Simple topic identification

Puteaux, Fall/Winter 2020-2021

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##  Natural Language Processing in Python  ##
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§1 Introduction to Natural Language Processing in Python

§1.2 Simple topic identification

1 Word counts with bag-of-words

1.1 What is bag-of-words?

- It is a basic method for finding topics in a text.
- Need first to create tokens using tokenization.
- And then count up all the tokens.
- The more frequent a word, the more important it might be.
- It can be a great way to determine the significant words in a text.

1.2 Code of bag-of-words in Python:

[1]:
```
from nltk.tokenize import word_tokenize
from collections import Counter

Counter(
    word_tokenize("""The cat is in the box. The cat likes the box. \
The box is over the cat."""))
```

[1]:
```
Counter({'The': 3,
         'cat': 3,
         'is': 2,
         'in': 1,
         'the': 3,
         'box': 3,
         '.': 3,
```

```
         'likes': 1,
         'over': 1})
```

[2]:
```
counter = Counter(
    word_tokenize("""The cat is in the box. The cat likes the box. \
    The box is over the cat."""))
counter.most_common(2)
```

[2]:
```
[('The', 3), ('cat', 3)]
```

1.3 Practice question for bag-of-words picker:

- It's time for a quick check on the understanding of bag-of-words. Which of the below options, with basic NLTK tokenization, map the bag-of-words for the following text?

    "The cat is in the box. The cat box."

    ☐ ('the', 3), ('box.', 2), ('cat', 2), ('is', 1).

    ☐ ('The', 3), ('box', 2), ('cat', 2), ('is', 1), ('in', 1), ('.', 1).

    ☐ ('the', 3), ('cat box', 1), ('cat', 1), ('box', 1), ('is', 1), ('in', 1).

    ☒ ('The', 2), ('box', 2), ('.', 2), ('cat', 2), ('is', 1), ('in', 1), ('the', 1).

▶ **Question-solving method:**

[3]:
```
from nltk.tokenize import word_tokenize
from collections import Counter

Counter(word_tokenize("The cat is in the box. The cat box."))
```

[3]:
```
Counter({'The': 2, 'cat': 2, 'is': 1, 'in': 1, 'the': 1, 'box': 2, '.': 2})
```

1.4 Practice exercises for word counts with bag-of-words:

▶ **Package pre-loading:**

[4]:
```
from nltk import word_tokenize
```

▶ **Data pre-loading:**

[5]:
```
article = open('ref1. Wikipedia article - Debugging.txt').read()
```

▶ **Bag-of-words `Counter` building practice:**

[6]:
```
# Import Counter
from collections import Counter

# Tokenize the article: tokens
```

```
tokens = word_tokenize(article)

# Convert the tokens into lowercase: lower_tokens
lower_tokens = [t.lower() for t in tokens]

# Create a Counter with the lowercase tokens: bow_simple
bow_simple = Counter(lower_tokens)

# Print the 10 most common tokens
print(bow_simple.most_common(10))
```

```
[(',', 151), ('the', 150), ('.', 89), ('of', 81), ("''", 66), ('to', 63), ('a',
60), ('``', 47), ('in', 44), ('and', 41)]
```

```
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2 Simple text preprocessing

2.1 Why preprocess?

- When performing machine learning or other statistical methods, it could help make for better input data.
- Examples:
  - *tokenization to create a bag of words*
  - *lowercasing words*
- Lemmatization/Stemming:
  - shorten words to their root stems
- Remove stop words, punctuation, or unwanted tokens.
- Good to experiment with different approaches.

2.2 Code of text preprocessing with Python:

[7]:
```
from nltk.tokenize import word_tokenize
from collections import Counter
```

[8]:
```python
from nltk.corpus import stopwords

text = """The cat is in the box. The cat likes the box.
The box is over the cat."""
tokens = [w for w in word_tokenize(text.lower()) if w.isalpha()]
no_stops = [t for t in tokens if t not in stopwords.words('english')]
Counter(no_stops).most_common(2)
```

[8]:
```
[('cat', 3), ('box', 3)]
```

[9]:
```python
from nltk.stem import WordNetLemmatizer

text = """Cats, dogs and birds are common pets. So are fish."""
tokens = [w for w in word_tokenize(text.lower()) if w.isalpha()]
no_stops = [t for t in tokens if t not in stopwords.words('english')]
wordnet_lemmatizer = WordNetLemmatizer()
lemmatized = [wordnet_lemmatizer.lemmatize(t) for t in no_stops]
print(lemmatized)
```

```
['cat', 'dog', 'bird', 'common', 'pet', 'fish']
```

2.3 Practice question for text preprocessing steps:

- Which of the following are useful text preprocessing steps?

  ☐ Stems, spelling corrections, lowercase.

  ☒ Lemmatization, lowercasing, removing unwanted tokens.

  ☐ Removing stop words, leaving in capital words.

  ☐ Strip stop words, word endings and digits.

2.4 Practice exercises for simple text preprocessing:

▶ **Package pre-loading:**

[10]:
```python
from nltk import word_tokenize
from collections import Counter
```

▶ **Data pre-loading:**

[11]:
```python
article = open('ref1. Wikipedia article - Debugging.txt').read()
tokens = word_tokenize(article)
lower_tokens = [t.lower() for t in tokens]
stopwords = open('ref2. English stopwords.txt').read()
english_stops = word_tokenize(stopwords)
```

▶ **Text preprocessing practice:**

[12]:
```python
# Import WordNetLemmatizer
from nltk.stem import WordNetLemmatizer

# Retain alphabetic words: alpha_only
alpha_only = [t for t in lower_tokens if t.isalpha()]

# Remove all stop words: no_stops
no_stops = [t for t in alpha_only if t not in english_stops]

# Instantiate the WordNetLemmatizer
wordnet_lemmatizer = WordNetLemmatizer()

# Lemmatize all tokens into a new list: lemmatized
lemmatized = [wordnet_lemmatizer.lemmatize(t) for t in no_stops]

# Create the bag-of-words: bow
bow = Counter(lemmatized)

# Print the 10 most common tokens
print(bow.most_common(10))
```

```
[('debugging', 40), ('system', 25), ('bug', 17), ('software', 16), ('problem',
15), ('tool', 15), ('computer', 14), ('process', 13), ('term', 13), ('debugger',
13)]
```

```
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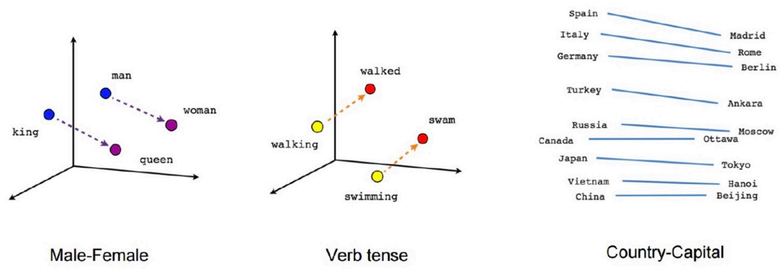
3 Introduction to gensim

3.1 What is gensim?

- It is a popular open-source NLP library.
- It uses top academic models to perform complex tasks:
  - building document or word vectors
  - performing topic identification and document comparison

3.2 What is a word vector?



3.3 Code of creating a gensim corpus:

[13]:
```
from gensim.corpora.dictionary import Dictionary
from nltk.tokenize import word_tokenize

my_documents = [
    'The movie was about a spaceship and aliens.',
    'I really liked the movie!',
    'Awesome action scenes, but boring characters.',
    'The movie was awful! I hate alien films.',
    'Space is cool! I liked the movie.',
    'More space films, please!',
]
```

[14]:
```
tokenized_docs = [word_tokenize(doc.lower()) for doc in my_documents]

dictionary = Dictionary(tokenized_docs)
dictionary.token2id
```

[14]:
```
{'.': 0,
 'a': 1,
 'about': 2,
 'aliens': 3,
 'and': 4,
 'movie': 5,
 'spaceship': 6,
 'the': 7,
 'was': 8,
 '!': 9,
 'i': 10,
 'liked': 11,
 'really': 12,
 ',': 13,
 'action': 14,
 'awesome': 15,
 'boring': 16,
```

```
 'but': 17,
 'characters': 18,
 'scenes': 19,
 'alien': 20,
 'awful': 21,
 'films': 22,
 'hate': 23,
 'cool': 24,
 'is': 25,
 'space': 26,
 'more': 27,
 'please': 28}
```

[15]:
```
corpus = [dictionary.doc2bow(doc) for doc in tokenized_docs]
corpus
```

[15]:
```
[[(0, 1), (1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1)],
 [(5, 1), (7, 1), (9, 1), (10, 1), (11, 1), (12, 1)],
 [(0, 1), (13, 1), (14, 1), (15, 1), (16, 1), (17, 1), (18, 1), (19, 1)],
 [(0, 1),
  (5, 1),
  (7, 1),
  (8, 1),
  (9, 1),
  (10, 1),
  (20, 1),
  (21, 1),
  (22, 1),
  (23, 1)],
 [(0, 1), (5, 1), (7, 1), (9, 1), (10, 1), (11, 1), (24, 1), (25, 1), (26, 1)],
 [(9, 1), (13, 1), (22, 1), (26, 1), (27, 1), (28, 1)]]
```

3.4 What are the advantages of creating a gensim corpus?

- First of all, gensim models can be easily saved, updated, and reused.
- Secondly, the dictionary created can also be updated.
- Lastly, the more advanced and feature-rich bag-of-words can be used in future exercises.

3.5 Practice question for word vectors:

- What are word vectors, and how do they help with NLP?

  ☐ They are similar to bags of words, just with numbers. You use them to count how many tokens there are.

  ☐ Word vectors are sparse arrays representing bigrams in the corpora. You can use them to compare two sets of words to one another.

☒ Word vectors are multi-dimensional mathematical representations of words created using deep learning methods. They give us insight into relationships between words in a corpus.

☐ Word vectors don't actually help NLP and are just hype.

3.6 Practice exercises for introduction to gensim:

▶ **Package pre-loading:**

[16]:
```
import zipfile

from nltk import word_tokenize
```

▶ **Data pre-loading:**

[17]:
```
file_name = 'ref4. Wikipedia articles.zip'
with zipfile.ZipFile(file_name, 'r') as archive:
    files = [
        archive.read(name) for name in archive.namelist()
        if name.endswith('.txt')
    ]

doc_tokens = [word_tokenize(file.decode("utf-8")) for file in files]

articles = []
stopwords = open('ref2. English stopwords.txt').read()
english_stops = word_tokenize(stopwords)
for i in range(len(doc_tokens)):
    lower_tokens = [t.lower() for t in doc_tokens[i]]
    alphanumeric_only = [t for t in lower_tokens if t.isalnum()]
    no_stops = [t for t in alphanumeric_only if t not in english_stops]
    articles.append(no_stops)
```

▶ **Gensim corpus creating and querying practice:**

[18]:
```
# Import Dictionary
from gensim.corpora.dictionary import Dictionary

# Create a Dictionary from the articles: dictionary
dictionary = Dictionary(articles)

# Select the id for "computer": computer_id
computer_id = dictionary.token2id.get("computer")

# Use computer_id with the dictionary to print the word
print(dictionary.get(computer_id))

# Create a MmCorpus: corpus
corpus = [dictionary.doc2bow(article) for article in articles]
```

```
# Print the first 10 word ids with their frequency counts from the fifth␣
↪document
print(corpus[4][:10])
```

```
computer
[(13, 2), (24, 1), (43, 1), (44, 6), (45, 1), (50, 1), (58, 1), (59, 1), (61,
7), (75, 1)]
```

▶ **Package pre-loading:**

[19]:
```
from collections import defaultdict
import itertools
```

▶ **Gensim bag-of-words practice:**

[20]:
```
# Save the fifth document: doc
doc = corpus[4]

# Sort the doc for frequency: bow_doc
bow_doc = sorted(doc, key=lambda w: w[1], reverse=True)

# Print the top 5 words of the document alongside the count
for word_id, word_count in bow_doc[:5]:
    print(dictionary.get(word_id), word_count)

# Create the defaultdict: total_word_count
total_word_count = defaultdict(int)
for word_id, word_count in itertools.chain.from_iterable(corpus):
    total_word_count[word_id] += word_count
```

```
language 54
programming 39
languages 30
code 22
computer 15
```

[21]:
```
# Save the fifth document: doc
doc = corpus[4]

# Sort the doc for frequency: bow_doc
bow_doc = sorted(doc, key=lambda w: w[1], reverse=True)

# Print the top 5 words of the document alongside the count
for word_id, word_count in bow_doc[:5]:
    print(dictionary.get(word_id), word_count)

# Create the defaultdict: total_word_count
```

```
total_word_count = defaultdict(int)
for word_id, word_count in itertools.chain.from_iterable(corpus):
    total_word_count[word_id] += word_count

# Create a sorted list from the defaultdict: sorted_word_count
sorted_word_count = sorted(total_word_count.items(),
                           key=lambda w: w[1],
                           reverse=True)

# Print the top 5 words across all documents alongside the count
for word_id, word_count in sorted_word_count[:5]:
    print(dictionary.get(word_id), word_count)
```

```
language 54
programming 39
languages 30
code 22
computer 15
computer 598
software 450
cite 322
ref 259
code 235

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4 Tf-idf with gensim

4.1 What is tf-idf?

- Tf-idf means term frequency - inverse document frequency.
- Allow determining the most important words in each document.
- Each corpus may have shared words beyond just stopwords.
- These words should be down-weighted in importance.
- Example:
  - *"sky" from the theme of astronomy*
- Ensures most common words don't show up as keywords.

- Keep document specific frequent words weighted high.

4.2 What is the tf-idf formula?

- $w_{i,j} = tf_{i,j} \times \log\left(\frac{N}{df_i}\right)$
  - $w_{i,j}$ = tf-idf weight for token i in document j
  - $tf_{i,j}$ = number of occurences of token i in document j
  - df_i = number of documents that contain token i
  - N = total number of documents

4.3 Code of tf-idf with gensim:

[22]:
```
from gensim.corpora.dictionary import Dictionary
from nltk.tokenize import word_tokenize

my_documents = [
    'The movie was about a spaceship and aliens.',
    'I really liked the movie!',
    'Awesome action scenes, but boring characters.',
    'The movie was awful! I hate alien films.',
    'Space is cool! I liked the movie.',
    'More space films, please!',
]

tokenized_docs = [word_tokenize(doc.lower()) for doc in my_documents]
dictionary = Dictionary(tokenized_docs)
corpus = [dictionary.doc2bow(doc) for doc in tokenized_docs]
```

[23]:
```
from gensim.models.tfidfmodel import TfidfModel

tfidf = TfidfModel(corpus)
tfidf[corpus[1]]
```

[23]:
```
[(5, 0.1746298276735174),
 (7, 0.1746298276735174),
 (9, 0.1746298276735174),
 (10, 0.29853166221463673),
 (11, 0.47316148988815415),
 (12, 0.7716931521027908)]
```

4.4 Practice question for what is tf-idf:

- To calculate the tf-idf weight for the word "computer", which appears five times in a document containing 100 words. Given a corpus containing 200 documents, with 20 documents mentioning the word "computer", so tf-idf can be calculated by multiplying term frequency with inverse document frequency.

- Notes:
  - term frequency = percentage share of the word compared to all tokens in the document
  - inverse document frequency = logarithm of the total number of documents in a corpus divided by the number of documents containing the term
- Which of the below options is correct?

  ☒ (5 / 100) * log(200 / 20)

  ☐ (5 * 100) / log(200 * 20)

  ☐ (20 / 5) * log(200 / 20)

  ☐ (200 * 5) * log(400 / 5)

4.5 Practice exercises for tf-idf with gensim:

▶ **Package pre-loading:**

[24]:
```
import zipfile

from nltk import word_tokenize

from gensim.corpora.dictionary import Dictionary
from gensim.models.tfidfmodel import TfidfModel
```

▶ **Data pre-loading:**

[25]:
```
file_name = 'ref4. Wikipedia articles.zip'
with zipfile.ZipFile(file_name, 'r') as archive:
    files = [
        archive.read(name) for name in archive.namelist()
        if name.endswith('.txt')
    ]

doc_tokens = [word_tokenize(file.decode("utf-8")) for file in files]
articles = []
stopwords = open('ref2. English stopwords.txt').read()
english_stops = word_tokenize(stopwords)
for i in range(len(doc_tokens)):
    lower_tokens = [t.lower() for t in doc_tokens[i]]
    alphanumeric_only = [t for t in lower_tokens if t.isalnum()]
    no_stops = [t for t in alphanumeric_only if t not in english_stops]
    articles.append(no_stops)

dictionary = Dictionary(articles)
corpus = [dictionary.doc2bow(article) for article in articles]

doc = corpus[4]
```

▶ **Wikipedia tf-idf practice:

[26]:
```python
# Create a new TfidfModel using the corpus: tfidf
tfidf = TfidfModel(corpus)

# Calculate the tfidf weights of doc: tfidf_weights
tfidf_weights = tfidf[doc]

# Print the first five weights
print(tfidf_weights[:5])
```

```
[(13, 0.021411676334320492), (24, 0.017389030559156224), (43,
0.008053565883888867), (45, 0.021821227698039212), (50, 0.013767661814150054)]
```

[27]:
```python
# Create a new TfidfModel using the corpus: tfidf
tfidf = TfidfModel(corpus)

# Calculate the tfidf weights of doc: tfidf_weights
tfidf_weights = tfidf[doc]

# Print the first five weights
print(tfidf_weights[:5])

# Sort the weights from highest to lowest: sorted_tfidf_weights
sorted_tfidf_weights = sorted(tfidf_weights, key=lambda w: w[1], reverse=True)

# Print the top 5 weighted words
for term_id, weight in sorted_tfidf_weights[:5]:
    print(dictionary.get(term_id), weight)
```

```
[(13, 0.021411676334320492), (24, 0.017389030559156224), (43,
0.008053565883888867), (45, 0.021821227698039212), (50, 0.013767661814150054)]
compiled 0.2182122769803921
compilation 0.21353333707313848
eiffel 0.17794444756094874
abstraction 0.1745698215843137
intermediate 0.16521194176980647
```