dog

Test sentence embeddings from complete vocabulary of 400000 words:

the: [-0.038194 -0.24487   0.72812 -0.39961   0.083172 0.043953 -0.39141
  0.3344   -0.57545   0.087459 0.28787 -0.06731   0.30906 -0.26384
 -0.13231 -0.20757   0.33395 -0.33848 -0.31743 -0.48336   0.1464
 -0.37304   0.34577   0.052041 0.44946 -0.46971   0.02628 -0.54155
 -0.15518 -0.14107 -0.039722 0.28277   0.14393   0.23464 -0.31021
  0.086173 0.20397   0.52624   0.17164 -0.082378 -0.71787 -0.41531
  0.20335 -0.12763   0.41367   0.55187   0.57908 -0.33477 -0.36559
 -0.54857 -0.062892 0.26584   0.30205   0.99775 -0.80481 -3.0243
  0.01254 -0.36942   2.2167   0.72201 -0.24978   0.92136   0.034514
```

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```
     0.46745    1.1079    -0.19358  -0.074575   0.23353   -0.052062 -0.22044
     0.057162  -0.15806   -0.30798  -0.41625    0.37972    0.15006   -0.53212
    -0.2055    -1.2526     0.071624  0.70565    0.49744   -0.42063    0.26148
    -1.538     -0.30223   -0.073438 -0.28312    0.37104   -0.25217    0.016215
    -0.017099  -0.38984    0.87424  -0.72569   -0.51058   -0.52028   -0.1459
     0.8278     0.27062  ]
quick:  [-0.43146   -0.22037   -0.22684   -0.10215   -0.31863   -0.11809
 -0.093402  -0.069789  -0.29029   -0.34006    0.099652  -0.059301
 -0.43764    0.19464    0.36997    0.73648   -0.53429   -0.3469
 -0.21415    0.62954    0.54868    0.29429   -0.32889   -0.61771
 -0.039648   0.91639   -0.64046    0.28725    0.095922  -0.38774
 -0.62958    0.33443   -0.4856    -0.2287     0.84277   -0.2204
 -0.13264   -0.18188    0.077686   0.080045  -0.018909  -0.26018
  0.29542   -0.89173   -0.39373   -0.35662    0.011656  -0.37658
  0.64576   -0.86503    0.12615    0.18984   -0.26936    0.56216
  0.38218   -2.1389    -0.0096116  0.15041    1.2586    -0.35475
 -0.33285    0.07292   -0.077262   0.049068   0.90212   -0.27539
 -0.20839    0.26349   -0.26515   -0.70593   -0.68474    0.38424
 -0.21889   -0.88545    0.38583    0.26481   -0.7641    -0.037501
 -0.020606  -0.71318    1.1045     0.0453    -0.41902   -0.47667
 -1.4088    -0.50376    0.88062    0.0072194 -0.42083   -0.62586
  0.59608    0.30444   -0.40999   -0.28204   -0.52321   -0.44695
  0.21083   -0.010209   0.0086056  0.63263  ]
brown:  [-4.3812e-01 -9.9389e-02 -2.6038e-01 -1.1084e+00  1.0550e-01 -5.4542e-02
  4.4868e-01  6.1750e-02 -5.8803e-01 -2.1738e-01 -3.6304e-01 -4.0887e-01
  3.7877e-02  8.4201e-01  1.0108e-01 -1.8530e-01  5.0486e-01 -3.4252e-01
  2.2516e-01 -2.6942e-02 -4.6399e-01  9.9140e-02  1.9596e-02 -6.7435e-01
  6.3123e-01  9.5930e-01  1.6215e-01 -4.3166e-01 -2.6642e-01  1.9136e-01
  4.5626e-01  6.8918e-01  3.6808e-01 -2.8273e-01 -4.6525e-01  5.9984e-01
  1.5369e-01  8.6585e-01  2.7917e-01  5.8380e-01 -4.6627e-01 -1.3590e+00
 -1.0387e-01  6.0146e-02 -5.2733e-01  1.3135e-01 -3.3766e-01  1.7893e-01
  4.4812e-01 -7.0502e-01  6.3793e-01 -7.9508e-01  1.3176e-01  9.7769e-01
 -2.3153e-01 -2.6450e+00 -1.1464e-01  2.7907e-01  4.9121e-01  5.1274e-01
  7.9559e-04  1.7932e-01 -2.9938e-01 -3.3465e-01  9.9161e-01 -6.0262e-01
  7.2080e-01  8.4681e-01 -2.3669e-01  1.3666e-01 -3.5330e-01  3.9442e-01
 -7.2818e-01  9.1664e-02  3.0441e-01  4.8352e-02 -4.1140e-01  3.4362e-01
  1.2569e-01  4.2484e-01  4.5470e-01  1.6292e-01 -1.3630e-01 -2.1827e-01
 -3.8261e-01 -9.2620e-01  5.1256e-01 -3.5184e-01  1.8316e-01  1.9807e-01
 -1.9681e-02 -7.2242e-01 -4.3439e-01  1.3449e-01 -8.4339e-01  1.3815e-02
 -1.1325e+00  1.8143e-01 -1.9537e-01 -3.6954e-01]
fox:  [ 0.16917   -0.99783    0.24429   -0.79687    0.036447  -0.56127
  0.17305    0.29287   -0.43291   -0.82274   -0.11437   -0.28808
  0.20501   -0.4878     0.50534   -0.2117     0.48474    0.20959
  0.26642    0.6839    -0.2629     0.14794    0.087969  -0.17349
  0.61804    0.63733    0.41145    0.46401   -0.2165     0.5
  0.65265    1.0608     0.19275    0.141      0.51356    0.72558
 -0.044848  -0.35761    0.49862    0.73592   -0.38307    0.12159
 -0.75345    0.80579   -0.48075   -0.40283   -0.49931   -0.60309
```

```
      0.26126    -0.24109    -0.55885    -0.10622     0.11289     0.49708
      0.015915   -2.452      -0.32529     0.20437     0.55361     0.60879
     -0.083061    0.60856     0.13958    -0.71847     1.1409      0.023752
      0.050995    0.29621    -0.16247     1.1456      0.16929    -0.0042113
     -0.4026     -0.073144    0.096698   -0.15248    -0.69435     0.28032
     -1.0238      0.58777    -0.34573    -0.60871     0.1842     -0.18736
     -0.49948    -0.18095    -0.71161     0.69437     0.37298    -0.308
      0.2455     -0.94515     0.20393    -0.14885    -1.1153     -0.52266
     -0.27841     0.027184    0.39712     0.17933    ]
jumps: [ 0.87831    0.76211    0.24562   -0.05516    0.10355   -0.6789    -0.36757
      0.52207    -0.37174    -0.10266     1.0164      0.97297     0.028706    0.22013
      0.36371     0.79072    -1.5199      0.72657     0.24994     0.07658     0.79373
      0.32268    -0.28497     0.30724     0.25493     0.049801   -0.68182     0.059687
      0.40362    -0.73308    -0.5968      0.2901      0.15876     0.070044    0.57204
      0.70252    -0.86423    -0.1618     -0.026244    0.19154    -0.14515     0.34694
     -0.62756     0.15429    -0.56114     0.15854    -0.56041    -0.39705     0.31183
     -0.19028    -0.53601     0.061462    0.12484     1.3302      0.34361    -1.1603
      0.10341     0.33138     0.74712     0.11517     0.17949     0.059578    0.22881
      0.52396    -0.43749     0.33677     0.028801   -0.67852     0.21443     0.038026
     -0.87474    -0.22532     0.020465    1.0772      0.71369    -0.14903    -0.53563
     -0.049547    0.23989    -0.19058     0.13683     0.29553    -0.20244    -0.40515
     -0.24246    -1.0324      0.32728    -0.46241     0.27757    -0.23512    -0.23432
      0.1031     -0.54905     0.21484    -0.16597    -0.34962    -0.16015    -0.2617
      0.41802    -0.055161]
over: [-2.9574e-01  3.5345e-01  6.3326e-01  1.9576e-01 -3.0256e-02  5.4244e-01
 -2.1091e-01  3.2894e-01 -4.8888e-01  1.8379e-01  2.4242e-01  4.0346e-01
  1.1973e-01  1.3143e-02  2.4154e-01 -4.0184e-01  2.2176e-01 -2.7837e-01
 -4.6930e-01 -5.4899e-02  6.5148e-01  1.5958e-01  5.9556e-01  3.3167e-01
  7.2649e-01 -4.3182e-01  1.7208e-01 -1.1584e-02 -2.6389e-01 -2.2073e-01
 -2.8538e-01  3.5863e-01  2.4592e-01  2.2143e-01 -7.6221e-01  3.9352e-01
 -2.3915e-02  4.3028e-01 -4.7099e-01  2.5162e-01 -5.9507e-01 -1.0495e+00
  1.7973e-01 -3.1621e-01  2.3788e-01 -8.8560e-02  3.4751e-01 -5.5950e-01
  1.2997e-01 -7.0101e-01  2.8850e-01  1.8111e-01 -2.3004e-01  2.0682e+00
 -1.4925e-01 -2.8700e+00 -4.6722e-03 -2.2819e-01  1.6623e+00  6.5951e-01
  2.1892e-01  6.3600e-01  1.0332e-01  1.3176e-03  4.4414e-01  2.0222e-01
  5.2490e-01  6.4131e-01  2.7416e-01  1.0695e-01 -1.2030e-01  4.7109e-02
 -5.3503e-01 -4.6869e-01 -7.6050e-02  1.0654e-03 -3.8456e-01 -2.4067e-02
 -7.5877e-01  5.2622e-01  1.3285e+00 -3.9051e-01 -1.2174e-01  5.1886e-01
 -1.0374e+00 -3.3789e-01  7.4933e-02  2.0036e-01  2.4703e-02 -2.9090e-01
 -3.2043e-01  2.0445e-02 -9.9185e-01  1.6802e-02 -6.0819e-01 -2.6601e-01
 -1.9549e-01  2.3127e-01  9.4771e-01 -9.5560e-02]
the: [-0.038194 -0.24487    0.72812   -0.39961    0.083172   0.043953 -0.39141
  0.3344    -0.57545    0.087459   0.28787   -0.06731    0.30906   -0.26384
 -0.13231   -0.20757    0.33395   -0.33848   -0.31743   -0.48336    0.1464
 -0.37304    0.34577    0.052041   0.44946   -0.46971    0.02628   -0.54155
 -0.15518   -0.14107   -0.039722   0.28277    0.14393    0.23464   -0.31021
  0.086173   0.20397    0.52624    0.17164   -0.082378 -0.71787   -0.41531
  0.20335   -0.12763    0.41367    0.55187    0.57908   -0.33477   -0.36559
```

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```
        -0.54857   -0.062892   0.26584    0.30205    0.99775   -0.80481   -3.0243
         0.01254   -0.36942    2.2167     0.72201   -0.24978    0.92136    0.034514
         0.46745    1.1079    -0.19358   -0.074575   0.23353   -0.052062 -0.22044
         0.057162 -0.15806   -0.30798   -0.41625    0.37972    0.15006   -0.53212
        -0.2055    -1.2526     0.071624   0.70565    0.49744   -0.42063    0.26148
        -1.538     -0.30223   -0.073438 -0.28312    0.37104   -0.25217    0.016215
        -0.017099 -0.38984    0.87424   -0.72569   -0.51058   -0.52028   -0.1459
         0.8278     0.27062 ]
lazy: [ 0.14481   -0.20397    0.3596    -0.59938   -0.93979    0.59784
        -0.21619    0.73051   -0.36588   -0.19962    0.14571    0.1642
         0.1086    -0.78575    0.53327    0.37127   -0.33013   -0.082276
         0.73923    0.86931    0.37934    1.2427    -0.19554   -0.53849
         0.20681    0.76727   -0.9714    -0.016255  -0.12529    0.36231
         0.13313    0.60993    0.44345   -0.3654     0.22531    0.72985
        -0.69992    0.14427    0.85324    0.21268   -0.46674    0.25746
        -0.88493    0.042164  -0.24125   -0.11241   -0.52837    0.38905
         0.35523    0.29078   -0.47363   -0.30561    0.072255   0.31778
        -0.64297   -0.3527     0.49651    0.29722    0.68888   -0.54184
         0.04863    0.26221   -0.61438   -0.2591     0.66305    0.25526
         0.42406   -0.22196   -0.053041  -0.80721   -0.89748   -0.1165
         0.45258    0.24817   -0.14874   -0.20952   -0.58499    0.5573
         0.47503   -0.6429    -0.11219    0.2627    -0.4951    -0.0085495
        -0.86135   -0.21422    0.0086754  0.35554   -0.48077   -0.39897
        -0.012746   0.13761   -0.20283    0.40565    0.056275  -0.35009
        -0.745     -0.42987   -0.56238   -0.13433  ]
dog: [ 0.30817    0.30938    0.52803   -0.92543   -0.73671    0.63475
        0.44197    0.10262   -0.09142   -0.56607   -0.5327     0.2013
        0.7704    -0.13983    0.13727    1.1128     0.89301   -0.17869
       -0.0019722  0.57289    0.59479    0.50428   -0.28991   -1.3491
        0.42756    1.2748    -1.1613    -0.41084    0.042804   0.54866
        0.18897    0.3759     0.58035    0.66975    0.81156    0.93864
       -0.51005   -0.070079   0.82819   -0.35346    0.21086   -0.24412
       -0.16554   -0.78358   -0.48482    0.38968   -0.86356   -0.016391
        0.31984   -0.49246   -0.069363   0.018869  -0.098286   1.3126
       -0.12116   -1.2399    -0.091429   0.35294    0.64645    0.089642
        0.70294    1.1244     0.38639    0.52084    0.98787    0.79952
       -0.34625    0.14095    0.80167    0.20987   -0.86007   -0.15308
        0.074523   0.40816    0.019208   0.51587   -0.34428   -0.24525
       -0.77984    0.27425    0.22418    0.20164    0.017431  -0.014697
       -1.0235    -0.39695   -0.0056188  0.30569    0.31748    0.021404
        0.11837   -0.11319    0.42456    0.53405   -0.16717   -0.27185
       -0.6255     0.12883    0.62529   -0.52086  ]
```

```python
[45]:  # ---------------------------------------------------------------
       # Define vocabulary size for the language model
       # To reduce the size of the vocabulary to the n most frequently used words
```

```python
EVOCABSIZE = 30000    # specify desired size of pre-defined embedding vocabulary

def default_factory():
    return EVOCABSIZE   # last/unknown-word row in limited_index_to_embedding
# dictionary has the items() function, returns list of (key, value) tuples
limited_word_to_index = defaultdict(default_factory, \
    {k: v for k, v in word_to_index.items() if v < EVOCABSIZE})

# Select the first EVOCABSIZE rows to the index_to_embedding
limited_index_to_embedding = index_to_embedding[0:EVOCABSIZE,:]
# Set the unknown-word row to be all zeros as previously
limited_index_to_embedding = np.append(limited_index_to_embedding,
    index_to_embedding[index_to_embedding.shape[0] - 1, :].\
        reshape(1,embedding_dim),
    axis = 0)

# Delete large numpy array to clear some CPU RAM
del index_to_embedding

# Verify the new vocabulary: should get same embeddings for test sentence
# Note that a small EVOCABSIZE may yield some zero vectors for embeddings
print('\nTest sentence embeddings from vocabulary of', EVOCABSIZE, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = limited_index_to_embedding[limited_word_to_index[word_]]
    print(word_ + ": ", embedding)
```

Test sentence embeddings from vocabulary of 30000 words:

```
the:  [-0.038194 -0.24487    0.72812  -0.39961    0.083172  0.043953 -0.39141
  0.3344    -0.57545    0.087459  0.28787  -0.06731    0.30906  -0.26384
 -0.13231  -0.20757    0.33395  -0.33848  -0.31743  -0.48336    0.1464
 -0.37304    0.34577    0.052041  0.44946  -0.46971    0.02628  -0.54155
 -0.15518  -0.14107   -0.039722  0.28277    0.14393    0.23464  -0.31021
  0.086173  0.20397    0.52624    0.17164  -0.082378 -0.71787  -0.41531
  0.20335  -0.12763    0.41367    0.55187    0.57908  -0.33477  -0.36559
 -0.54857  -0.062892   0.26584    0.30205    0.99775  -0.80481  -3.0243
  0.01254  -0.36942    2.2167     0.72201  -0.24978    0.92136    0.034514
  0.46745    1.1079    -0.19358  -0.074575  0.23353  -0.052062 -0.22044
  0.057162 -0.15806   -0.30798  -0.41625    0.37972    0.15006  -0.53212
 -0.2055   -1.2526     0.071624  0.70565    0.49744  -0.42063    0.26148
 -1.538    -0.30223   -0.073438 -0.28312    0.37104  -0.25217    0.016215
 -0.017099 -0.38984    0.87424  -0.72569  -0.51058  -0.52028  -0.1459
  0.8278     0.27062 ]
quick:  [-0.43146   -0.22037   -0.22684   -0.10215   -0.31863   -0.11809
 -0.093402 -0.069789  -0.29029   -0.34006    0.099652  -0.059301
```

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```
  -0.43764      0.19464      0.36997      0.73648     -0.53429     -0.3469
  -0.21415      0.62954      0.54868      0.29429     -0.32889     -0.61771
  -0.039648     0.91639     -0.64046      0.28725      0.095922    -0.38774
  -0.62958      0.33443     -0.4856      -0.2287       0.84277     -0.2204
  -0.13264     -0.18188      0.077686     0.080045    -0.018909    -0.26018
   0.29542     -0.89173     -0.39373     -0.35662      0.011656    -0.37658
   0.64576     -0.86503      0.12615      0.18984     -0.26936      0.56216
   0.38218     -2.1389      -0.0096116    0.15041      1.2586      -0.35475
  -0.33285      0.07292     -0.077262     0.049068     0.90212     -0.27539
  -0.20839      0.26349     -0.26515     -0.70593     -0.68474      0.38424
  -0.21889     -0.88545      0.38583      0.26481     -0.7641      -0.037501
  -0.020606    -0.71318      1.1045       0.0453      -0.41902     -0.47667
  -1.4088      -0.50376      0.88062      0.0072194   -0.42083     -0.62586
   0.59608      0.30444     -0.40999     -0.28204     -0.52321     -0.44695
   0.21083     -0.010209     0.0086056    0.63263    ]
brown: [-4.3812e-01 -9.9389e-02 -2.6038e-01 -1.1084e+00  1.0550e-01 -5.4542e-02
  4.4868e-01  6.1750e-02 -5.8803e-01 -2.1738e-01 -3.6304e-01 -4.0887e-01
  3.7877e-02  8.4201e-01  1.0108e-01 -1.8530e-01  5.0486e-01 -3.4252e-01
  2.2516e-01 -2.6942e-02 -4.6399e-01  9.9140e-02  1.9596e-02 -6.7435e-01
  6.3123e-01  9.5930e-01  1.6215e-01 -4.3166e-01 -2.6642e-01  1.9136e-01
  4.5626e-01  6.8918e-01  3.6808e-01 -2.8273e-01 -4.6525e-01  5.9984e-01
  1.5369e-01  8.6585e-01  2.7917e-01  5.8380e-01 -4.6627e-01 -1.3590e+00
 -1.0387e-01  6.0146e-02 -5.2733e-01  1.3135e-01 -3.3766e-01  1.7893e-01
  4.4812e-01 -7.0502e-01  6.3793e-01 -7.9508e-01  1.3176e-01  9.7769e-01
 -2.3153e-01 -2.6450e+00 -1.1464e-01  2.7907e-01  4.9121e-01  5.1274e-01
  7.9559e-04  1.7932e-01 -2.9938e-01 -3.3465e-01  9.9161e-01 -6.0262e-01
  7.2080e-01  8.4681e-01 -2.3669e-01  1.3666e-01 -3.5330e-01  3.9442e-01
 -7.2818e-01  9.1664e-02  3.0441e-01  4.8352e-02 -4.1140e-01  3.4362e-01
  1.2569e-01  4.2484e-01  4.5470e-01  1.6292e-01 -1.3630e-01 -2.1827e-01
 -3.8261e-01 -9.2620e-01  5.1256e-01 -3.5184e-01  1.8316e-01  1.9807e-01
 -1.9681e-02 -7.2242e-01 -4.3439e-01  1.3449e-01 -8.4339e-01  1.3815e-02
 -1.1325e+00  1.8143e-01 -1.9537e-01 -3.6954e-01]
fox: [ 0.16917   -0.99783     0.24429    -0.79687     0.036447   -0.56127
   0.17305     0.29287    -0.43291    -0.82274    -0.11437    -0.28808
   0.20501    -0.4878      0.50534    -0.2117      0.48474     0.20959
   0.26642     0.6839     -0.2629      0.14794     0.087969   -0.17349
   0.61804     0.63733     0.41145     0.46401    -0.2165      0.5
   0.65265     1.0608      0.19275     0.141       0.51356     0.72558
  -0.044848   -0.35761     0.49862     0.73592    -0.38307     0.12159
  -0.75345     0.80579    -0.48075    -0.40283    -0.49931    -0.60309
   0.26126    -0.24109    -0.55885    -0.10622     0.11289     0.49708
   0.015915   -2.452      -0.32529     0.20437     0.55361     0.60879
  -0.083061    0.60856     0.13958    -0.71847     1.1409      0.023752
   0.050995    0.29621    -0.16247     1.1456      0.16929    -0.0042113
  -0.4026     -0.073144    0.096698   -0.15248    -0.69435     0.28032
  -1.0238      0.58777    -0.34573    -0.60871     0.1842     -0.18736
  -0.49948    -0.18095    -0.71161     0.69437     0.37298    -0.308
   0.2455     -0.94515     0.20393    -0.14885    -1.1153     -0.52266
```

```
         -0.27841     0.027184    0.39712     0.17933   ]
jumps: [ 0.87831    0.76211    0.24562   -0.05516    0.10355   -0.6789    -0.36757
   0.52207   -0.37174   -0.10266    1.0164     0.97297    0.028706   0.22013
   0.36371    0.79072   -1.5199     0.72657    0.24994    0.07658    0.79373
   0.32268   -0.28497    0.30724    0.25493    0.049801  -0.68182    0.059687
   0.40362   -0.73308   -0.5968     0.2901     0.15876    0.070044   0.57204
   0.70252   -0.86423   -0.1618    -0.026244   0.19154   -0.14515    0.34694
  -0.62756    0.15429   -0.56114    0.15854   -0.56041   -0.39705    0.31183
  -0.19028   -0.53601    0.061462   0.12484    1.3302     0.34361   -1.1603
   0.10341    0.33138    0.74712    0.11517    0.17949    0.059578   0.22881
   0.52396   -0.43749    0.33677    0.028801  -0.67852    0.21443    0.038026
  -0.87474   -0.22532    0.020465   1.0772     0.71369   -0.14903   -0.53563
  -0.049547   0.23989   -0.19058    0.13683    0.29553   -0.20244   -0.40515
  -0.24246   -1.0324     0.32728   -0.46241    0.27757   -0.23512   -0.23432
   0.1031    -0.54905    0.21484   -0.16597   -0.34962   -0.16015   -0.2617
   0.41802   -0.055161]
over:  [-2.9574e-01  3.5345e-01  6.3326e-01  1.9576e-01 -3.0256e-02  5.4244e-01
 -2.1091e-01  3.2894e-01 -4.8888e-01  1.8379e-01  2.4242e-01  4.0346e-01
  1.1973e-01  1.3143e-02  2.4154e-01 -4.0184e-01  2.2176e-01 -2.7837e-01
 -4.6930e-01 -5.4899e-02  6.5148e-01  1.5958e-01  5.9556e-01  3.3167e-01
  7.2649e-01 -4.3182e-01  1.7208e-01 -1.1584e-02 -2.6389e-01 -2.2073e-01
 -2.8538e-01  3.5863e-01  2.4592e-01  2.2143e-01 -7.6221e-01  3.9352e-01
 -2.3915e-02  4.3028e-01 -4.7099e-01  2.5162e-01 -5.9507e-01 -1.0495e+00
  1.7973e-01 -3.1621e-01  2.3788e-01 -8.8560e-02  3.4751e-01 -5.5950e-01
  1.2997e-01 -7.0101e-01  2.8850e-01  1.8111e-01 -2.3004e-01  2.0682e+00
 -1.4925e-01 -2.8700e+00 -4.6722e-03 -2.2819e-01  1.6623e+00  6.5951e-01
  2.1892e-01  6.3600e-01  1.0332e-01  1.3176e-03  4.4414e-01  2.0222e-01
  5.2490e-01  6.4131e-01  2.7416e-01  1.0695e-01 -1.2030e-01  4.7109e-02
 -5.3503e-01 -4.6869e-01 -7.6050e-02  1.0654e-03 -3.8456e-01 -2.4067e-02
 -7.5877e-01  5.2622e-01  1.3285e+00 -3.9051e-01 -1.2174e-01  5.1886e-01
 -1.0374e+00 -3.3789e-01  7.4933e-02  2.0036e-01  2.4703e-02 -2.9090e-01
 -3.2043e-01  2.0445e-02 -9.9185e-01  1.6802e-02 -6.0819e-01 -2.6601e-01
 -1.9549e-01  2.3127e-01  9.4771e-01 -9.5560e-02]
the: [-0.038194 -0.24487    0.72812   -0.39961    0.083172  0.043953 -0.39141
   0.3344    -0.57545    0.087459   0.28787   -0.06731    0.30906   -0.26384
  -0.13231   -0.20757    0.33395   -0.33848   -0.31743   -0.48336    0.1464
  -0.37304    0.34577    0.052041   0.44946   -0.46971    0.02628   -0.54155
  -0.15518   -0.14107   -0.039722   0.28277    0.14393    0.23464   -0.31021
   0.086173   0.20397    0.52624    0.17164   -0.082378 -0.71787   -0.41531
   0.20335   -0.12763    0.41367    0.55187    0.57908   -0.33477   -0.36559
  -0.54857   -0.062892   0.26584    0.30205    0.99775   -0.80481   -3.0243
   0.01254   -0.36942    2.2167     0.72201   -0.24978    0.92136    0.034514
   0.46745    1.1079    -0.19358   -0.074575   0.23353   -0.052062 -0.22044
   0.057162  -0.15806   -0.30798   -0.41625    0.37972    0.15006   -0.53212
  -0.2055    -1.2526     0.071624   0.70565    0.49744   -0.42063    0.26148
  -1.538     -0.30223   -0.073438  -0.28312    0.37104   -0.25217    0.016215
  -0.017099  -0.38984    0.87424   -0.72569   -0.51058   -0.52028   -0.1459
   0.8278     0.27062  ]
```

```
lazy:  [ 0.14481    -0.20397     0.3596     -0.59938    -0.93979     0.59784
  -0.21619      0.73051    -0.36588    -0.19962     0.14571     0.1642
   0.1086      -0.78575     0.53327     0.37127    -0.33013    -0.082276
   0.73923      0.86931     0.37934     1.2427     -0.19554    -0.53849
   0.20681      0.76727    -0.9714     -0.016255   -0.12529     0.36231
   0.13313      0.60993     0.44345    -0.3654      0.22531     0.72985
  -0.69992      0.14427     0.85324     0.21268    -0.46674     0.25746
  -0.88493      0.042164   -0.24125    -0.11241    -0.52837     0.38905
   0.35523      0.29078    -0.47363    -0.30561     0.072255    0.31778
  -0.64297     -0.3527      0.49651     0.29722     0.68888    -0.54184
   0.04863      0.26221    -0.61438    -0.2591      0.66305     0.25526
   0.42406     -0.22196    -0.053041   -0.80721    -0.89748    -0.1165
   0.45258      0.24817    -0.14874    -0.20952    -0.58499     0.5573
   0.47503     -0.6429     -0.11219     0.2627     -0.4951     -0.0085495
  -0.86135     -0.21422     0.0086754   0.35554    -0.48077    -0.39897
  -0.012746     0.13761    -0.20283     0.40565     0.056275   -0.35009
  -0.745       -0.42987    -0.56238    -0.13433   ]
dog:  [ 0.30817     0.30938     0.52803    -0.92543    -0.73671     0.63475
   0.44197      0.10262    -0.09142    -0.56607    -0.5327      0.2013
   0.7704      -0.13983     0.13727     1.1128      0.89301    -0.17869
  -0.0019722    0.57289     0.59479     0.50428    -0.28991    -1.3491
   0.42756      1.2748     -1.1613     -0.41084     0.042804    0.54866
   0.18897      0.3759      0.58035     0.66975     0.81156     0.93864
  -0.51005     -0.070079    0.82819    -0.35346     0.21086    -0.24412
  -0.16554     -0.78358    -0.48482     0.38968    -0.86356    -0.016391
   0.31984     -0.49246    -0.069363    0.018869   -0.098286    1.3126
  -0.12116     -1.2399     -0.091429    0.35294     0.64645     0.089642
   0.70294      1.1244      0.38639     0.52084     0.98787     0.79952
  -0.34625      0.14095     0.80167     0.20987    -0.86007    -0.15308
   0.074523     0.40816     0.019208    0.51587    -0.34428    -0.24525
  -0.77984      0.27425     0.22418     0.20164     0.017431   -0.014697
  -1.0235      -0.39695    -0.0056188   0.30569     0.31748     0.021404
   0.11837     -0.11319     0.42456     0.53405    -0.16717    -0.27185
  -0.6255       0.12883     0.62529    -0.52086   ]
```

```
[46]:  # create list of lists of lists for embeddings
       embeddings = []
       for doc in documents:
           embedding = []
           for word in doc:
               embedding.append(limited_index_to_embedding[limited_word_to_index[word]])
           embeddings.append(embedding)



       # ------------------------------------------------------
       # Check on the embeddings list of list of lists
       # ------------------------------------------------------
```

```python
# Show the first word in the first document
test_word = documents[0][0]
print('First word in first document:', test_word)
print('Embedding for this word:\n',
      limited_index_to_embedding[limited_word_to_index[test_word]])
print('Corresponding embedding from embeddings list of list of lists\n',
      embeddings[0][0][:])
```

```
First word in first document: while
Embedding for this word:
 [ 0.094157    0.46457     0.4535     -0.15074     0.27223     0.4545
 -0.14906     0.15345    -0.061775   -0.080787    0.53914    -0.39179
  0.083668   -0.10328     0.27425    -0.80995    -0.11588    -0.32288
 -0.23434     0.19782     0.47749     0.027463    0.49629     0.41455
  0.55198     0.13814    -0.14193    -0.65181    -0.055301   -0.026074
 -0.26557     0.16076    -0.32292    -0.10203     0.08234     0.13615
  0.27754     0.19405    -0.2348     -0.12201    -0.39889    -0.6782
  0.42633     0.21963    -0.20309     0.16836     0.013425   -0.35281
 -0.069011   -0.93563     0.16361    -0.13117     0.099808    1.8998
 -0.26605    -2.4321     -0.34386    -0.46084     1.3691      0.72702
 -0.18504     0.18016     0.085648    0.46807     0.12802     0.28034
  0.68951     0.36221     0.66845     0.32295    -0.58005    -0.27069
  0.15057    -0.46084    -0.21336     0.36952    -0.23539     0.075712
 -0.71302    -0.27551     0.64845     0.10345    -0.64706     0.29101
 -1.4154     -0.31586    -0.26086     0.24959    -0.20852    -0.28688
 -0.075658   -0.63833    -0.0040848   0.21971    -0.91796     0.271
 -0.30677    -0.23741     0.69147    -0.16581   ]
Corresponding embedding from embeddings list of list of lists
 [ 0.094157    0.46457     0.4535     -0.15074     0.27223     0.4545
 -0.14906     0.15345    -0.061775   -0.080787    0.53914    -0.39179
  0.083668   -0.10328     0.27425    -0.80995    -0.11588    -0.32288
 -0.23434     0.19782     0.47749     0.027463    0.49629     0.41455
  0.55198     0.13814    -0.14193    -0.65181    -0.055301   -0.026074
 -0.26557     0.16076    -0.32292    -0.10203     0.08234     0.13615
  0.27754     0.19405    -0.2348     -0.12201    -0.39889    -0.6782
  0.42633     0.21963    -0.20309     0.16836     0.013425   -0.35281
 -0.069011   -0.93563     0.16361    -0.13117     0.099808    1.8998
 -0.26605    -2.4321     -0.34386    -0.46084     1.3691      0.72702
 -0.18504     0.18016     0.085648    0.46807     0.12802     0.28034
  0.68951     0.36221     0.66845     0.32295    -0.58005    -0.27069
  0.15057    -0.46084    -0.21336     0.36952    -0.23539     0.075712
 -0.71302    -0.27551     0.64845     0.10345    -0.64706     0.29101
 -1.4154     -0.31586    -0.26086     0.24959    -0.20852    -0.28688
 -0.075658   -0.63833    -0.0040848   0.21971    -0.91796     0.271
 -0.30677    -0.23741     0.69147    -0.16581   ]
```

```
[47]:  # -------------------------------------------------------
       # Make embeddings a numpy array for use in an RNN
       # Create training and test sets with Scikit Learn
       # -------------------------------------------------------
       embeddings_array = np.array(embeddings)

       # Define the labels to be used 500 negative (0) and 500 positive (1)
       thumbs_down_up = np.concatenate((np.zeros((500), dtype = np.int32),
                              np.ones((500), dtype = np.int32)), axis = 0)

       # Scikit Learn for random splitting of the data
       from sklearn.model_selection import train_test_split

       RANDOM_SEED = 9999
       # Random splitting of the data in to training (80%) and test (20%)
       X_train, X_test, y_train, y_test = \
           train_test_split(embeddings_array, thumbs_down_up, test_size=0.20,
                         random_state = RANDOM_SEED)


       # --------------------------------------------------------------------------  ⌴
        ↪
       # We use a very simple Recurrent Neural Network for this assignment
       # Geron, A. 2017. Hands-On Machine Learning with Scikit-Learn & TensorFlow:
       #    Concepts, Tools, and Techniques to Build Intelligent Systems.
       #    Sebastopol, Calif.: O'Reilly. [ISBN-13 978-1-491-96229-9]
       #    Chapter 14 Recurrent Neural Networks, pages 390-391
       #    Source code available at https://github.com/ageron/handson-ml
       #    Jupyter notebook file 14_recurrent_neural_networks.ipynb
       #    See section on Training an sequence Classifier, # In [34]:
       #    which uses the MNIST case data...  we revise to accommodate
       #    the movie review data in this assignment
       # --------------------------------------------------------------------------
       reset_graph()

       n_steps = embeddings_array.shape[1]  # number of words per document
       n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
       n_neurons = 20  # analyst specified number of neurons
       n_outputs = 2  # thumbs-down or thumbs-up

       learning_rate = 0.001

       X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
       y = tf.placeholder(tf.int32, [None])

       basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
       outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)
```

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```python
logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train6 = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test6 = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train6, 'Test accuracy:', acc_test6)
```

```
 ---- Epoch  0  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
 Batch  7  training observations from  700  to  799

 Train accuracy: 0.52 Test accuracy: 0.505

 ---- Epoch  1  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.53 Test accuracy: 0.535


---- Epoch  2  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.55 Test accuracy: 0.535


---- Epoch  3  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.55 Test accuracy: 0.53


---- Epoch  4  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.58 Test accuracy: 0.56


---- Epoch  5  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.575


---- Epoch  6  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.555


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.565


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.62 Test accuracy: 0.565


---- Epoch  9  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.58


---- Epoch  10  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.59


---- Epoch  11  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.585


---- Epoch  12  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.585


---- Epoch  13  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.6


---- Epoch  14  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.67 Test accuracy: 0.605


---- Epoch  15  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.625


---- Epoch  16  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.635


---- Epoch  17  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.64


---- Epoch  18  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.63


---- Epoch  19  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.78 Test accuracy: 0.635

---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.63

---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.625

---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.66

---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.655


---- Epoch  24  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.665


---- Epoch  25  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655


---- Epoch  26  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.64


---- Epoch  27  ----


Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.66


---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.67


---- Epoch  29  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.67


---- Epoch  30  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.665
```

```
---- Epoch  31  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.66


---- Epoch  32  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.66


---- Epoch  33  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.655


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.645


---- Epoch  35  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.645


---- Epoch  36  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.655


---- Epoch  37  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.65


---- Epoch  38  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.655


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.655


---- Epoch  40  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.655


---- Epoch  41  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.655
```

```
---- Epoch  42  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  43  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.665


---- Epoch  44  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.67


---- Epoch  45  ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.87 Test accuracy: 0.66


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.65


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.65


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.67


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
  Batch  3   training observations from  300   to   399
  Batch  4   training observations from  400   to   499
  Batch  5   training observations from  500   to   599
  Batch  6   training observations from  600   to   699
  Batch  7   training observations from  700   to   799

  Train accuracy: 0.89 Test accuracy: 0.64
```

[48]:
```python
RANDOM_SEED = 1234

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)


reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                       logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
```

```python
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train6b = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test6b = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train6b, 'Test accuracy:', acc_test6b)
```

```
---- Epoch  0  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.54 Test accuracy: 0.52

---- Epoch  1  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.58 Test accuracy: 0.56

---- Epoch  2  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.555


---- Epoch  3  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.555


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.565


---- Epoch  5  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.55


---- Epoch  6  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.52


---- Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.535


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.535


---- Epoch  9  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.55
```

```
---- Epoch   10  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.63 Test accuracy: 0.555


---- Epoch   11  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.64 Test accuracy: 0.565


---- Epoch   12  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.66 Test accuracy: 0.565


---- Epoch   13  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
```

```
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.67 Test accuracy: 0.585


---- Epoch  14  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.67 Test accuracy: 0.6


---- Epoch  15  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.68 Test accuracy: 0.61


---- Epoch  16  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.67 Test accuracy: 0.61


---- Epoch  17  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.605


---- Epoch  18  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.605


---- Epoch  19  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.6


---- Epoch  20  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.69 Test accuracy: 0.6
```

```
---- Epoch  21  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.605


---- Epoch  22  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.605


---- Epoch  23  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.61


---- Epoch  24  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.74 Test accuracy: 0.62

---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.74 Test accuracy: 0.625

---- Epoch  26  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.75 Test accuracy: 0.635

---- Epoch  27  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.75 Test accuracy: 0.65

---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.65


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.655


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.655


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.655


---- Epoch  32  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.65


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.65


---- Epoch  34  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655


---- Epoch  35  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.82 Test accuracy: 0.655


---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655


---- Epoch  37  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.655


---- Epoch  38  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.65


---- Epoch  39  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.65


---- Epoch  40  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.65


---- Epoch  41  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.66


---- Epoch  42  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.655


---- Epoch  43  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.89 Test accuracy: 0.655


---- Epoch  44  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.89 Test accuracy: 0.665


---- Epoch  45  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.9 Test accuracy: 0.665


---- Epoch  46  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 0.9 Test accuracy: 0.665

---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.91 Test accuracy: 0.67

---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.92 Test accuracy: 0.67

---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.93 Test accuracy: 0.67
```

```python
[49]: RANDOM_SEED = 42

      # To make output stable across runs
      def reset_graph(seed= RANDOM_SEED):
          tf.reset_default_graph()
          tf.set_random_seed(seed)
```

```python
    np.random.seed(seed)

reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.001

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train6c = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test6c = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train6c, 'Test accuracy:', acc_test6c)


  ---- Epoch  0  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.52 Test accuracy: 0.505


---- Epoch  1  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.53 Test accuracy: 0.535


---- Epoch  2  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.55 Test accuracy: 0.535


---- Epoch  3  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.55 Test accuracy: 0.53


---- Epoch  4  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.58 Test accuracy: 0.56


---- Epoch  5  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.575


---- Epoch  6  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.555


---- Epoch  7  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.59 Test accuracy: 0.565


---- Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.62 Test accuracy: 0.565


---- Epoch  9  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.63 Test accuracy: 0.58


---- Epoch  10  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.59


---- Epoch  11  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.66 Test accuracy: 0.585


---- Epoch  12  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.585


---- Epoch  13  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.65 Test accuracy: 0.6


---- Epoch  14  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 0.67 Test accuracy: 0.605


---- Epoch  15  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.7 Test accuracy: 0.625


---- Epoch  16  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.73 Test accuracy: 0.635


---- Epoch  17  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.71 Test accuracy: 0.64


---- Epoch  18  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.78 Test accuracy: 0.63


---- Epoch  19  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.78 Test accuracy: 0.635


---- Epoch  20  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.79 Test accuracy: 0.63


---- Epoch  21  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.79 Test accuracy: 0.625


---- Epoch  22  ----


Batch  0   training observations from  0   to   99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.79 Test accuracy: 0.66


---- Epoch  23  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.655


---- Epoch  24  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.8 Test accuracy: 0.665


---- Epoch  25  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.655
```

```
---- Epoch  26  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.83 Test accuracy: 0.64


---- Epoch  27  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.82 Test accuracy: 0.66


---- Epoch  28  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.82 Test accuracy: 0.67


---- Epoch  29  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.82 Test accuracy: 0.67


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.665


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.66


---- Epoch  32  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.66


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.655


---- Epoch  34  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.85 Test accuracy: 0.645


---- Epoch  35  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.645


---- Epoch  36  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.655
```

```
---- Epoch  37  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.65


---- Epoch  38  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.655


---- Epoch  39  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.655


---- Epoch  40  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 0.87 Test accuracy: 0.655


---- Epoch  41  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.655


---- Epoch  42  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.66


---- Epoch  43  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.86 Test accuracy: 0.665


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.67


---- Epoch  45  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.87 Test accuracy: 0.66


---- Epoch  46  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.88 Test accuracy: 0.65


---- Epoch  47  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.65


---- Epoch  48  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.83 Test accuracy: 0.67


---- Epoch  49  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.89 Test accuracy: 0.64
```

0.7   Summary of models and runs

```python
[50]: test_avg1 = (acc_test1 + acc_test1b + acc_test1c) / 3
      test_avg2 = (acc_test2 + acc_test2b + acc_test2c) / 3
      test_avg3 = (acc_test3 + acc_test3b + acc_test3c) / 3
      test_avg4 = (acc_test4 + acc_test4b + acc_test4c) / 3
      test_avg5 = (acc_test5 + acc_test5b + acc_test5c) / 3
      test_avg6 = (acc_test6 + acc_test6b + acc_test6c) / 3


      summary_models = {
          'Name' : ['GloVe.6B', 'GloVe.6B', 'GloVe.Twitter', 'GloVe.Twitter', 'GloVe.
       ↪6B', 'GloVe.6B'],
          'Number of Dimensions' : [50, 100, 50, 100, 50, 100],
          'Vocab Size' : ['10K', '10K', '10K', '10K', '30K', '30K'],
          'Test Accuracy' : [round(acc_test1, 3), round(acc_test2, 3),␣
       ↪round(acc_test3, 3),
                           round(acc_test4, 3), round(acc_test5, 3),␣
       ↪round(acc_test6, 3)],
          'Test Accuracy #2' : [round(acc_test1b, 3), round(acc_test2b, 3),␣
       ↪round(acc_test3b, 3),
```

```
                          round(acc_test4b, 3), round(acc_test5b, 3),␣
       ↪round(acc_test6b, 3)],
          'Test Accuracy #3' : [round(acc_test1c, 3), round(acc_test2c, 3),␣
       ↪round(acc_test3c, 3),
                          round(acc_test4c, 3), round(acc_test5c, 3),␣
       ↪round(acc_test6c, 3)],
          'Test Accuracy Average' : [round(test_avg1, 3), round(test_avg2, 3),␣
       ↪round(test_avg3, 3),
                              round(test_avg4, 3), round(test_avg5, 3),␣
       ↪round(test_avg6, 3)]
       }
```

```
[51]: import pandas as pd
      summary_models_df = pd.DataFrame(summary_models)
      summary_models_df
```

```
[51]:              Name  Number of Dimensions Vocab Size  Test Accuracy  \
      0         GloVe.6B                    50        10K          0.675
      1         GloVe.6B                   100        10K          0.635
      2   GloVe.Twitter                    50        10K          0.655
      3   GloVe.Twitter                   100        10K          0.640
      4         GloVe.6B                    50        30K          0.635
      5         GloVe.6B                   100        30K          0.640

         Test Accuracy #2  Test Accuracy #3  Test Accuracy Average
      0             0.645             0.635                  0.652
      1             0.590             0.635                  0.620
      2             0.640             0.655                  0.650
      3             0.680             0.640                  0.653
      4             0.655             0.635                  0.642
      5             0.670             0.640                  0.650
```

```
[52]: test_avg1 = (acc_test1 + acc_test1b + acc_test1c) / 3
      test_avg2 = (acc_test2 + acc_test2b + acc_test2c) / 3
      test_avg3 = (acc_test3 + acc_test3b + acc_test3c) / 3
      test_avg4 = (acc_test4 + acc_test4b + acc_test4c) / 3
      test_avg5 = (acc_test5 + acc_test5b + acc_test5c) / 3
      test_avg6 = (acc_test6 + acc_test6b + acc_test6c) / 3

      model_average = {
          'Name' : ['GloVe.6B', 'GloVe.6B', 'GloVe.Twitter', 'GloVe.Twitter', 'GloVe.
       ↪6B', 'GloVe.6B'],
          'Number of Dimensions' : [50, 100, 50, 100, 50, 100],
          'Vocab Size' : ['10K', '10K', '10K', '10K', '30K', '30K'],
          'Test Accuracy Average' : [round(test_avg1, 3), round(test_avg2, 3),␣
       ↪round(test_avg3, 3),
                              round(test_avg4, 3), round(test_avg5, 3),␣
       ↪round(test_avg6, 3)],
```

```
}

model_average_df = pd.DataFrame(model_average)
model_average_df
```

[52]:
```
             Name  Number of Dimensions Vocab Size  Test Accuracy Average
0        GloVe.6B                    50        10K                  0.652
1        GloVe.6B                   100        10K                  0.620
2  GloVe.Twitter                    50        10K                  0.650
3  GloVe.Twitter                   100        10K                  0.653
4        GloVe.6B                    50        30K                  0.642
5        GloVe.6B                   100        30K                  0.650
```

[53]:
```python
#https://stackoverflow.com/questions/19726663/
↪how-to-save-the-pandas-dataframe-series-data-as-a-figure/39358752#39358752

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import six

#df = pd.DataFrame()
#df['date'] = ['2016-04-01', '2016-04-02', '2016-04-03']
#df['calories'] = [2200, 2100, 1500]
#df['sleep hours'] = [2200, 2100, 1500]
#df['gym'] = [True, False, False]

def render_mpl_table(data, col_width=3.0, row_height=0.625, font_size=14,
                     header_color='#40466e', row_colors=['#f1f1f2', 'w'],
↪edge_color='w',
                     bbox=[0, 0, 1, 1], header_columns=0,
                     ax=None, **kwargs):
    if ax is None:
        size = (np.array(data.shape[::-1]) + np.array([0, 1])) * np.
↪array([col_width, row_height])
        fig, ax = plt.subplots(figsize=size)
        ax.axis('off')

    mpl_table = ax.table(cellText=data.values, bbox=bbox, colLabels=data.
↪columns, **kwargs)

    mpl_table.auto_set_font_size(False)
    mpl_table.set_fontsize(font_size)

    for k, cell in six.iteritems(mpl_table._cells):
        cell.set_edgecolor(edge_color)
        if k[0] == 0 or k[1] < header_columns:
            cell.set_text_props(weight='bold', color='w')
```

```
                cell.set_facecolor(header_color)
          else:
                cell.set_facecolor(row_colors[k[0]%len(row_colors) ])
      return ax

model_average_table = render_mpl_table(model_average_df, header_columns=0,␣
  ↪col_width=4.0)
model_average_table
plt.savefig('model_average_table.pdf')
```

[54]:
```
model_summary_table = render_mpl_table(summary_models_df, header_columns=0,␣
  ↪col_width=4.0)
model_summary_table
plt.savefig('model_summary_table.pdf')
```

Name	Number of Dimensions	Vocab Size	Test Accuracy	Test Accuracy #2	Test Accuracy #3	Test Accuracy Average
GloVe.6B	50	10K	0.675000011920929	0.6449999809265137	0.6349999904632568	0.652
GloVe.6B	100	10K	0.6349999904632568	0.5899999737739563	0.6349999904632568	0.62
GloVe.Twitter	50	10K	0.6549999713897705	0.6399999856948853	0.6549999713897705	0.65
GloVe.Twitter	100	10K	0.6399999856948853	0.6800000071525574	0.6399999856948853	0.653
GloVe.6B	50	30K	0.6349999904632568	0.6549999713897705	0.6349999904632568	0.642
GloVe.6B	100	30K	0.6399999856948853	0.6700000166893005	0.6399999856948853	0.65

[55]:
```
#https://github.com/pandas-dev/pandas/issues/14023
#https://phantomjs.org/screen-capture.html

#summary_models_df.to_html()
```

[ ]:

0.8 Additional model: GRU cell, GloVe.Twitter, 100 dimensions, vocabulary size = 100,000

[56]:
```
# -----------------------------------------------------------
# Select the pre-defined embeddings source
# Define vocabulary size for the language model
# Create a word_to_embedding_dict for GloVe.6B.50d
embeddings_directory = 'embeddings/glove.twitter.27B'
filename3 = 'glove.twitter.27B.100d.txt'
embeddings_filename = os.path.join(embeddings_directory, filename3)
# -----------------------------------------------------------


print('\nLoading embeddings from', embeddings_filename)
word_to_index, index_to_embedding = \
    load_embedding_from_disks(embeddings_filename, with_indexes=True)
print("Embedding loaded from disks.")
```

```python
# Additional background code from
# https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
# shows the general structure of the data structures for word embeddings
# This code is modified for our purposes in language modeling
vocab_size, embedding_dim = index_to_embedding.shape
print("Embedding is of shape: {}".format(index_to_embedding.shape))
print("This means (number of words, number of dimensions per word)\n")
print("The first words are words that tend occur more often.")


REMOVE_STOPWORDS = False  # no stopword removal


EVOCABSIZE = 100000  # specify desired size of pre-defined embedding vocabulary


def default_factory():
    return EVOCABSIZE  # last/unknown-word row in limited_index_to_embedding
# dictionary has the items() function, returns list of (key, value) tuples
limited_word_to_index = defaultdict(default_factory, \
    {k: v for k, v in word_to_index.items() if v < EVOCABSIZE})

# Select the first EVOCABSIZE rows to the index_to_embedding
limited_index_to_embedding = index_to_embedding[0:EVOCABSIZE,:]
# Set the unknown-word row to be all zeros as previously
limited_index_to_embedding = np.append(limited_index_to_embedding,
    index_to_embedding[index_to_embedding.shape[0] - 1, :].\
        reshape(1,embedding_dim),
    axis = 0)

# Delete large numpy array to clear some CPU RAM
del index_to_embedding

# Verify the new vocabulary: should get same embeddings for test sentence
# Note that a small EVOCABSIZE may yield some zero vectors for embeddings
print('\nTest sentence embeddings from vocabulary of', EVOCABSIZE, 'words:\n')
for word in words_in_test_sentence:
    word_ = word.lower()
    embedding = limited_index_to_embedding[limited_word_to_index[word_]]
    print(word_ + ": ", embedding)
```


Loading embeddings from embeddings/glove.twitter.27B/glove.twitter.27B.100d.txt
Embedding loaded from disks.
Embedding is of shape: (1193515, 100)
This means (number of words, number of dimensions per word)

The first words are words that tend occur more often.

```
Test sentence embeddings from vocabulary of 100000 words:

the:  [ 9.5152e-02  3.7024e-01  5.4291e-01  1.9621e-01  4.8205e-02  3.2033e-01
 -5.9638e-01  1.5868e-02 -1.2989e-01 -6.3028e-01  8.1944e-02  2.4164e-01
 -6.0990e+00 -6.8557e-01  5.0354e-01 -3.4089e-02  1.1705e-01 -7.7403e-03
 -8.6512e-02  4.3617e-01 -4.3982e-01  2.6125e-01 -4.0348e-02 -1.9194e-01
  8.3204e-02 -5.8246e-01 -3.1923e-02  1.2630e-01  4.0120e-01  6.8906e-02
 -1.0517e-01 -2.0804e-01 -4.2554e-01  4.7799e-01  3.4651e-01  2.4057e-01
  5.0244e-02 -7.2587e-02 -2.4347e-03 -5.0342e-01 -1.0601e+00 -3.1586e-01
 -3.2457e-02 -7.6317e-02  7.9045e-01  8.6367e-02 -1.9632e-01  5.7566e-02
  8.4129e-01 -4.2020e-01 -1.1335e-03 -8.5632e-02  6.1910e-02  2.1423e-01
 -1.0356e-01 -3.6946e-02 -2.6005e-01 -3.5657e-01  5.4321e-02  3.0875e-02
  1.4092e-01 -9.1998e-02 -4.1841e-01 -3.1135e-01 -1.4937e-01 -2.2699e-04
 -3.3454e-01 -1.4848e-01 -1.1944e-01 -2.7174e-01  3.1320e-01 -1.0998e-01
 -4.7524e-01  1.4056e-01  3.9641e-01 -4.9413e-02 -4.2601e-01 -2.3576e-01
  6.1482e-02 -3.5313e-02  2.4161e+00  2.8979e-01  3.8882e-01  3.6779e-01
  2.0685e-01  1.3992e-01 -4.2459e-01  4.4590e-01  2.6234e-01 -4.4834e-01
  3.7196e-03 -2.2521e-01  1.4764e-01 -3.6417e-01 -1.8493e-01  2.2282e-01
  4.7626e-01 -5.1083e-01  4.6877e-01  3.4882e-01]
quick:  [ 0.50111    0.37708   -0.19973   -0.55111    0.17148    0.019936
  0.50052    0.017863  -0.43901    0.4485    -0.22766   -0.087691
 -3.5079    -0.62763   -0.75083   -0.19767   -0.39356    0.3996
 -0.081026  -0.53157   -0.38539   -0.61069    0.10148   -0.10846
 -0.29013    0.61234    0.027151  -0.044352  -0.40846    0.42045
 -0.22149    0.018245  -0.25989   -0.049784   0.28018    0.26186
 -0.22841   -0.28096    0.046061   0.26917   -0.41851    0.25948
  0.10509    0.75517    0.43909    0.07024    0.053149   0.59465
 -0.23239    0.37033   -0.29459   -0.040892  -0.37618    0.015432
  0.056196  -0.25702   -0.16717    0.2405     0.29895   -0.64143
  0.91313   -0.057541   0.20291    1.0468     0.65415   -0.94901
  0.49342    0.014261   0.14139    0.17338   -0.76048    0.53518
  0.26007    0.34376    0.057837  -0.55036    0.66677   -0.31764
  0.41491   -0.025773   1.5507     0.394     -0.31088   -0.53684
  0.15205    0.70041   -0.1879    -0.24963   -0.16778   -0.34475
 -0.51597    0.010533  -0.59016   -0.44993    0.80113    0.051259
 -0.49647    0.59636    0.0075998  0.28048  ]
brown:  [-0.26106   -0.75489   -0.022668   0.055802  -0.77145    0.05871
  0.3852     0.40926   -0.97445   -0.33838    0.47742   -0.01054
 -3.1085    -0.55482    0.35536    0.44814    0.29137    0.16997
  0.66486    0.22324    0.32805   -0.40968   -0.19862    0.3546
  0.30566   -0.55413   -0.54773    0.25429   -0.72556   -0.22337
  0.16802    0.14168   -1.0443    -0.57601   -0.21027    0.18212
 -0.81012   -0.71126   -0.39691   -0.13592   -0.37764   -0.52612
 -0.80185    0.31638   -0.073107  -0.74961    0.44858   -0.0039955
 -0.22895   -0.95689   -0.70048   -0.15495    0.30279    0.51368
 -0.51663    0.053121  -0.23784    0.49018    0.47278    0.29428
 -0.42305    0.39041   -0.051611  -0.30997    0.12854   -0.67797
 -0.23172    0.13328    0.43269   -0.28219    0.56389   -0.52302
```

```
    0.52544     0.20713    -0.4926      0.2071    -0.012374    0.62647
    0.38548     0.5472      1.5739      0.38571   -0.095062   -0.70715
   -0.37873    -0.065873    0.34776     0.80396   -0.34771     0.43994
   -0.23445    -0.36284    -0.11516    -0.68272   -0.027322    0.24447
   -0.088484    0.34491    -0.55879     0.343     ]
fox: [ 0.64344     0.0086088  0.50145    -0.70381   -0.36289    -0.51602
    0.3751     -0.0078184  0.10752    -0.29124     0.61808    -0.036332
   -2.4467     -0.0050135  0.18236    -0.18152    -0.19349    -0.19442
    0.3793      0.46691     0.03579    -0.48468    -0.45103    -0.045509
    0.6732     -1.4904     -0.23975    -0.26736    -0.058426    0.11573
    0.79477     0.09746    -0.36717    -0.20758     0.099006   -0.51114
   -0.023912    0.14275    -0.87894     0.13728    -0.26524    -0.33326
    0.25857    -0.27703     0.5022      0.7164     -0.26708     0.018559
    0.39153    -0.42015    -0.55746    -0.2797     -0.36874     0.090716
   -0.29017     0.25543    -0.016203    0.014775   -0.45174    -0.48211
   -0.18746     0.59934    -0.20146    -0.3756     -0.11143     0.26213
    0.15496     0.53471     0.43618    -0.7356      0.34366    -0.036715
   -0.2377     -0.3525     -0.5546      0.44059    -0.17759     0.50194
   -0.59675    -0.0427      1.5432      0.22326     0.40868     0.70572
   -0.17751     0.071547    0.84483     0.3794     -0.67034    -0.54685
   -0.55382    -0.88651    -0.25728    -0.1996     -0.15984     0.37977
    0.62406     0.037116   -0.427       0.029686 ]
jumps: [-0.28348     0.1648      1.4019     -0.85675     0.027551    0.5412
    0.88782     0.046905   -0.45316    -0.60368     0.55262     1.205
   -2.0585      0.51703    -0.32351    -0.30435     0.45369     0.31998
   -0.96374    -0.60021     0.47335    -0.74688     0.47179    -0.2158
   -0.09306     0.83334    -0.74749    -0.089607   -0.17782     1.2692
    0.6947      0.043769    0.52786    -0.010808   -0.16553    -0.074203
   -0.49438     0.39217     0.16966    -0.73894     0.57277     0.55778
   -0.30532    -0.24023     0.96471     0.19401     0.40399     0.1934
    0.084298    0.66986    -0.19846     0.29749     0.3546     -0.23385
   -0.14053     0.29882     0.69889     0.19321     0.95773    -0.18805
   -0.22225    -0.23144     0.38776     0.0037293   0.24487    -0.33569
   -0.17885     0.73331     0.26516    -0.098724    0.31112    -0.33525
   -0.63795    -0.97048    -0.63374     0.25719     0.23121    -1.4143
    1.011      -0.014403    0.8709      0.57321     0.40159     0.302
   -0.43126    -0.16309     0.81327     0.45568    -0.14238    -0.69614
   -0.21193    -0.13398    -0.20042     0.14101     0.47543    -0.36219
    0.71711    -0.47106     0.35576     0.46552   ]
over: [-1.3037e-01  2.0490e-01  4.2575e-01 -3.1239e-01 -5.4739e-01  2.1011e-01
  -7.2276e-03 -6.3219e-02 -1.2984e-02 -8.2143e-02  2.5385e-01  3.2791e-01
  -4.9173e+00  3.1567e-01 -2.0232e-01 -2.5671e-01 -1.8498e-03  4.3715e-01
  -1.0066e+00  2.5198e-02 -3.9015e-02 -3.4754e-01 -2.8745e-02  6.5716e-01
   1.0906e+00  2.3102e-01  5.5719e-01 -4.6840e-01 -5.8515e-01 -2.9006e-01
  -2.6508e-01  3.9253e-01 -5.1165e-01  2.4492e-02  8.1263e-01 -4.2014e-01
  -3.4857e-01  3.5984e-01  1.5941e-01 -6.9736e-01 -1.4426e+00 -9.9337e-03
  -2.3335e-01 -4.6266e-01  2.6243e-01 -2.9373e-01  4.8860e-01  7.2830e-01
  -3.2475e-02  6.2540e-01 -4.3399e-01 -1.0553e-01  3.1752e-01 -1.5631e-01
```

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```
    -2.4268e-01 -3.9298e-01 -3.7478e-01 -6.6699e-02  1.5477e-01  7.4870e-01
    -2.3318e-01  9.7446e-02 -4.4590e-01 -6.1845e-02  1.7504e-01  7.3357e-01
     8.8520e-01 -1.9843e-01  2.5146e-01 -3.8909e-01 -3.0322e-01  4.3190e-01
     5.9478e-02 -2.7233e-01 -3.8758e-01  5.1850e-01 -1.6175e-01 -7.5551e-01
     5.5890e-01  1.0797e-01  1.4943e+00  1.6329e-01  6.6365e-01  1.2885e-01
    -9.8670e-02 -4.8738e-02  1.3253e-01 -1.6620e-01 -4.2653e-01 -1.7694e-01
    -2.6400e-01  1.0666e-01 -1.9857e-02  1.2652e-01  1.5045e-01 -7.6070e-02
    -3.4198e-01 -1.4165e-01  4.8806e-01  5.2860e-01]
the: [ 9.5152e-02  3.7024e-01  5.4291e-01  1.9621e-01  4.8205e-02  3.2033e-01
    -5.9638e-01  1.5868e-02 -1.2989e-01 -6.3028e-01  8.1944e-02  2.4164e-01
    -6.0990e+00 -6.8557e-01  5.0354e-01 -3.4089e-02  1.1705e-01 -7.7403e-03
    -8.6512e-02  4.3617e-01 -4.3982e-01  2.6125e-01 -4.0348e-02 -1.9194e-01
     8.3204e-02 -5.8246e-01 -3.1923e-02  1.2630e-01  4.0120e-01  6.8906e-02
    -1.0517e-01 -2.0804e-01 -4.2554e-01  4.7799e-01  3.4651e-01  2.4057e-01
     5.0244e-02 -7.2587e-02 -2.4347e-03 -5.0342e-01 -1.0601e+00 -3.1586e-01
    -3.2457e-02 -7.6317e-02  7.9045e-01  8.6367e-02 -1.9632e-01  5.7566e-02
     8.4129e-01 -4.2020e-01 -1.1335e-03 -8.5632e-02  6.1910e-02  2.1423e-01
    -1.0356e-01 -3.6946e-02 -2.6005e-01 -3.5657e-01  5.4321e-02  3.0875e-02
     1.4092e-01 -9.1998e-02 -4.1841e-01 -3.1135e-01 -1.4937e-01 -2.2699e-04
    -3.3454e-01 -1.4848e-01 -1.1944e-01 -2.7174e-01  3.1320e-01 -1.0998e-01
    -4.7524e-01  1.4056e-01  3.9641e-01 -4.9413e-02 -4.2601e-01 -2.3576e-01
     6.1482e-02 -3.5313e-02  2.4161e+00  2.8979e-01  3.8882e-01  3.6779e-01
     2.0685e-01  1.3992e-01 -4.2459e-01  4.4590e-01  2.6234e-01 -4.4834e-01
     3.7196e-03 -2.2521e-01  1.4764e-01 -3.6417e-01 -1.8493e-01  2.2282e-01
     4.7626e-01 -5.1083e-01  4.6877e-01  3.4882e-01]
lazy: [ 1.4021e-01 -6.1686e-01  6.6047e-01  4.5844e-01 -4.7073e-02  5.6833e-01
     4.7711e-01 -3.0135e-01  2.5490e-01  2.7677e-01 -7.2243e-01 -4.7596e-01
    -3.1877e+00 -3.0520e-01 -1.1225e+00  1.1409e-01 -1.6397e-01 -6.2531e-01
    -6.4549e-01 -7.0767e-01 -1.3721e-01  1.6656e-01 -1.5643e-01 -5.8997e-01
     5.3493e-01  4.2989e-01 -1.6078e-01  3.1838e-01 -1.7478e-01 -6.6117e-02
    -9.1278e-02 -2.2732e-01 -6.2848e-01  3.7686e-01 -6.0958e-01  3.7723e-02
     1.3443e-01  5.8768e-01  1.0611e-01  1.0578e+00 -7.9843e-01  1.5644e-02
     5.1333e-01 -2.6829e-01  8.6280e-02 -4.8820e-01 -7.8925e-02  5.7910e-01
    -8.3873e-01  7.4992e-01 -4.7451e-01  5.3792e-01  2.5934e-01 -2.5577e-01
    -7.2746e-01  7.2324e-01 -3.5029e-01  2.3883e-01  2.2178e-01  2.3307e-01
    -2.4567e-01  2.3833e-01  6.6281e-01 -1.1956e-01 -2.3183e-02 -7.2004e-01
    -4.5729e-02  6.8426e-01  3.5203e-01  5.6147e-01 -6.6437e-01  4.0224e-01
    -3.9397e-01 -1.1179e-01  1.5747e-01 -1.4167e-03  1.0760e+00  6.7952e-01
    -3.5587e-01 -7.7132e-02  2.0712e+00  4.2989e-01 -3.2253e-01  1.9375e-02
     6.2629e-01  3.2018e-01  3.3936e-01 -9.2320e-02  2.8323e-01  1.4915e-01
     2.3714e-01  4.1720e-01 -1.6513e-01  1.8810e-01  7.0461e-01  2.5950e-01
    -1.0690e-01  9.0640e-01  2.2023e-01 -1.9887e-01]
dog: [ 5.0779e-01 -1.0274e+00  4.8136e-01 -9.4170e-02  4.4837e-01 -5.2291e-01
     5.1498e-01 -3.8927e-02  3.5867e-01 -6.5994e-02 -8.2882e-01  7.6179e-01
    -3.8030e+00 -1.0576e-02  2.1654e-01  5.9712e-01  3.7424e-01 -2.2629e-02
    -1.0331e-02 -3.3966e-01  9.4336e-02  2.6253e-01 -4.0161e-01 -7.9532e-03
     1.0206e+00 -3.5793e-01 -5.6500e-01  5.8815e-01 -8.1847e-01  3.0293e-01
     4.7199e-01 -9.7429e-02 -6.1226e-01 -1.7797e-01 -1.1616e-01  3.2586e-01
```

```
    1.1498e-01 -1.9030e-01  1.1591e-02  4.6478e-01 -1.6805e-01  2.1972e-01
   -2.5938e-01 -1.3541e-02  7.0714e-01  7.8106e-01  7.9917e-01  1.0389e+00
    5.2792e-01 -1.1160e-01 -6.2275e-01  3.0692e-02  3.3847e-01 -5.3092e-01
   -9.9688e-02  2.1596e-01  6.0522e-01  1.2356e+00 -3.4528e-03 -9.7514e-02
   -2.4938e-01  2.1539e-01  4.4643e-01  9.5375e-02 -2.7366e-01 -2.8537e-01
   -4.0894e-01  4.8223e-01  3.0318e-01  1.9440e-01  8.3242e-01 -5.0378e-01
    3.0090e-01 -4.9792e-01  5.0297e-01  3.2685e-02 -5.1790e-01 -2.3541e-01
    2.2960e-01 -6.3588e-01  1.6270e+00  6.2832e-01 -7.4846e-01  6.0073e-01
   -1.1215e-02 -3.2113e-01  1.4339e-01 -6.0809e-02  8.8218e-02  6.5936e-01
   -4.6127e-01 -3.7644e-01 -1.1330e-01  1.5875e-01  3.9119e-01  6.7659e-01
   -7.1224e-02  1.7458e-01 -3.3406e-02  7.3152e-01]
```

[57]:
```python
# create list of lists of lists for embeddings
embeddings = []
for doc in documents:
    embedding = []
    for word in doc:
        embedding.append(limited_index_to_embedding[limited_word_to_index[word]])
    embeddings.append(embedding)



# -----------------------------------------------------
# Check on the embeddings list of list of lists
# -----------------------------------------------------
# Show the first word in the first document
test_word = documents[0][0]
print('First word in first document:', test_word)
print('Embedding for this word:\n',
      limited_index_to_embedding[limited_word_to_index[test_word]])
print('Corresponding embedding from embeddings list of list of lists\n',
      embeddings[0][0][:])
```

```
First word in first document: while
Embedding for this word:
 [-4.7197e-02 -2.4357e-01  1.0880e-01 -5.6693e-01 -3.8555e-02  1.5236e-01
 -4.4097e-02 -3.5602e-02  2.5351e-01 -6.9209e-01 -5.5410e-04  1.8290e-03
 -5.1479e+00  3.6846e-01 -3.4871e-01 -9.0599e-02 -2.9809e-01 -1.1419e-01
 -8.5266e-01 -1.8206e-01 -7.7734e-01 -1.2525e-02  2.4790e-01 -4.6548e-04
  1.9668e-01  6.5513e-01 -4.8212e-01 -1.7646e-01  2.6732e-01  2.8195e-01
  4.1784e-01  2.3964e-02 -2.9772e-01  3.6287e-01 -7.5949e-03  1.8756e-01
 -8.4115e-02 -1.3346e-01  1.1355e-01  4.3278e-01 -7.8362e-02  1.9060e-01
  3.5403e-01  1.4928e-01  7.2068e-01 -3.5885e-01  1.1589e-01  5.2705e-01
 -4.1823e-01  2.0411e-01 -5.0177e-01 -2.2404e-01  5.5086e-01 -2.2030e-01
 -5.2023e-02  5.7555e-02 -1.8871e-01  3.0119e-02  6.2221e-01  1.0051e-01
  1.5656e-01 -2.9829e-02  2.8033e-01 -4.5078e-01  5.2535e-01 -8.6973e-03
  1.4169e-01  2.4950e-01  2.9821e-01  1.5145e-01 -1.7910e-01  1.4797e-01
  7.3218e-02 -8.1712e-01 -6.1936e-02  1.8336e-01 -1.0639e-01 -2.1006e-01
```

```
     1.4606e-01  2.3040e-01  1.2416e+00  8.3053e-02 -4.7140e-01  4.7603e-01
     1.3378e-01 -5.0239e-01  1.3375e-01  1.4129e-01  2.0460e-01  1.4739e-01
     5.0854e-01 -1.6517e-01 -3.5384e-01  2.1834e-02 -5.1504e-01  9.7128e-02
     1.3943e-01 -1.3130e-01  1.1166e-01  3.2966e-02]
 Corresponding embedding from embeddings list of list of lists
  [-4.7197e-02 -2.4357e-01  1.0880e-01 -5.6693e-01 -3.8555e-02  1.5236e-01
  -4.4097e-02 -3.5602e-02  2.5351e-01 -6.9209e-01 -5.5410e-04  1.8290e-03
  -5.1479e+00  3.6846e-01 -3.4871e-01 -9.0599e-02 -2.9809e-01 -1.1419e-01
  -8.5266e-01 -1.8206e-01 -7.7734e-01 -1.2525e-02  2.4790e-01 -4.6548e-04
   1.9668e-01  6.5513e-01 -4.8212e-01 -1.7646e-01  2.6732e-01  2.8195e-01
   4.1784e-01  2.3964e-02 -2.9772e-01  3.6287e-01 -7.5949e-03  1.8756e-01
  -8.4115e-02 -1.3346e-01  1.1355e-01  4.3278e-01 -7.8362e-02  1.9060e-01
   3.5403e-01  1.4928e-01  7.2068e-01 -3.5885e-01  1.1589e-01  5.2705e-01
  -4.1823e-01  2.0411e-01 -5.0177e-01 -2.2404e-01  5.5086e-01 -2.2030e-01
  -5.2023e-02  5.7555e-02 -1.8871e-01  3.0119e-02  6.2221e-01  1.0051e-01
   1.5656e-01 -2.9829e-02  2.8033e-01 -4.5078e-01  5.2535e-01 -8.6973e-03
   1.4169e-01  2.4950e-01  2.9821e-01  1.5145e-01 -1.7910e-01  1.4797e-01
   7.3218e-02 -8.1712e-01 -6.1936e-02  1.8336e-01 -1.0639e-01 -2.1006e-01
   1.4606e-01  2.3040e-01  1.2416e+00  8.3053e-02 -4.7140e-01  4.7603e-01
   1.3378e-01 -5.0239e-01  1.3375e-01  1.4129e-01  2.0460e-01  1.4739e-01
   5.0854e-01 -1.6517e-01 -3.5384e-01  2.1834e-02 -5.1504e-01  9.7128e-02
   1.3943e-01 -1.3130e-01  1.1166e-01  3.2966e-02]
```

```python
[58]: RANDOM_SEED = 9999

      # To make output stable across runs
      def reset_graph(seed= RANDOM_SEED):
          tf.reset_default_graph()
          tf.set_random_seed(seed)
          np.random.seed(seed)

      reset_graph()


      # Random splitting of the data in to training (80%) and test (20%)
      X_train, X_test, y_train, y_test = \
          train_test_split(embeddings_array, thumbs_down_up, test_size=0.20,
                           random_state = RANDOM_SEED)

      n_steps = embeddings_array.shape[1]   # number of words per document
      n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
      n_neurons = 20   # analyst specified number of neurons
      n_outputs = 2   # thumbs-down or thumbs-up


      learning_rate = 0.01


      X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
```

```python
y = tf.placeholder(tf.int32, [None])

#basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons) #original code
#lstm_cell = tf.contrib.rnn.BasicLSTMCell(num_units=n_neurons) # received error
gru_cell = tf.contrib.rnn.GRUCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(gru_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train7 = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test7 = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train7, 'Test accuracy:', acc_test7)
```

```
WARNING:tensorflow:From <ipython-input-58-151934fbe315>:29: GRUCell.__init__
(from tensorflow.python.ops.rnn_cell_impl) is deprecated and will be removed in
a future version.
Instructions for updating:
This class is equivalent as tf.keras.layers.GRUCell, and will be replaced by
that in Tensorflow 2.0.

  ---- Epoch  0  ----

  Batch  0  training observations from  0  to  99
  Batch  1  training observations from  100  to  199
  Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.64 Test accuracy: 0.535


---- Epoch  1  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.61 Test accuracy: 0.63


---- Epoch  2  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.74 Test accuracy: 0.72


---- Epoch  3  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.78 Test accuracy: 0.75


---- Epoch  4  ----
```

```
Batch  0  training observations from  0  to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.84 Test accuracy: 0.785


---- Epoch  5  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.88 Test accuracy: 0.78


---- Epoch  6  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.91 Test accuracy: 0.79


---- Epoch  7  ----


Batch  0  training observations from  0  to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799
```

```
Train accuracy: 0.96 Test accuracy: 0.785


---- Epoch  8  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.96 Test accuracy: 0.785


---- Epoch  9  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.98 Test accuracy: 0.77


---- Epoch  10  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.99 Test accuracy: 0.75


---- Epoch  11  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.78


---- Epoch  12  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.94 Test accuracy: 0.735


---- Epoch  13  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.76


---- Epoch  14  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.665


---- Epoch  15  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.95 Test accuracy: 0.75


---- Epoch   16   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.98 Test accuracy: 0.74


---- Epoch   17   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch   18   ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  19  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.745


---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.745


---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.735


---- Epoch  23  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.735


---- Epoch  24  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.735


---- Epoch  25  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.745


---- Epoch  26  ----


Batch  0   training observations from  0   to   99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.745


---- Epoch  27  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.745


---- Epoch  28  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74
```

```
---- Epoch  30  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  31  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  32  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  33  ----

Batch  0  training observations from  0   to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  34  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  35  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  36  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  37  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  38  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  40  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74
```

```
---- Epoch  41  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.735


---- Epoch  42  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  43  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  44  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  45  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.74


---- Epoch  49  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.74
```

```python
[59]: RANDOM_SEED = 1234

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.01

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

#basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons) #original code
#lstm_cell = tf.contrib.rnn.BasicLSTMCell(num_units=n_neurons) # received error
gru_cell = tf.contrib.rnn.GRUCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(gru_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
```

```python
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                          logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train7b = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test7b = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train7b, 'Test accuracy:', acc_test7b)
```

```
 ---- Epoch  0  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
 Batch  4  training observations from  400  to  499
 Batch  5  training observations from  500  to  599
 Batch  6  training observations from  600  to  699
 Batch  7  training observations from  700  to  799

 Train accuracy: 0.66 Test accuracy: 0.58

 ---- Epoch  1  ----

 Batch  0  training observations from  0  to  99
 Batch  1  training observations from  100  to  199
 Batch  2  training observations from  200  to  299
 Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.68 Test accuracy: 0.625


---- Epoch  2  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.77 Test accuracy: 0.685


---- Epoch  3  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.81 Test accuracy: 0.73


---- Epoch  4  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.84 Test accuracy: 0.755


---- Epoch  5  ----
```

```
Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.91 Test accuracy: 0.755


---- Epoch  6  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.93 Test accuracy: 0.745


---- Epoch  7  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.97 Test accuracy: 0.745


---- Epoch  8  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799
```

```
Train accuracy: 0.97 Test accuracy: 0.715


---- Epoch  9  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.93 Test accuracy: 0.715


---- Epoch  10  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  11  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.735


---- Epoch  12  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.72


---- Epoch  13  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  14  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.98 Test accuracy: 0.71


---- Epoch  15  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.96 Test accuracy: 0.71


---- Epoch  16  ----

Batch  0  training observations from  0  to  99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.99 Test accuracy: 0.71


---- Epoch  17  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.97 Test accuracy: 0.69


---- Epoch  18  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.72


---- Epoch  19  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.71
```

```
---- Epoch  20  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.735


---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.715


---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
```

```
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  24  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.72


---- Epoch  25  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.715


---- Epoch  26  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.72


---- Epoch  27  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  28  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.735


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.735
```

```
---- Epoch  31  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  32  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  33  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  34  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  35  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  37  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.73


---- Epoch  38  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  39  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  40  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  41  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  42  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  43  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  44  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  45  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  46  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.725


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.73
```

[60]:
```python
RANDOM_SEED = 42

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]  # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.01

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

#basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=n_neurons) #original code
#lstm_cell = tf.contrib.rnn.BasicLSTMCell(num_units=n_neurons) # received error
gru_cell = tf.contrib.rnn.GRUCell(num_units=n_neurons)
outputs, states = tf.nn.dynamic_rnn(gru_cell, X, dtype=tf.float32)

logits = tf.layers.dense(states, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
                                                logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

init = tf.global_variables_initializer()

n_epochs = 50
batch_size = 100

with tf.Session() as sess:
```

```
    init.run()
    for epoch in range(n_epochs):
        print('\n  ---- Epoch ', epoch, ' ----\n')
        for iteration in range(y_train.shape[0] // batch_size):
            X_batch = X_train[iteration*batch_size:(iteration + 1)*batch_size,:]
            y_batch = y_train[iteration*batch_size:(iteration + 1)*batch_size]
            print('  Batch ', iteration, ' training observations from ',
                    iteration*batch_size, ' to ', (iteration + 1)*batch_size-1,)
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_train7c = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test7c = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print('\n  Train accuracy:', acc_train7c, 'Test accuracy:', acc_test7c)
```

```
---- Epoch  0  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.56 Test accuracy: 0.56

---- Epoch  1  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 0.64 Test accuracy: 0.61

---- Epoch  2  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
```

```
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.76 Test accuracy: 0.67


---- Epoch  3  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.79 Test accuracy: 0.71


---- Epoch  4  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.87 Test accuracy: 0.745


---- Epoch  5  ----

Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 0.91 Test accuracy: 0.77


---- Epoch  6  ----

Batch  0   training observations from   0   to   99
```

```
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.92 Test accuracy: 0.78


----  Epoch  7  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.94 Test accuracy: 0.795


----  Epoch  8  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.96 Test accuracy: 0.79


----  Epoch  9  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 0.99 Test accuracy: 0.755
```

```
---- Epoch   10   ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.77


---- Epoch   11   ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 0.98 Test accuracy: 0.735


---- Epoch   12   ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
Batch  6  training observations from  600   to   699
Batch  7  training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.76


---- Epoch   13   ----

Batch  0  training observations from   0  to   99
Batch  1  training observations from  100   to   199
Batch  2  training observations from  200   to   299
Batch  3  training observations from  300   to   399
Batch  4  training observations from  400   to   499
Batch  5  training observations from  500   to   599
```

```
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 0.96 Test accuracy: 0.725


---- Epoch  14  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.78


---- Epoch  15  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.785


---- Epoch  16  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
Batch  2   training observations from  200   to   299
Batch  3   training observations from  300   to   399
Batch  4   training observations from  400   to   499
Batch  5   training observations from  500   to   599
Batch  6   training observations from  600   to   699
Batch  7   training observations from  700   to   799


Train accuracy: 1.0 Test accuracy: 0.77


---- Epoch  17  ----


Batch  0   training observations from  0   to   99
Batch  1   training observations from  100   to   199
```

```
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.75


---- Epoch  18  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.745


---- Epoch  19  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.75


---- Epoch  20  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755
```

```
---- Epoch  21  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.75


---- Epoch  22  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  23  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.75


---- Epoch  24  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
```

```
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  25  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  26  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  27  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799

Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  28  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
```

```
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  29  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  30  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  31  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  32  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.76


---- Epoch  33  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  34  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  35  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  36  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  37  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  38  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.76


---- Epoch  39  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
```

```
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 1.0 Test accuracy: 0.76


---- Epoch  40  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  41  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 1.0 Test accuracy: 0.75


---- Epoch  42  ----


Batch  0   training observations from   0   to   99
Batch  1   training observations from   100   to   199
Batch  2   training observations from   200   to   299
Batch  3   training observations from   300   to   399
Batch  4   training observations from   400   to   499
Batch  5   training observations from   500   to   599
Batch  6   training observations from   600   to   699
Batch  7   training observations from   700   to   799


Train accuracy: 1.0 Test accuracy: 0.75


---- Epoch  43  ----
```

```
Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  44  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  45  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  46  ----


Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799
```

```
Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  47  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  48  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755


---- Epoch  49  ----

Batch  0  training observations from  0  to  99
Batch  1  training observations from  100  to  199
Batch  2  training observations from  200  to  299
Batch  3  training observations from  300  to  399
Batch  4  training observations from  400  to  499
Batch  5  training observations from  500  to  599
Batch  6  training observations from  600  to  699
Batch  7  training observations from  700  to  799


Train accuracy: 1.0 Test accuracy: 0.755
```

0.9 Multilayer RNN: modified from Geron, GloVe.Twitter, 100 dimensions, vocabulary size 10,000

```python
[61]: # --------------------------------------------------------------
      # Select the pre-defined embeddings source
      # Define vocabulary size for the language model
      # Create a word_to_embedding_dict for GloVe.6B.50d
      embeddings_directory = 'embeddings/glove.twitter.27B'
      filename3 = 'glove.twitter.27B.100d.txt'
      embeddings_filename = os.path.join(embeddings_directory, filename3)
      # --------------------------------------------------------------


      print('\nLoading embeddings from', embeddings_filename)
      word_to_index, index_to_embedding = \
          load_embedding_from_disks(embeddings_filename, with_indexes=True)
      print("Embedding loaded from disks.")

      # Additional background code from
      # https://github.com/guillaume-chevalier/GloVe-as-a-TensorFlow-Embedding-Layer
      # shows the general structure of the data structures for word embeddings
      # This code is modified for our purposes in language modeling
      vocab_size, embedding_dim = index_to_embedding.shape
      print("Embedding is of shape: {}".format(index_to_embedding.shape))
      print("This means (number of words, number of dimensions per word)\n")
      print("The first words are words that tend occur more often.")



      REMOVE_STOPWORDS = False   # no stopword removal


      EVOCABSIZE = 10000   # specify desired size of pre-defined embedding vocabulary


      def default_factory():
          return EVOCABSIZE  # last/unknown-word row in limited_index_to_embedding
      # dictionary has the items() function, returns list of (key, value) tuples
      limited_word_to_index = defaultdict(default_factory, \
          {k: v for k, v in word_to_index.items() if v < EVOCABSIZE})

      # Select the first EVOCABSIZE rows to the index_to_embedding
      limited_index_to_embedding = index_to_embedding[0:EVOCABSIZE,:]
      # Set the unknown-word row to be all zeros as previously
      limited_index_to_embedding = np.append(limited_index_to_embedding,
          index_to_embedding[index_to_embedding.shape[0] - 1, :].\
              reshape(1,embedding_dim),
          axis = 0)
```

```python
# Delete large numpy array to clear some CPU RAM
del index_to_embedding

# create list of lists of lists for embeddings
embeddings = []
for doc in documents:
    embedding = []
    for word in doc:
        embedding.append(limited_index_to_embedding[limited_word_to_index[word]])
    embeddings.append(embedding)
```

Loading embeddings from embeddings/glove.twitter.27B/glove.twitter.27B.100d.txt
Embedding loaded from disks.
Embedding is of shape: (1193515, 100)
This means (number of words, number of dimensions per word)

The first words are words that tend occur more often.

[62]:
```python
#modified code from
#https://github.com/ageron/handson-ml/blob/master/14_recurrent_neural_networks.
 ↪ipynb

RANDOM_SEED = 9999

from keras.layers import SimpleRNNCell, StackedRNNCells, RNN

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

# Random splitting of the data in to training (80%) and test (20%)
X_train, X_test, y_train, y_test = \
    train_test_split(embeddings_array, thumbs_down_up, test_size=0.20,
                     random_state = RANDOM_SEED)


reset_graph()

n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.1
```

```python
X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

n_neurons = 128
n_layers = 2

layers = [tf.keras.layers.SimpleRNNCell(units=2, dropout=0.2)
          for layer in range(n_layers)]
multi_layer_cell = tf.keras.layers.StackedRNNCells(layers)
outputs, states = tf.nn.dynamic_rnn(multi_layer_cell, X, dtype=tf.float32)
```

Using TensorFlow backend.

WARNING:tensorflow:From /Users/jmwanat/anaconda3/envs/tf/lib/python3.7/site-packages/tensorflow/python/keras/backend.py:4010: calling dropout (from tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.

[63]:
```python
states_concat = tf.concat(axis=1, values=states)
logits = tf.layers.dense(states_concat, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
    logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

def shuffle_batch(X, y, batch_size):
    rnd_idx = np.random.permutation(len(X))
    n_batches = len(X) // batch_size
    for batch_idx in np.array_split(rnd_idx, n_batches):
        X_batch, y_batch = X[batch_idx], y[batch_idx]
        yield X_batch, y_batch
```

[64]:
```python
n_epochs = 20
batch_size = 100

init = tf.global_variables_initializer()

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
```

```
        for X_batch, y_batch in shuffle_batch(X_train, y_train, batch_size):
            X_batch = X_batch.reshape((-1, n_steps, n_inputs))
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_batch8 = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test8 = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print(epoch, "Last batch accuracy:", acc_batch8, "Test accuracy:",␣
↪acc_test8)
```

```
0 Last batch accuracy: 0.51 Test accuracy: 0.45
1 Last batch accuracy: 0.5 Test accuracy: 0.485
2 Last batch accuracy: 0.58 Test accuracy: 0.495
3 Last batch accuracy: 0.52 Test accuracy: 0.53
4 Last batch accuracy: 0.58 Test accuracy: 0.51
5 Last batch accuracy: 0.5 Test accuracy: 0.555
6 Last batch accuracy: 0.63 Test accuracy: 0.485
7 Last batch accuracy: 0.57 Test accuracy: 0.53
8 Last batch accuracy: 0.63 Test accuracy: 0.54
9 Last batch accuracy: 0.66 Test accuracy: 0.535
10 Last batch accuracy: 0.56 Test accuracy: 0.55
11 Last batch accuracy: 0.6 Test accuracy: 0.555
12 Last batch accuracy: 0.61 Test accuracy: 0.57
13 Last batch accuracy: 0.55 Test accuracy: 0.525
14 Last batch accuracy: 0.57 Test accuracy: 0.525
15 Last batch accuracy: 0.65 Test accuracy: 0.55
16 Last batch accuracy: 0.63 Test accuracy: 0.535
17 Last batch accuracy: 0.65 Test accuracy: 0.575
18 Last batch accuracy: 0.63 Test accuracy: 0.555
19 Last batch accuracy: 0.61 Test accuracy: 0.555
```

```python
[65]: RANDOM_SEED = 1234

      # To make output stable across runs
      def reset_graph(seed= RANDOM_SEED):
          tf.reset_default_graph()
          tf.set_random_seed(seed)
          np.random.seed(seed)

      reset_graph()


      n_steps = embeddings_array.shape[1]   # number of words per document
      n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
      n_neurons = 20   # analyst specified number of neurons
      n_outputs = 2   # thumbs-down or thumbs-up

      learning_rate = 0.1
```

```python
X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

n_neurons = 128
n_layers = 2

layers = [tf.keras.layers.SimpleRNNCell(units=2, dropout=0.2)
          for layer in range(n_layers)]
multi_layer_cell = tf.keras.layers.StackedRNNCells(layers)
outputs, states = tf.nn.dynamic_rnn(multi_layer_cell, X, dtype=tf.float32)

states_concat = tf.concat(axis=1, values=states)
logits = tf.layers.dense(states_concat, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,␣
 ↪logits=logits)
loss = tf.reduce_mean(xentropy)
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))

n_epochs = 20
batch_size = 100

init = tf.global_variables_initializer()

with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        for X_batch, y_batch in shuffle_batch(X_train, y_train, batch_size):
            X_batch = X_batch.reshape((-1, n_steps, n_inputs))
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_batch8b = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test8b = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print(epoch, "Last batch accuracy:", acc_batch8b, "Test accuracy:",␣
 ↪acc_test8b)
```

```
0 Last batch accuracy: 0.53 Test accuracy: 0.53
1 Last batch accuracy: 0.56 Test accuracy: 0.565
2 Last batch accuracy: 0.54 Test accuracy: 0.485
3 Last batch accuracy: 0.58 Test accuracy: 0.545
4 Last batch accuracy: 0.69 Test accuracy: 0.55
5 Last batch accuracy: 0.54 Test accuracy: 0.495
6 Last batch accuracy: 0.69 Test accuracy: 0.525
7 Last batch accuracy: 0.69 Test accuracy: 0.55
```

```
8 Last batch accuracy: 0.61 Test accuracy: 0.53
9 Last batch accuracy: 0.62 Test accuracy: 0.495
10 Last batch accuracy: 0.64 Test accuracy: 0.505
11 Last batch accuracy: 0.65 Test accuracy: 0.525
12 Last batch accuracy: 0.66 Test accuracy: 0.525
13 Last batch accuracy: 0.61 Test accuracy: 0.565
14 Last batch accuracy: 0.72 Test accuracy: 0.54
15 Last batch accuracy: 0.6 Test accuracy: 0.575
16 Last batch accuracy: 0.65 Test accuracy: 0.545
17 Last batch accuracy: 0.61 Test accuracy: 0.57
18 Last batch accuracy: 0.71 Test accuracy: 0.585
19 Last batch accuracy: 0.56 Test accuracy: 0.55
```

[66]:
```python
RANDOM_SEED = 42

# To make output stable across runs
def reset_graph(seed= RANDOM_SEED):
    tf.reset_default_graph()
    tf.set_random_seed(seed)
    np.random.seed(seed)

reset_graph()


n_steps = embeddings_array.shape[1]   # number of words per document
n_inputs = embeddings_array.shape[2]   # dimension of  pre-trained embeddings
n_neurons = 20   # analyst specified number of neurons
n_outputs = 2   # thumbs-down or thumbs-up

learning_rate = 0.1

X = tf.placeholder(tf.float32, [None, n_steps, n_inputs])
y = tf.placeholder(tf.int32, [None])

n_neurons = 128
n_layers = 2

layers = [tf.keras.layers.SimpleRNNCell(units=2, dropout=0.2)
          for layer in range(n_layers)]
multi_layer_cell = tf.keras.layers.StackedRNNCells(layers)
outputs, states = tf.nn.dynamic_rnn(multi_layer_cell, X, dtype=tf.float32)

states_concat = tf.concat(axis=1, values=states)
logits = tf.layers.dense(states_concat, n_outputs)
xentropy = tf.nn.sparse_softmax_cross_entropy_with_logits(labels=y,
  →logits=logits)
loss = tf.reduce_mean(xentropy)
```

```python
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
training_op = optimizer.minimize(loss)
correct = tf.nn.in_top_k(logits, y, 1)
accuracy = tf.reduce_mean(tf.cast(correct, tf.float32))


n_epochs = 20
batch_size = 100


init = tf.global_variables_initializer()


with tf.Session() as sess:
    init.run()
    for epoch in range(n_epochs):
        for X_batch, y_batch in shuffle_batch(X_train, y_train, batch_size):
            X_batch = X_batch.reshape((-1, n_steps, n_inputs))
            sess.run(training_op, feed_dict={X: X_batch, y: y_batch})
        acc_batch8c = accuracy.eval(feed_dict={X: X_batch, y: y_batch})
        acc_test8c = accuracy.eval(feed_dict={X: X_test, y: y_test})
        print(epoch, "Last batch accuracy:", acc_batch8c, "Test accuracy:",
 ↪acc_test8c)
```

```
0 Last batch accuracy: 0.55 Test accuracy: 0.525
1 Last batch accuracy: 0.61 Test accuracy: 0.47
2 Last batch accuracy: 0.62 Test accuracy: 0.52
3 Last batch accuracy: 0.54 Test accuracy: 0.535
4 Last batch accuracy: 0.55 Test accuracy: 0.47
5 Last batch accuracy: 0.67 Test accuracy: 0.545
6 Last batch accuracy: 0.51 Test accuracy: 0.475
7 Last batch accuracy: 0.55 Test accuracy: 0.48
8 Last batch accuracy: 0.52 Test accuracy: 0.55
9 Last batch accuracy: 0.6 Test accuracy: 0.545
10 Last batch accuracy: 0.5 Test accuracy: 0.48
11 Last batch accuracy: 0.59 Test accuracy: 0.55
12 Last batch accuracy: 0.5 Test accuracy: 0.535
13 Last batch accuracy: 0.66 Test accuracy: 0.545
14 Last batch accuracy: 0.61 Test accuracy: 0.55
15 Last batch accuracy: 0.59 Test accuracy: 0.535
16 Last batch accuracy: 0.62 Test accuracy: 0.535
17 Last batch accuracy: 0.56 Test accuracy: 0.53
18 Last batch accuracy: 0.66 Test accuracy: 0.545
19 Last batch accuracy: 0.59 Test accuracy: 0.555
```

0.10 Summary of extra models

```python
[67]: test_avg7 = (acc_test7 + acc_test7b + acc_test7c) / 3
      test_avg8 = (acc_test8 + acc_test8b + acc_test8c) / 3

      summary_extra_models = {
          'Model' : ['GRU cell', 'Multilayer RNN'],
          'Name' : ['GloVe.Twitter', 'GloVe.Twitter'],
          'Number of Dimensions' : [100, 100],
          'Vocab Size' : ['100K', '10K'],
          'Test Accuracy' : [round(acc_test7, 3), round(acc_test8, 3)],
          'Test Accuracy #2' : [round(acc_test7b, 3), round(acc_test8b, 3)],
          'Test Accuracy #3' : [round(acc_test7c, 3), round(acc_test8c, 3)],
          'Test Accuracy Average' : [round(test_avg7, 3), round(test_avg8, 3)]
      }

      summary_extra_models_df = pd.DataFrame(summary_extra_models)
      summary_extra_models_df
```

```
[67]:               Model            Name  Number of Dimensions Vocab Size  \
      0          GRU cell  GloVe.Twitter                   100       100K
      1  Multilayer RNN  GloVe.Twitter                   100        10K

         Test Accuracy  Test Accuracy #2  Test Accuracy #3  Test Accuracy Average
      0          0.740              0.73             0.755                  0.742
      1          0.555              0.55             0.555                  0.553
```

```python
[ ]:
```