# 04_Neural_Net_Keras

September 18, 2021

## 1 Category Prediction on BBC-news data

[1]:
```
import numpy as np
import pandas as pd
import pylab as plt
import seaborn as sns

import json, re
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer

from sklearn.model_selection import train_test_split
from helper import plot_history, calc_prediction, process_text

from sklearn.metrics import accuracy_score, confusion_matrix, f1_score,␣
↪roc_auc_score
from sklearn.metrics import average_precision_score, recall_score

data_dir = './'
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     /Users/gshyam/nltk_data…
[nltk_data]   Package stopwords is already up-to-date!
```

[2]:
```
import json

with open(data_dir+"label_dict.json", 'r') as fp:
    label_dict = json.load(fp)

with open(data_dir+"label_dict_reversed.json", 'r') as fp:
    label_dict_reversed = json.load(fp)

print (label_dict, label_dict_reversed)

df = pd.read_csv(data_dir+'bbc_text_processed.csv')
print ('data.shape:',df.shape)
df.head(2)
```

```
{'tech': 0, 'business': 1, 'sport': 2, 'entertainment': 3, 'politics': 4} {'0':
'tech', '1': 'business', '2': 'sport', '3': 'entertainment', '4': 'politics'}
data.shape: (2225, 5)
```

[2]:
```
    category                                               text  label  \
0       tech  tv future in the hands of viewers with home th…      0
1   business  worldcom boss  left books alone  former worldc…      1

                                      text_processed  text_len
0  tv futur hand viewer home theatr system plasma…       407
1  worldcom boss left book alon former worldcom b…       186
```

[3]:
```
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.utils import to_categorical


MAX_SEQ_LEN = 2000 # length of each text
MAX_WORDS   = 1000 # use only this many max used words

def prepare_inputs(df, column, text_to_matrix=False):
    X_train_, X_test, y_train_, y_test = train_test_split(df[column].values,
                                                          df['label'].values,
                                                          test_size=0.2)
    X_train,  X_val, y_train, y_val = train_test_split(X_train_,
                                                       y_train_,
                                                       test_size=0.25)

    tokenizer = Tokenizer(num_words=MAX_WORDS)
    tokenizer.fit_on_texts(X_train)

    if text_to_matrix:
        X_train = tokenizer.texts_to_matrix(X_train)
        X_val   = tokenizer.texts_to_matrix(X_val)
        X_test  = tokenizer.texts_to_matrix(X_test)
    else:
        X_train = tokenizer.texts_to_sequences(X_train)
        X_val   = tokenizer.texts_to_sequences(X_val)
        X_test  = tokenizer.texts_to_sequences(X_test)

        X_train = pad_sequences(X_train, maxlen=MAX_SEQ_LEN,
                                padding='post', truncating='post')
        X_val   = pad_sequences(X_val,   maxlen=MAX_SEQ_LEN,
                                padding='post', truncating='post')
        X_test  = pad_sequences(X_test,  maxlen=MAX_SEQ_LEN,
                                padding='post', truncating='post')
```

```
    y_train = to_categorical(y_train)
    y_val   = to_categorical(y_val)
    y_test  = to_categorical(y_test)

    print (f"X_train.shape: {X_train.shape} y_train.shape:{y_train.shape}" )
    print (f"X_test.shape: {X_test.shape} y_test.shape:{y_test.shape}" )
    print (f"X_val.shape: {X_val.shape} y_val.shape:{y_val.shape}" )

    return (X_train, X_val, X_test, y_train, y_val, y_test, tokenizer)
```

[4]:
```
(X_train_m, X_val_m, X_test_m, y_train_m,
 y_val_m, y_test_m, tokenizer_m) = prepare_inputs(df,
                                                  "text_processed",
                                                  text_to_matrix=True)
```

```
X_train.shape: (1335, 1000) y_train.shape:(1335, 5)
X_test.shape: (445, 1000) y_test.shape:(445, 5)
X_val.shape: (445, 1000) y_val.shape:(445, 5)
```

[5]:
```
(X_train_s, X_val_s, X_test_s, y_train_s,
 y_val_s, y_test_s, tokenizer) = prepare_inputs(df,
                                                  "text_processed",
                                                  text_to_matrix=False)
```

```
X_train.shape: (1335, 2000) y_train.shape:(1335, 5)
X_test.shape: (445, 2000) y_test.shape:(445, 5)
X_val.shape: (445, 2000) y_val.shape:(445, 5)
```

## 2 Models: Dense Layers, LSTM layers

[6]:
```
from keras.models import Sequential
from keras.optimizers import Adam
from keras.layers import Dense, Dropout, Flatten, LSTM, Bidirectional
from keras.layers import Conv1D, MaxPooling1D, GlobalMaxPool1D,␣
 ↪BatchNormalization
from keras.layers.embeddings import Embedding
```

[7]:
```
def make_model_dense(X_train, y_train):
    model = Sequential()
    model.add(Dense(16, input_shape=(X_train.shape[1],), activation='relu'))
    #model.add(Dropout(0.5))
    model.add(Dense(y_train.shape[1], activation='softmax'))
    opt = Adam(learning_rate=0.001)
    model.compile(loss='categorical_crossentropy', optimizer=opt,␣
 ↪metrics=['accuracy'])
    return model
```

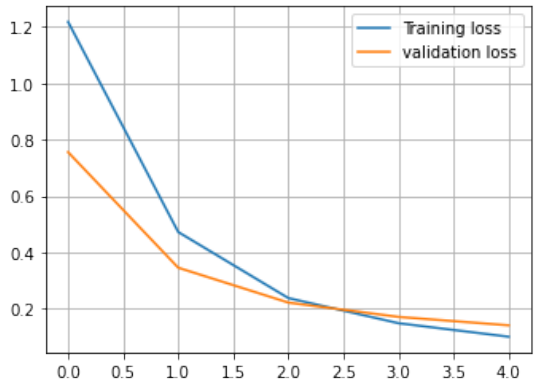
```
def make_model_lstm(X_train, y_train, embedding_length = 16):
    model = Sequential()
    model.add(Embedding(MAX_WORDS, embedding_length,␣
 ↪input_length=2000))#input_length=X_train.shape[1]))
    model.add(LSTM(16, activation='relu'))#, return_sequences=True))
    model.add(Dropout(0.2))
    model.add(BatchNormalization())
    model.add(Flatten())
    model.add(Dense(y_train.shape[1], activation='softmax'))
    model.compile(loss='categorical_crossentropy', optimizer='adam',␣
 ↪metrics=['accuracy'])
    return model
```

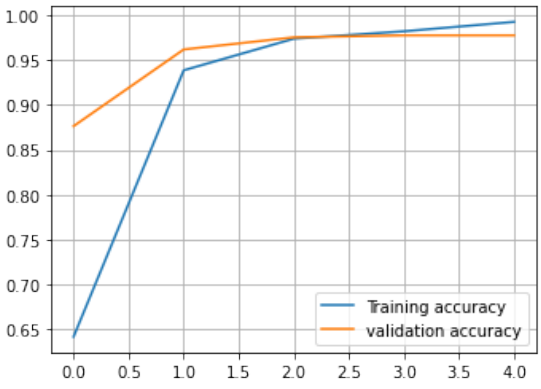
[8]:
```
model_dense_m = make_model_dense(X_train_m, y_train_m)
model_dense_m.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 16)                16016
_________________________________________________________________
dense_1 (Dense)              (None, 5)                 85
=================================================================
Total params: 16,101
Trainable params: 16,101
Non-trainable params: 0
_________________________________________________________________
```

[9]:
```
history_dense_m = model_dense_m.fit(X_train_m, y_train_m,
                                    validation_data=(X_val_m, y_val_m),
                                    epochs=5, batch_size=32, verbose=0)

plot_history(history_dense_m)
```



[ ]:

[10]:
```
# model_dense_s = make_model_dense(X_train_s, y_train_s)
# model_dense_s.summary()

# history_dense_s = model_dense_m.fit(X_train_s, y_train_s,
#                                     validation_data=(X_val_s, y_val_s),
#                                     epochs=5, batch_size=32, verbose=1)

# plot_history(history_dense_s)
```

[ ]:

## 3 Model: LSTM+Dense

[11]:
```
def make_model(X, y, embedding_length = 16):
    model = Sequential()
    model.add(Embedding(MAX_WORDS, embedding_length, input_length=X.shape[1]))
    model.add(LSTM(16, activation='relu'))#, return_sequences=True))
    model.add(Dropout(0.2))
    model.add(BatchNormalization())
    model.add(Flatten())
    model.add(Dense(y.shape[1], activation='softmax'))
    model.compile(loss='categorical_crossentropy', optimizer='adam',␣
 ↪metrics=['accuracy'])
    return model

model2 = make_model(X_train_s, y_train_s)
model2.summary()
```

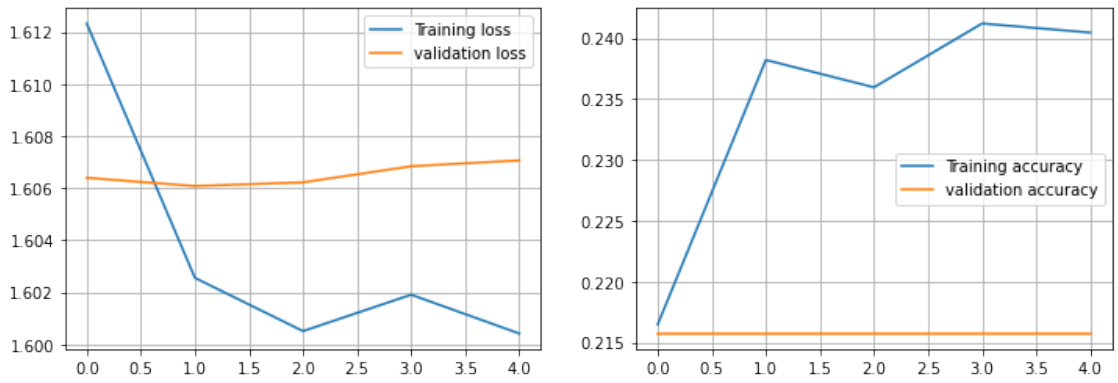
```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding (Embedding)        (None, 2000, 16)          16000
_________________________________________________________________
lstm (LSTM)                  (None, 16)                2112
_________________________________________________________________
dropout (Dropout)            (None, 16)                0
_________________________________________________________________
batch_normalization (BatchNo (None, 16)                64
_________________________________________________________________
flatten (Flatten)            (None, 16)                0
_________________________________________________________________
```

```
dense_2 (Dense)              (None, 5)                 85
=================================================================
Total params: 18,261
Trainable params: 18,229
Non-trainable params: 32
_________________________________________________________________
```

[12]:
```
history2 = model2.fit(X_train_s, y_train_s,
                      validation_data=(X_val_s, y_val_s),
                      epochs=5,
                      batch_size=16,
                      verbose=1)
```

```
Epoch 1/5
84/84 [==============================] - 59s 698ms/step - loss: 1.6123 -
accuracy: 0.2165 - val_loss: 1.6064 - val_accuracy: 0.2157
Epoch 2/5
84/84 [==============================] - 50s 597ms/step - loss: 1.6025 -
accuracy: 0.2382 - val_loss: 1.6061 - val_accuracy: 0.2157
Epoch 3/5
84/84 [==============================] - 51s 601ms/step - loss: 1.6005 -
accuracy: 0.2360 - val_loss: 1.6062 - val_accuracy: 0.2157
Epoch 4/5
84/84 [==============================] - 50s 601ms/step - loss: 1.6019 -
accuracy: 0.2412 - val_loss: 1.6068 - val_accuracy: 0.2157
Epoch 5/5
84/84 [==============================] - 46s 549ms/step - loss: 1.6004 -
accuracy: 0.2404 - val_loss: 1.6071 - val_accuracy: 0.2157
```

[13]:
```
plot_history(history2)
```




Not extirely sure why LSTM performs so poorly for this dataset (only 20% validation accuracy). I should understand LSTM better, I guess.

Anyway, let's continue with model1 for prediction on test data.

### 3.1 Prediction

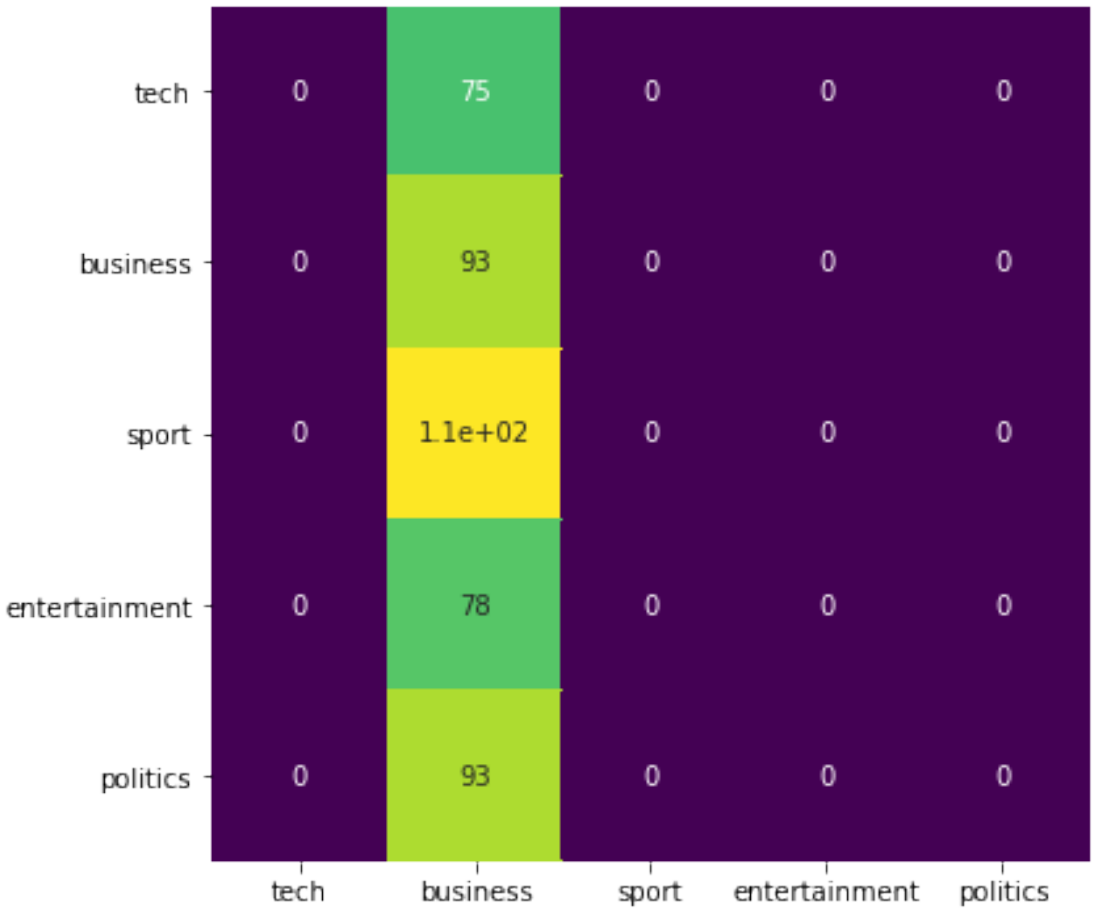
[14]:
```
calc_prediction(model2, X_test_s, y_test_s, categorical=True, ax=None)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.00      0.00      0.00        75
           1       0.21      1.00      0.35        93
           2       0.00      0.00      0.00       106
           3       0.00      0.00      0.00        78
           4       0.00      0.00      0.00        93

    accuracy                           0.21       445
   macro avg       0.04      0.20      0.07       445
weighted avg       0.04      0.21      0.07       445


/usr/local/lib/python3.8/site-packages/sklearn/metrics/_classification.py:1221:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

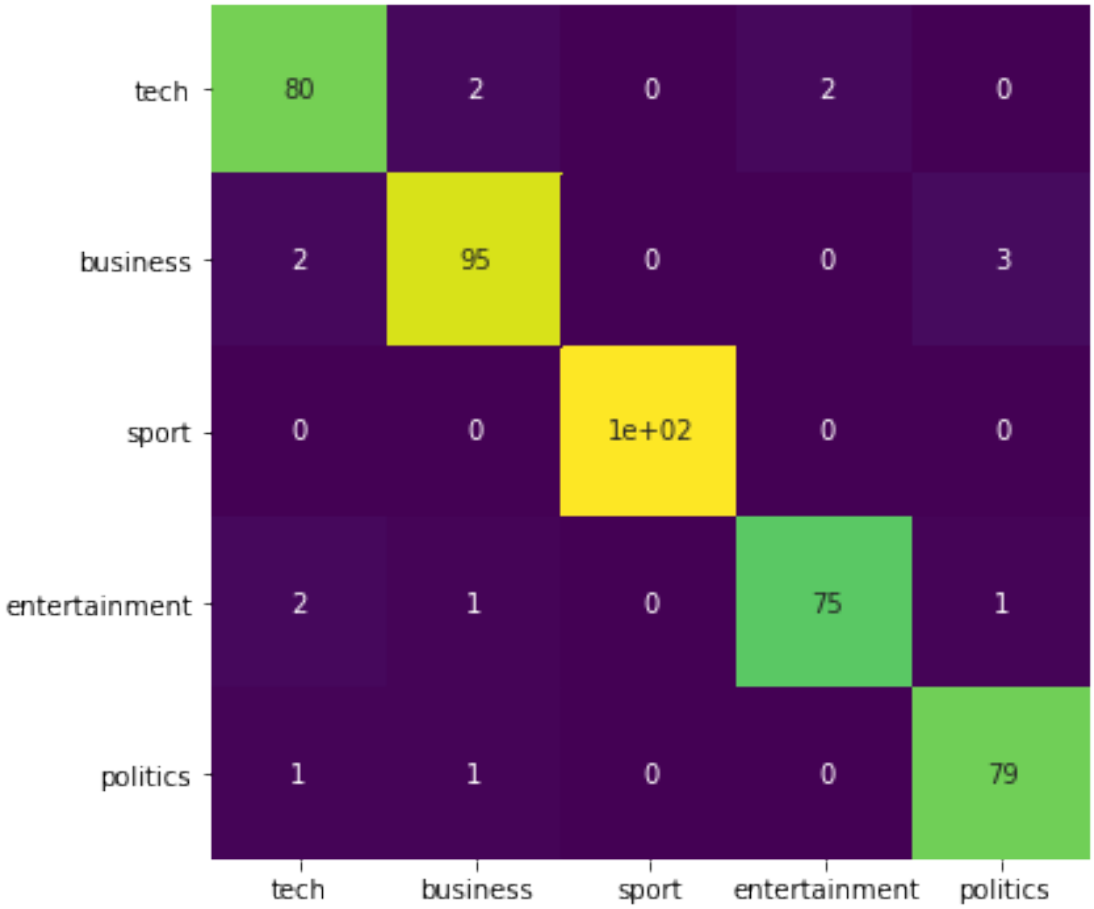



[15]:
```
calc_prediction(model_dense_m, X_test_m, y_test_m, categorical=True, ax=None)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.94      0.95      0.95        84
           1       0.96      0.95      0.95       100
           2       1.00      1.00      1.00       101
           3       0.97      0.95      0.96        79
           4       0.95      0.98      0.96        81

    accuracy                           0.97       445
   macro avg       0.97      0.97      0.97       445
weighted avg       0.97      0.97      0.97       445
```




### 3.2 Save the Model, tokenizer and configs

[16]:
```
import pickle
import json

model_dense_m.save('model_dense')

with open('tokenizer.pkl', 'wb') as fp:
    pickle.dump(tokenizer, fp)

with open('label_dict.json', 'w') as fp:
    json.dump(label_dict, fp, indent = 4)
```

```
WARNING:tensorflow:From /usr/local/lib/python3.8/site-
packages/tensorflow/python/training/tracking/tracking.py:111:
Model.state_updates (from tensorflow.python.keras.engine.training) is deprecated
and will be removed in a future version.
Instructions for updating:
```

```
This property should not be used in TensorFlow 2.0, as updates are applied
automatically.
WARNING:tensorflow:From /usr/local/lib/python3.8/site-
packages/tensorflow/python/training/tracking/tracking.py:111: Layer.updates
(from tensorflow.python.keras.engine.base_layer) is deprecated and will be
removed in a future version.
Instructions for updating:
This property should not be used in TensorFlow 2.0, as updates are applied
automatically.
INFO:tensorflow:Assets written to: model_dense/assets
```

### 3.3 Load the saved Model, tokenizer and configs

[17]:
```
# loading the saved model, vocab, filtered_words
from tensorflow.keras.models import load_model
model = load_model('./model_dense')

with open('tokenizer.pkl', 'rb') as fp:
    tokenizer=pickle.load(fp)

with open('label_dict.json', 'r') as fp:
    label_dict=json.load(fp)

print ("Model Loaded.")
```

```
Model Loaded.
```

### 3.4 Predictions

[18]:
```
def Prediction(doc, model=model, tokenizer=tokenizer, label_dict=label_dict):
    doc_processed = process_text(doc)
    X_in = tokenizer.texts_to_matrix([doc_processed])
    y_out = model.predict(X_in)
    category_indx = np.argmax(y_out,axis=1)[0]
    category = [i for i in list(label_dict.keys()) if␣
 ↪label_dict[i]==category_indx][0]
    print (f"The following text\n\n {doc} \n\n\
    is categorized as \n\n {category}")
```

[19]:
```
doc="Mr Trump responded on Tuesday with his lengthiest statement since he left␣
 ↪office a month\
ago. The Republican Party can never again be respected or strong with \
political 'leaders' like Senator Mitch McConnell at its helm, the press release␣
 ↪reads."
```

[20]:
```
Prediction(doc)
```

```
The following text

 Mr Trump responded on Tuesday with his lengthiest statement since he left
office a monthago. The Republican Party can never again be respected or strong
with political 'leaders' like Senator Mitch McConnell at its helm, the press
release reads.

    is categorized as

 politics
```

[21]:
```
doc=" R. Ashwin took 5 wickets in what became the last innings of the series\
to secure an innings and a 25 runs."
Prediction(doc)
```

```
The following text

  R. Ashwin took 5 wickets in what became the last innings of the seriesto
secure an innings and a 25 runs.

    is categorized as

 entertainment
```

[ ]:

[ ]: