91258 - Natural Language Processing

Lesson 2. Tokens

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Words

What is a word?

Basic element of language that carries an objective or practical meaning, can be used on its own, and is uninterruptible

- Speech: The smallest sequence of phonemes that can be uttered in isolation with objective or practical meaning
- Text: Sequences of graphemes ("letters") [...] delimited by spaces [...] or by other graphical conventions

`https://en.wikipedia.org/wiki/Word` (old version)

Simplistic operational definition
A word is a sequence of characters surrounded by spaces

Arguable, as multiple scholars claim; in particular across languages (Bender, 2013; Haspelmath, 2011)

Words

Lexicon

The set of all tokens (words!) in document d (or a corpus C)[1]

[1] Typically we will use lowercase symbols for single instances and uppercase for collections

Words

Tokenisers

We have a tokeniser, kindly provided by Church (1994)[2]

```
tokens = re.findall('[A-Za-z]+', txt)
```

Python provides a "similar" tool

```
tokens = txt.split()
```

What if `txt` is the following?[3]

```
txt = """Thomas Jefferson started building Monticello
at the age of 26."""
```

</> **Let us see it working**

[2] See PBR / P4P

[3] Example borrowed from Lane et al. (2019, p. 34)

Words

Tokenisers

Building a better regular expression[4]

```
tokens = re.split(r'([-\s.,;!?])+', txt)
```

What if we have the following text?

```
txt = "Monticello wasn't designated as UNESCO World
                          Heritage Site until 1987"
```

</> **Let us see it working**

[4] Borrowed from Lane et al. (2019, p. 43)

Words

NLTK

- One of the leading platforms to work with human language data in python[5]
- Easy-to-use interfaces to over 50 corpora and lexical resources such as WordNet
- Suite of text processing libraries for classification, **tokenization**, stemming, tagging, parsing [...]

http://www.nltk.org

[5] See also stanza and huggingface

Words

Spacy

- "Industrial-strength Natural Language Processing"[6]
- Support for 66+ languages
- Pre-trained word vectors and modules for **tokenization**, lemmatisation, tagging, parsing [...]

https://spacy.io

[6] See also stanza and huggingface

Words

Installing NLTK and spacy

```
$ pip install --user -U nltk
$ pip install --user -U numpy
$ python
>>> import nltk
```

```
$ pip install --user -U spacy
$ python
>>> import spacy
```

Words

Using (one of the) spacy tokenisers

```
# loading the library
import spacy

# downloading the model
import spacy.cli
spacy.cli.download("en_core_web_sm")
```

```
nlp = spacy.load("en_core_web_sm")
doc = nlp(txt)
print([token.text for token in doc])
```

</> **Let us see it work**

Words

Using (one of) the NLTK tokenisers

```
from nltk.tokenize import TreebankWordTokenizer
tokenizer = TreebankWordTokenizer()
sentence = "Monticello wasn't designated as UNESCO
                                World
Heritage Site until 1987"
tokenizer.tokenize(sentence)
```

Normalisation

Normalisation

Case folding

Ignoring differences in the spelling of a word which involves only capitalisation (Lane et al., 2019, p. 54)

```
# We know how to deal with this, don't we?
```

PROS `Tea==tea`; the vocabulary is smaller

CONS `The Joker` is not a character any longer

</> **Let us see it working**

Normalisation

Stemming

"Eliminate the small meaning differences of pluralisation or possessive endings of words or [...] verb form" (Lane et al., 2019, p. 57)

```
import re

def stem(phrase):
    return ' '.join([re.findall('^(.*ss|.*?)(s)?$',
        word)[0][0].strip("'") for word in phrase.
                                    lower()
        .split()])

stem('houses')
stem("Doctor House's calls")
stem("stress")
```

</> **Let us see it working**

Normalisation

Stemming: Porter and Snowball

Once again, people have developed (and released) more sophisticated stemming algorithms
`https://tartarus.org/martin/PorterStemmer/`
`http://snowball.tartarus.org/`

```
from nltk.stem.porter import PorterStemmer
stemmer = PorterStemmer()
' '.join([stemmer.stem(w).strip("'") for w in
 "dish washer's washed dishes".split()])
```

</> **Let us see it working**

Normalisation

Lemmatisation

Associating several words down to their semantic common root (adapted from (Lane et al., 2019, p. 59))

PROS Stemming might alter the meaning of a word

CONS It is more expensive; it requires a knowledge base of synonyms and endings, and part-of-speech tags

Normalisation

Lemmatisation: re-use, re-use!

The NLTK way

```
import nltk
nltk.download('wordnet')

from nltk.stem import WordNetLemmatizer
lemmatizer = WordNetLemmatizer()

lemmatizer.lemmatize("better")
lemmatizer.lemmatize("better", pos="a")
```

The spacy way

```
doc = nlp("better")
print([token.lemma_ for token in doc])
```

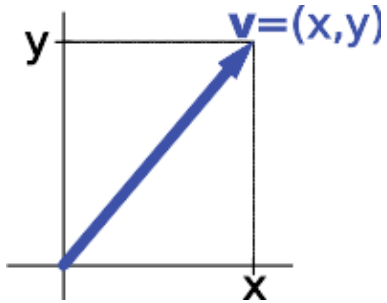
</> **Let us see them working**

Representations

Representations

Vectors

An (Euclidean) vector is an entity endowed with a magnitude (the length of the line segment (a, b)) and a direction (the direction from a to b).



https://en.wikipedia.org/wiki/Vector_(mathematics_and_physics)
https://en.wikipedia.org/wiki/Vector_space

Representations

Bag of Words (BoW)

Turning words into numbers[7]

```
sentence = """Thomas Jefferson began building
Monticello at the age of 26."""

sentence_bow = {}
for token in sentence.split():
     sentence_bow[token] = 1
sorted(sentence_bow.items())
```

</> **Let us see it working**

[7] From (Lane et al., 2019, p. 35)

Representations

Bag of Words (BoW)

Using **pandas** (data structures for data analysis, time series, statistics)[8]

```
import pandas as pd

sentences = """Thomas Jefferson began building
                                Monticello at
the age of 26.\n"""
sentences += """Construction was done mostly by local
                                masons
and carpenters.\n"""
sentences += "He moved into the South Pavilion in 1770
                                .\n"
sentences += """Turning Monticello into a neoclassical
masterpiece was Jefferson's obsession."""
corpus = {}
for i, sent in enumerate(sentences.split('\n')):
    corpus['sent{}'.format(i)] = dict((tok, 1) for tok
                                        in
          sent.split())
df = pd.DataFrame.from_records(corpus).fillna(0).
                                astype(int).T
df[df.columns[:10]]
```

Representations

One-Hot Vectors

Turning words into numbers[9]

```
import numpy as np
sentence = "Thomas Jefferson began building Monticello
                                at
the age of 26."
token_sequence = str.split(sentence)
vocab = sorted(set(token_sequence))
print(vocab)
```

```
num_tokens = len(token_sequence)
vocab_size = len(vocab)
onehot_vectors = np.zeros((num_tokens, vocab_size),
                                int)
for i, word in enumerate(token_sequence):
   onehot_vectors[i, vocab.index(word)] = 1

' '.join(vocab)
onehot_vectors
```

[9] From (Lane et al., 2019, p. 35)

Representations

One-Hot Vectors

Turning words into numbers[10]

```
import pandas as pd
pd.DataFrame(onehot_vectors, columns=vocab)
```

[10] From (Lane et al., 2019, p. 35)

References

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