Rotman

NATURAL LANGUAGE PROCESSING

March 22, 2020 Prepared by Niti / FinHUB

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Agenda

1. Intro to Natural Language Processing (NLP)

2. Basics of Data Preprocessing in NLP
   - ➢ Tokenization
   - ➢ Normalization

3. Vectorization
   - ➢ Frequency Vectors
   - ➢ TFIDF Vectors

4. Developing NLP Pipelines

1. Natural Language Processing

1.1 What is Natural Language Processing?

"*Natural Language Processing (NLP) is a subfield of linguistics, computer science, information engineering, and artificial intelligence concerned with the interactions between computers and human (natural) languages*".

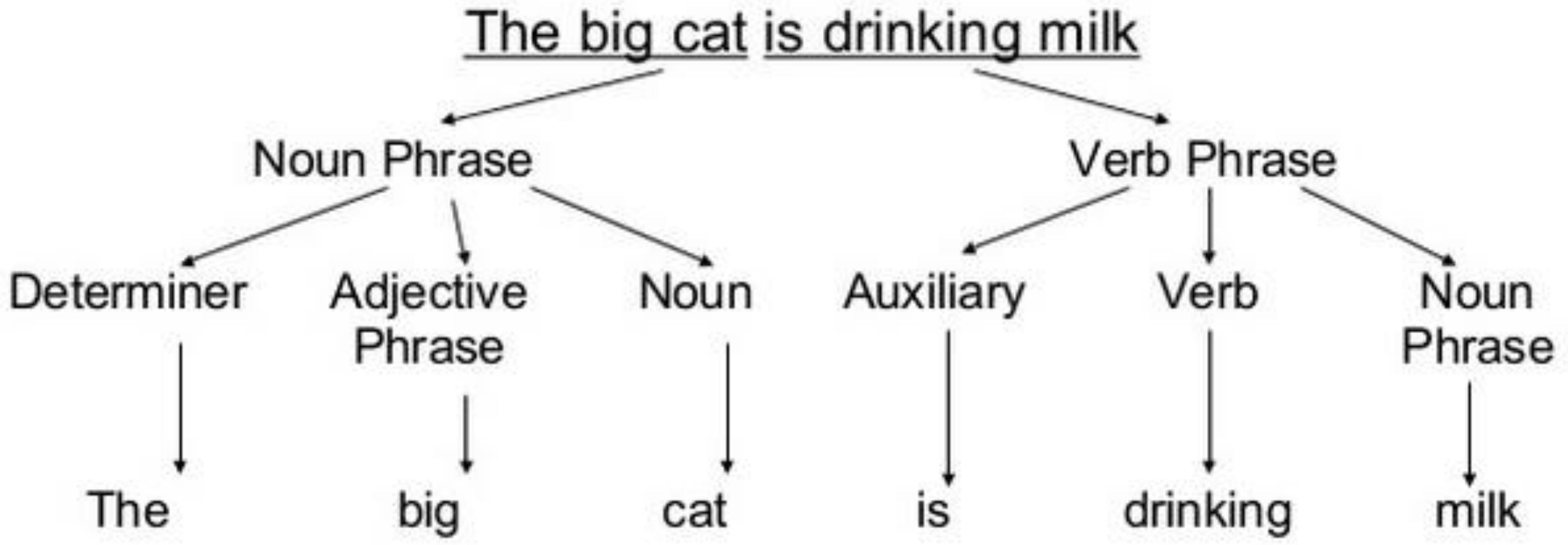
- Wikipedia

1.2 What is Natural Language?

- Human languages

- Consists of :
  - Vocabulary, set of words
  - Text made of sequence of words from vocabulary
  - Language is constructed of a set of all possible texts

1.3 Syntactic Analysis of Natural Language



1.4 Why NLP is useful?

- Applications of NLP include
  - spam filtering
  - search engines,
  - checking spelling and grammar
  - social website feeds,
  - speech recognition,
  - language translation, etc.

- Google Translate, for instance, is an example of NLP model

1.5 NLP Libraries in Python

- Natural language toolkit (NLTK)
- Scikit-Learn
- Gensim
- SpaCy
- TextBlob
- CoreNLP

1.6 What is NLTK?

- leading platform in Python NLP library

- provides easy-to-use interfaces to over 50 corpora and lexical resources such as WordNet

- provides a suite of text processing libraries for tokenization, stemming, tagging, parsing, semantic reasoning and an active discussion forum

2. Basic Data Preprocessing for NLP

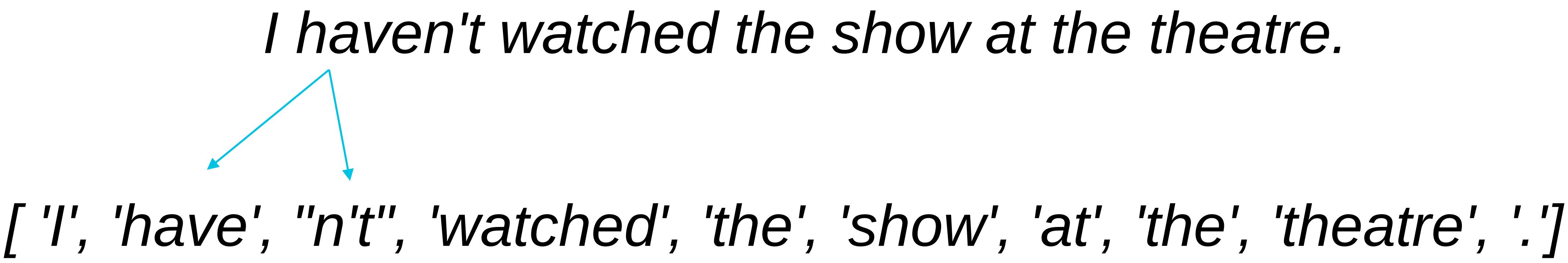
2.1 Tokenization

- Splitting text into sections

- Tokenization is the process of breaking a stream of text up into words, phrases, symbols and other meaningful elements called tokens

2.1 Tokenization – an example

- Using NLTK’s “word_tokenize” function -



I haven't watched the show at the theatre.

['I', 'have', "n't", 'watched', 'the', 'show', 'at', 'the', 'theatre', '.']

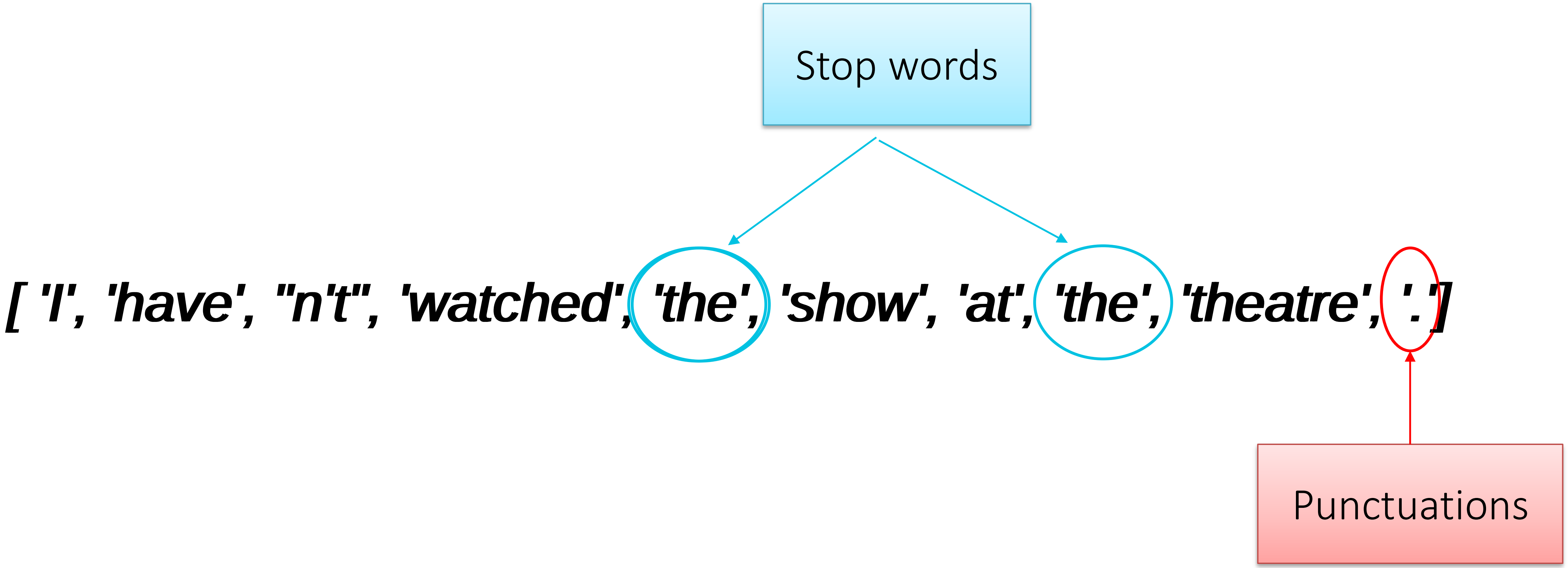
2.2 Normalization

- Process of transforming text into a single canonical form

- Tokenization + more
  - ➢ Convert all letters to lower or upper case
  - ➢ Removing punctuations
  - ➢ Removing white spaces
  - ➢ Removing stops words
  - ➢ Part of speech (POS) tagging

- Process of normalization is different for different corpus

2.2 Normalization



['I', 'have', "n't", 'watched', 'the', 'show', 'at', 'the', 'theatre', '.']

Stop words

Punctuations

There is no universal list of stop words

2.3 Normalization – Stemming

- Process of reducing a word to its stem, base of root form
  - ➢ Stemmer, stemming, stemmed → stem
  - ➢ Girls, girl → girl

- Goal is to remove word affixes, which generally indicate plurality in Latin languages

- Stemming is useful because it is a fast feature reduction method

2.3 Normalization – Lemmatization

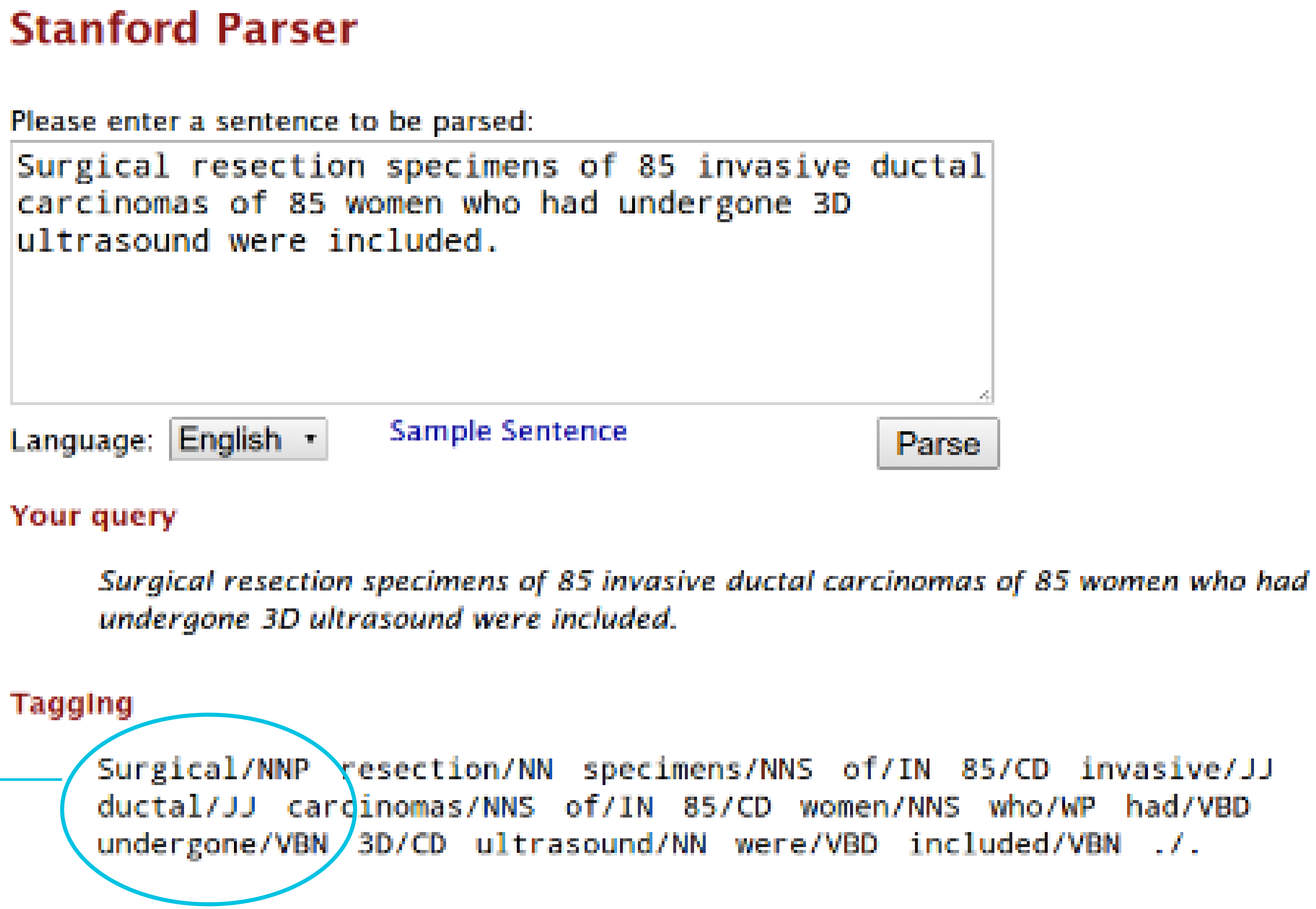
- Process of reducing a word to its lemma
    - ➢ gardening → to garden
    - ➢ Gardener, garden → gardener, garden

- It can handle irregular cases as well as handle tokens with different parts of speech.

- Lemmatization takes time but is generally more effective in its representation.

2.5 Normalization – POS Tagging

- Assigning syntactic tag to each word in a sentence



Please enter a sentence to be parsed:

```
Surgical resection specimens of 85 invasive ductal
carcinomas of 85 women who had undergone 3D
ultrasound were included.
```

Language: English

Your query

Surgical resection specimens of 85 invasive ductal carcinomas of 85 women who had undergone 3D ultrasound were included.

Tagging

```
Surgical/NNP resection/NN specimens/NNS of/IN 85/CD invasive/JJ
ductal/JJ carcinomas/NNS of/IN 85/CD women/NNS who/WP had/VBD
undergone/VBN 3D/CD ultrasound/NN were/VBD included/VBN ./.
```

- **NNP**: Proper Noun, singular
- **JJ**: Adjective
- **VBN**: Verb, past participle

3. Vectorization

3.1 Vectorization

- To apply machine learning to NLP, we must convert the natural texts into numeric data i.e vectorization

- Features must represent attributes and properties of documents, such as its content as well as meta data - document length, author, source, etc.

- Vectorization creates a high-dimensional semantic space where documents that have similar meaning are closer together and those that are different are farther apart.

3.2 Methods of Vectorization

- Frequency vector
- One-Hot Encoding
- TFIDF
- Distributed Representation
    - Word2vec
    - Doc2vec

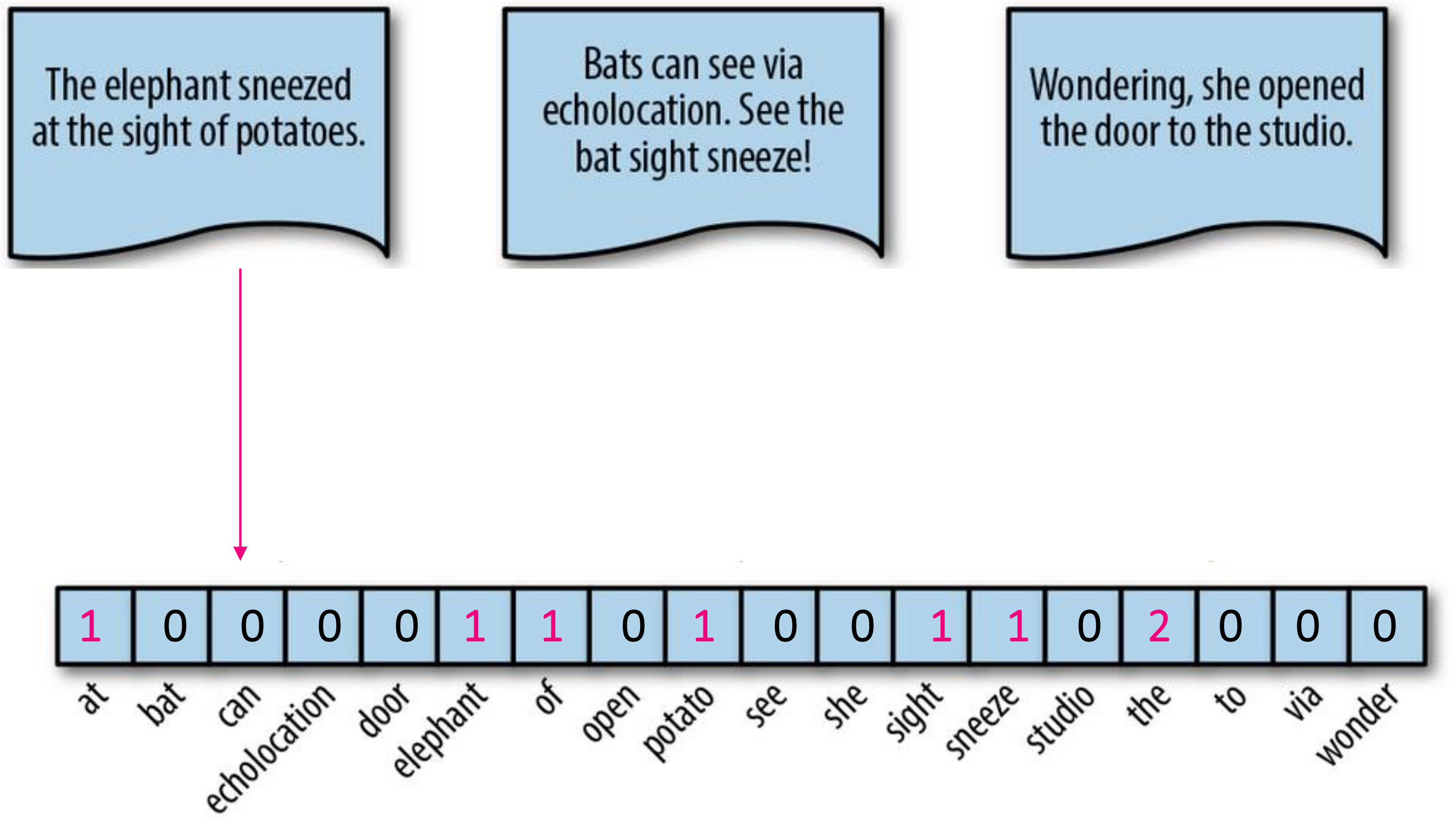
3.3 Vectorization – Frequency Vectors

- The simplest vectorization method is the bag of words (BOW) model that encodes meaning and similarity based on vocabulary

- Every document from the corpus is represented as a vector whose length is equal to the vocabulary of the corpus

- The simplest vector encoding model is to simply fill in the vector with the frequency of each word as it appears in the document

3.3 Vectorization – Frequency Vectors



The elephant sneezed at the sight of potatoes.

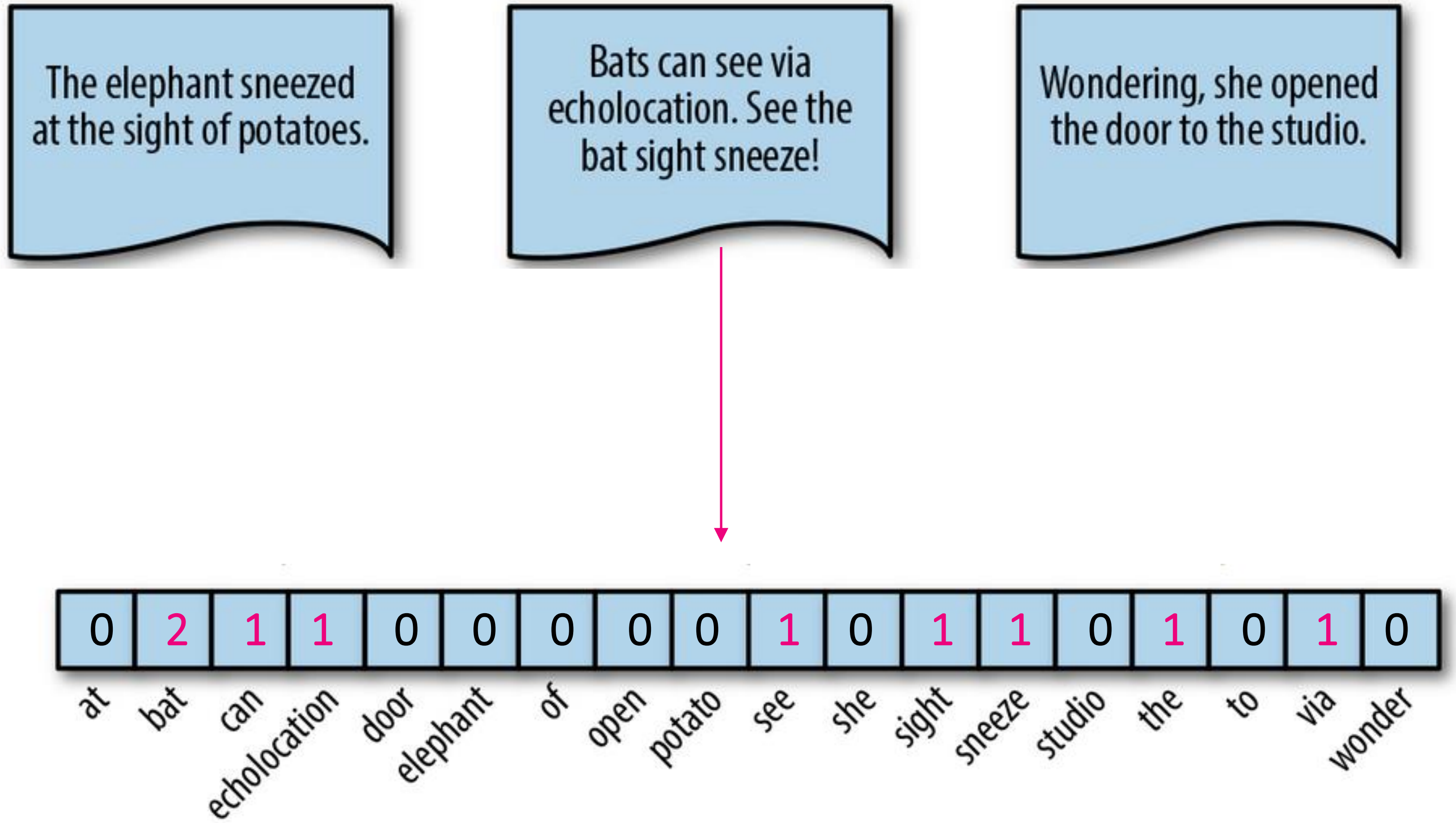
Bats can see via echolocation. See the bat sight sneeze!

Wondering, she opened the door to the studio.

at	bat	can	echolocation	door	elephant	of	open	potato	see	she	sight	sneeze	studio	the	to	via	wonder
1	0	0	0	0	1	1	0	1	0	0	1	1	0	2	0	0	0

https://www.oreilly.com/library/view/applied-text-analysis/9781491963036/ch04.html

3.3 Vectorization – Frequency Vectors



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0	2	1	1	0	0	0	0	0	1	0	1	1	0	1	0	1	0

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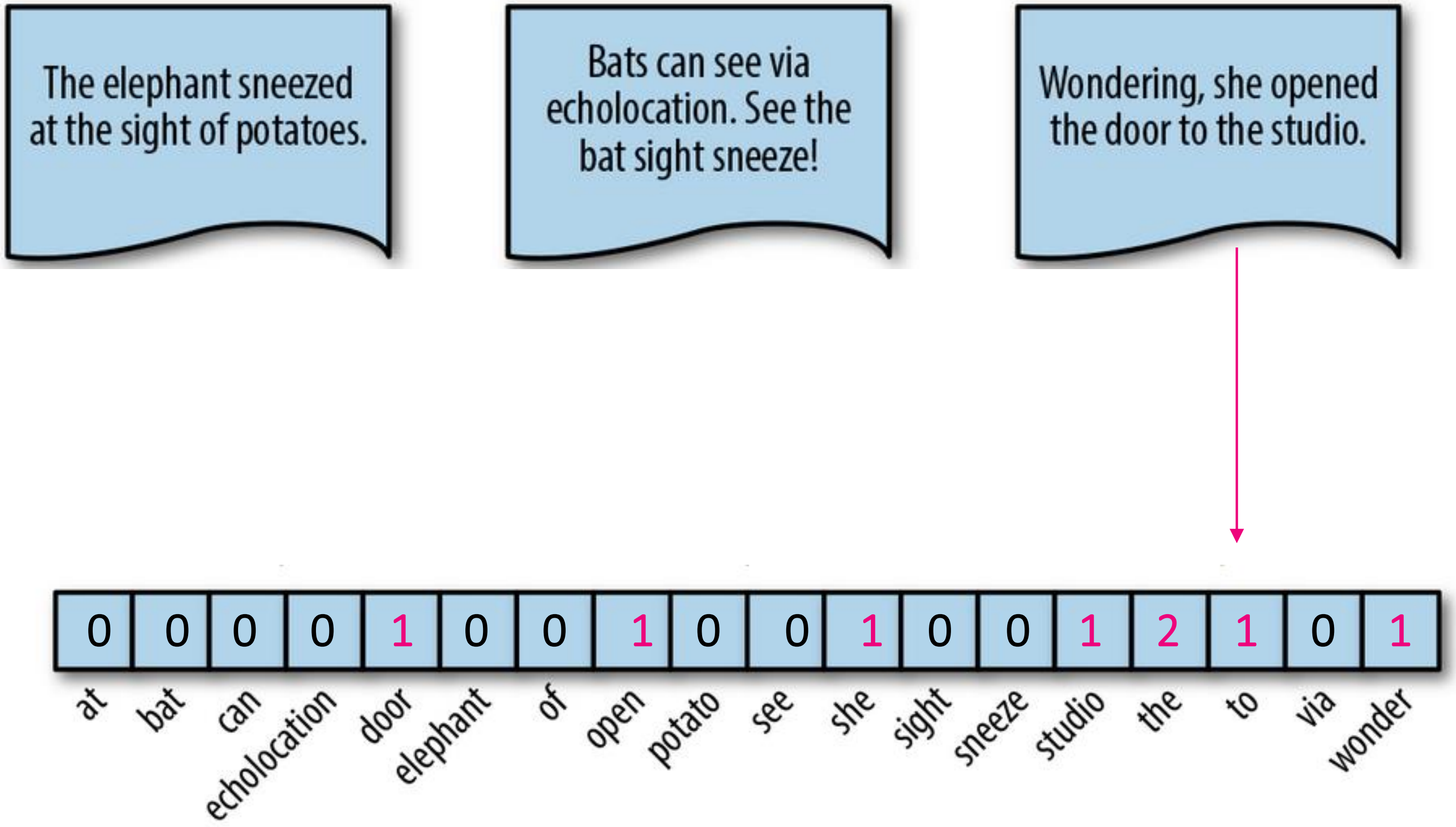
3.3 Vectorization – Frequency Vectors



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0	0	0	0	1	0	0	1	0	0	1	0	0	1	2	1	0	1

https://www.oreilly.com/library/view/applied-text-analysis/9781491963036/ch04.html

3.3 Vectorization – Frequency Vectors

Drawbacks:

- can be extremely sparse when vocabularies get larger
- significant impact on speed of ML model
- disregard grammar and the relative position of words in documents
- frequently appearing tokens are considered significant than less frequent tokens
- context of the corpus is ignored

3.4 Vectorization – TFIDF Vectors

- Are meanings most likely encoded in more rare terms from a document?

- Term Frequency - Inverse Document Frequency

- Normalizes the frequency of tokens in a document with respect to the rest of the corpus

- Emphasizes terms that are very relevant to a specific document

3.4 Vectorization – TFIDF Vectors

Two steps to measure the relevance of a token to a document

$$\text{TF- IDF} = \text{TF}(t, d) \times \text{IDF}(t)$$

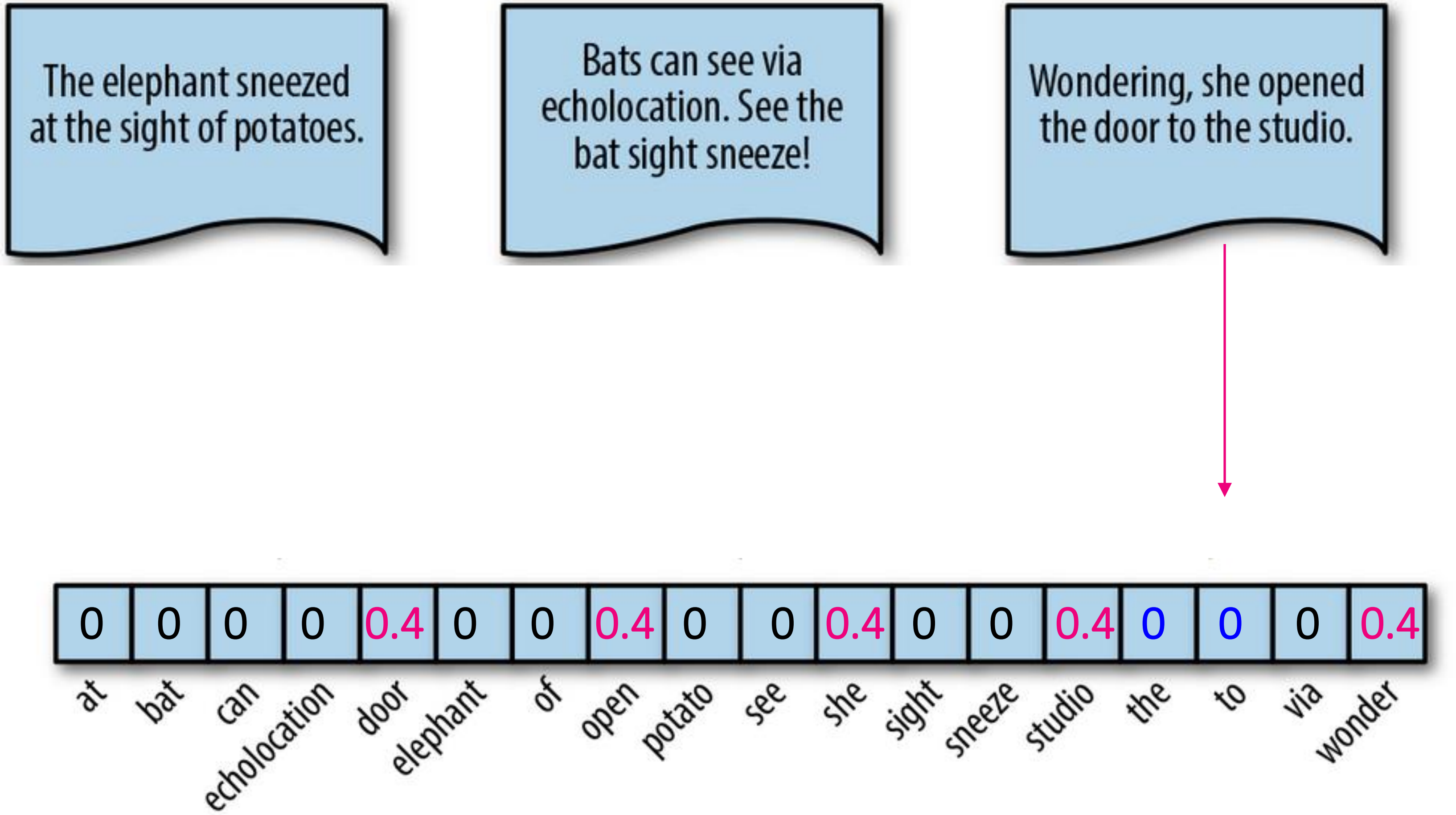
Term Frequency

Number of times term, t appears in a document, d

Inverse Document Frequency

$$\log \frac{1 + \text{no. of documents}}{1 + \text{df}(d, t)}$$

3.4 Vectorization – TFIDF Vectors



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at	bat	can	echolocation	door	elephant	of	open	potato	see	she	sight	sneeze	studio	the	to	via	wonder
0	0	0	0	0.4	0	0	0.4	0	0	0.4	0	0	0.4	0	0	0	0.4

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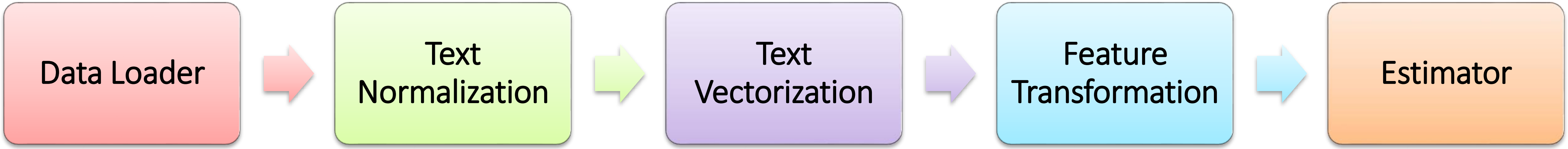
4. NLP Pipelines

4.1 NLP Pipelines

- Machine learning processes have series of transformers on raw data
- In each step the data is transformed to be ready for the next step until is it passed to the final estimator/classifier



4.1 NLP Pipelines

- It can become tedious to track the transformed data from one step to the next
- Pipeline objects enable us to integrate a series of transformers that combine normalization, vectorization and feature analysis into a single, well-defined mechanism.

Questions?

Thank you