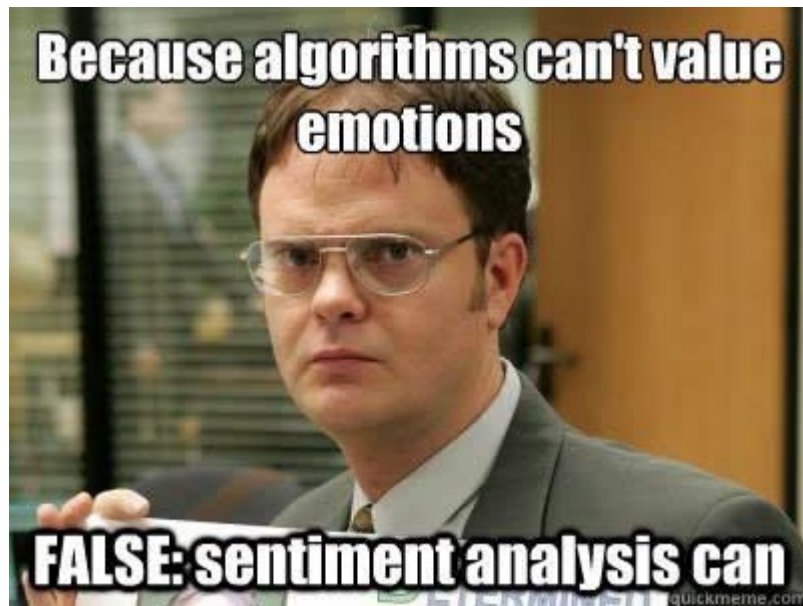


Machine Learning System Design

Module 0: Introduction to NLP

Hamza Farooq



01

Introduction

Nice to meet you all!

- My name is Hamza Farooq
- Currently @ Google
- 15+ of experience in Machine Learning
- Adjunct Professor at U. of Minnesota, and Santa Clara University



Class Etiquette

- This is an in person virtual class, please keep your video on – as much as possible
- Raise your hand [virtually] or drop a question in the chat
- Take your assignments seriously
- When in doubt, use email or [slack](#)
- I will be sharing all recordings

02

Here we go!

We live in a
world of NLP

What is NLP anyways?

Natural Language Processing(NLP) is defined as the branch of Artificial Intelligence that provides computers with the capability of understanding text and spoken words in the same way a human being can.

It incorporates machine learning models, statistics, and deep learning models into computational linguistics i.e. rule-based modeling of human language to allow computers to understand text, spoken words and understands human language, intent, and sentiment.

Applications – 1


- Information retrieval
- Information extraction
- Question answering

Google

list of good sushi restaurant in nyc


Q All News Shopping Maps Images More Tools

About 505,000,000 results (1.29 seconds)




4.0+ rating Sushi Price Hours


Sushi Nakazawa
4.7 ★★★★★ (1,038) · \$\$\$\$ · Sushi
23 Commerce St
Closes soon · 11PM
Dine-in · No takeout · No delivery



Sushi Yasuda
4.4 ★★★★★ (1,119) · \$\$\$\$ · Japanese
204 E 43rd St
Closes soon · 11PM
"Good sushi, but over priced"



Blue Ribbon Sushi
4.5 ★★★★★ (1,193) · \$\$ · Sushi
119 Sullivan St
Closes soon · 11PM
"Good sushi, extensive menu."

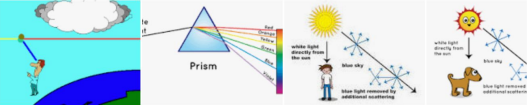


View all

why is the sky blue

Q All Books Videos Images News More Tools

Q Child Q Bill Nye Q Adult Q Daddy



Thus, as sunlight of all colors passes through air, the **blue** part causes charged particles to oscillate faster than does the red part. ... More of the sunlight entering the atmosphere is **blue** than violet, however, and our eyes are somewhat more sensitive to **blue** light than to violet light, so the **sky** appears **blue**. Apr 7, 2003

<https://www.scientificamerican.com/article/why-is-the-sky-blue/>

Why is the sky blue? - Scientific American

About featured snippets Feedback

People also ask

- Why is the sky blue short answer?
- Is the sky blue because of the ocean?
- Why is the sky blue explain to a child?
- What is the reason the sky looks blue?

Feedback

Applications -2

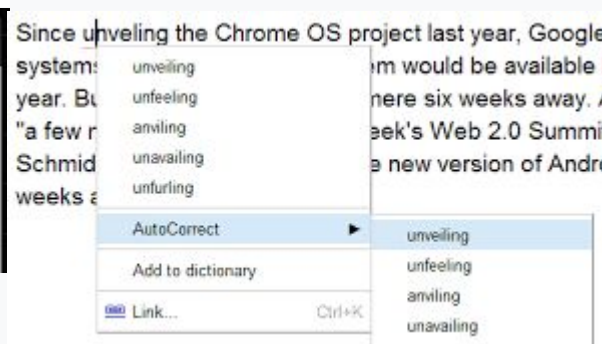
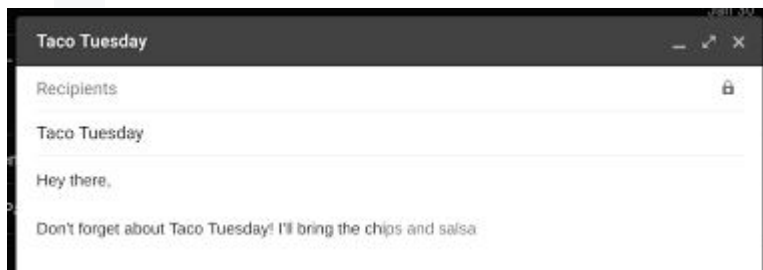
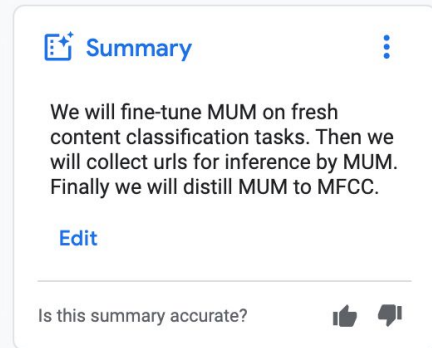
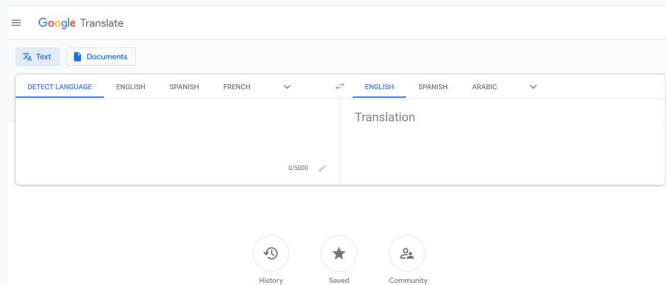
Machine Translation

Summarization

Auto Completion

Spell Correction

Many More...



NLP Ambiguities

There are different types of ambiguities present in natural language:

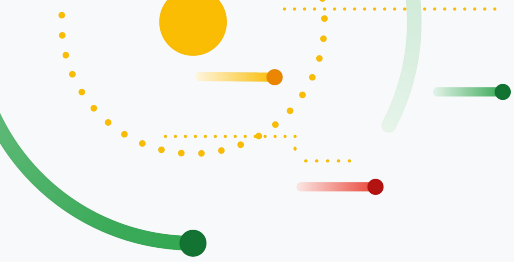
1. Lexical Ambiguity: It is defined as the ambiguity associated with the meaning of a single word. A single word can have different meanings. Also, a single word can be a noun, adjective, or verb. For example, The word “bank” can have different meanings. It can be a financial bank or a riverbank. Similarly, the word “clean” can be a noun, adverb, adjective, or verb.

NLP Ambiguities

2. Syntactic Ambiguity: It is defined as the ambiguity associated with the way the words are parsed. For example, The sentence “Visiting relatives can be boring.” This sentence can have two different meanings. One is that visiting a relative’s house can be boring. The second is that visiting relatives at your place can be boring.

NLP Ambiguities

3. Semantic Ambiguity: It is defined as ambiguity when the meaning of the words themselves can be ambiguous. For example, The sentence “Mary knows a little french.” In this sentence the word “little french” is ambiguous. As we don’t know whether it is about the language french or a person.



Common NLP tasks

Common NLP tasks

NLP systems

- Natural language understanding
- Natural language generation and summarization
- Natural language translation

Natural language understanding

- Extract information (e.g. about entities or events) from text
- Translate raw text into a meaning representation
- Reason about information given in text
- Execute NL instructions

Natural language generation and summarization

- Translate database entries or meaning representations to raw natural language text
- Produce (appropriate) utterances/responses in a dialog
- Summarize (newspaper or scientific) articles, describe images

Natural language translation

- Translate one natural language to another

Common NLP tasks

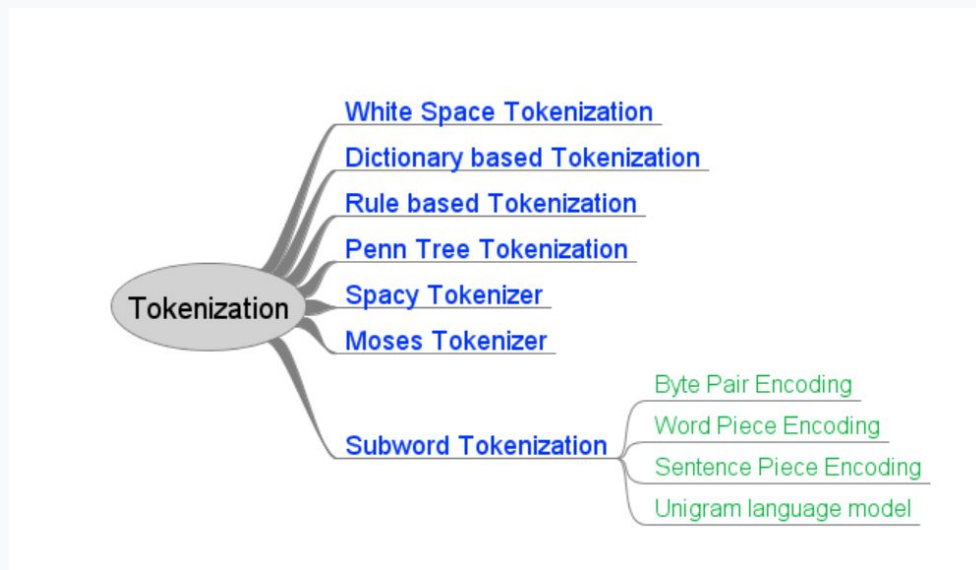
- **Tokenization**

- POS tagging
- Word sense disambiguation
- Dependency Parsing
- Syntactic parsing
- Semantic analysis
- Coreference resolution
- Named Entity Recognition (NER)
- Text representation
- Text classification
- Natural language generation
- Multimodal NLP

- Tokenization is the process of breaking down a text into individual units called tokens.
- Tokens are typically words, but can also be phrases or even individual characters, depending on the application.
- Tokenization is a crucial step in natural language processing tasks such as machine translation, sentiment analysis, and named entity recognition.

Common NLP tasks

- **Tokenization**
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Common NLP tasks

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- POS stands for Part-of-Speech, which is a linguistic term used to describe the grammatical category of a word in a sentence.
 - POS tagging is the process of assigning each word in a text with its corresponding POS category, such as noun, verb, adjective, or adverb.
 - POS tagging is a critical component in various natural language processing tasks, including text-to-speech conversion, information retrieval, and machine translation.

Common NLP tasks

- Tokenization
- **POS tagging**
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Open the pod door, Hal.



Verb Det Noun Noun , Name .
Open the pod door , Hal .

open:
verb, adjective, or noun?
Verb: ***open the door***
Adjective: ***the open door***
Noun: ***in the open***

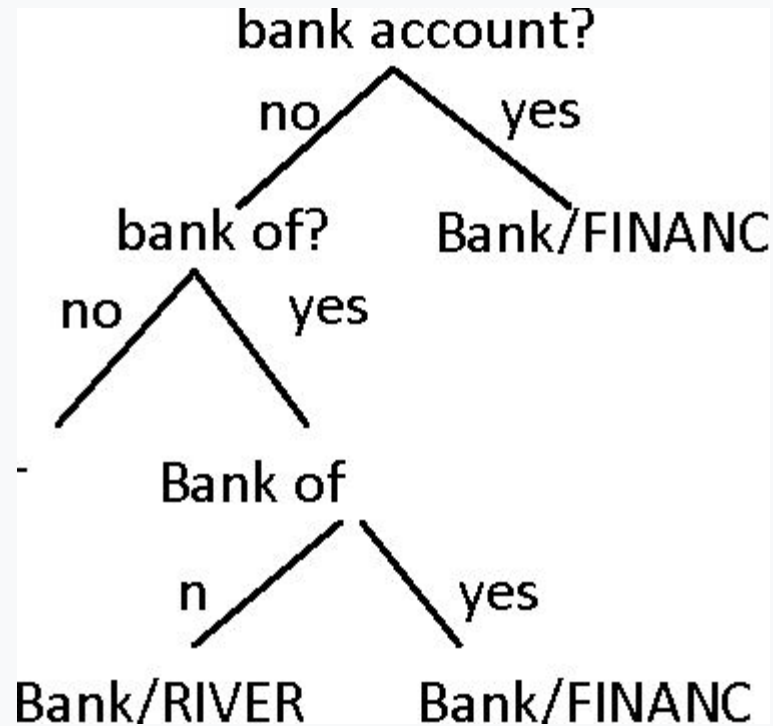
Common NLP tasks

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- Word sense disambiguation is the process of identifying the correct meaning of a word with multiple possible meanings based on the context in which it appears.
- This is a crucial task in natural language processing because words often have different meanings depending on the context in which they are used.
- Word sense disambiguation is used in various applications, including information retrieval, machine translation, and question answering systems.

Common NLP tasks

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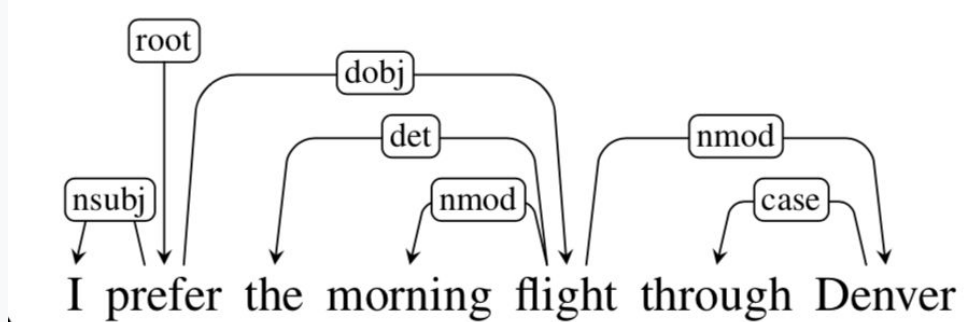


Common NLP tasks

- Tokenization
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 - **Dependency Parsing**
 - Syntactic parsing
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- Dependency parsing is the process of analyzing the grammatical structure of a sentence by identifying the relationships between words in a sentence.
 - It involves identifying the subject, object, and other dependent clauses and phrases, and representing them as a tree-like structure known as a dependency tree.
 - Dependency parsing is used in various natural language processing applications, including sentiment analysis, named entity recognition, and machine translation.

Common NLP tasks

- Tokenization
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- **Head-Dependent:** In the arrows representing relationship, the origin word is the Head & the destination word is Dependent.
- **Root:** Word which is the root of our parse tree. It is 'prefer' in the above example.
- **Grammar Functions and Arcs:** Tags between each Head-Dependent pair is a grammar function determining the relation between the Head & Dependent. The arrowhead carrying the tag is called an Arc.

Clausal Argument Relations	Description
NSUBJ	Nominal subject
DOBJ	Direct object
IOBJ	Indirect object
CCOMP	Clausal complement
XCOMP	Open clausal complement
Nominal Modifier Relations	Description
NMOD	Nominal modifier
AMOD	Adjectival modifier
NUMMOD	Numeric modifier
APPOS	Appositional modifier
DET	Determiner
CASE	Prepositions, postpositions and other case markers
Other Notable Relations	Description
CONJ	Conjunct
CC	Coordinating conjunction

Common NLP tasks

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- Syntactic parsing is the process of analyzing the grammatical structure of a sentence to determine its syntactic components, such as nouns, verbs, adjectives, and adverbs.
 - It involves identifying the parts of speech of each word in the sentence and grouping them together into phrases and clauses based on their syntactic relationships.
 - Syntactic parsing is used in various natural language processing applications, including text-to-speech conversion, machine translation, and information retrieval.

Common NLP tasks

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- POS tagging is the process of labeling individual words in a sentence with their part of speech, such as noun, verb, adjective, or adverb, while syntactic parsing involves analyzing the relationships between the words to determine the overall grammatical structure of the sentence.
- For example, consider the sentence "John eats pizza." POS tagging would label "John" as a proper noun and "eats" as a verb, while syntactic parsing would identify "John" as the subject of the verb "eats" and "pizza" as the object of the verb.
- In short, POS tagging is concerned with the individual words, while syntactic parsing focuses on the overall sentence structure.

Common NLP tasks

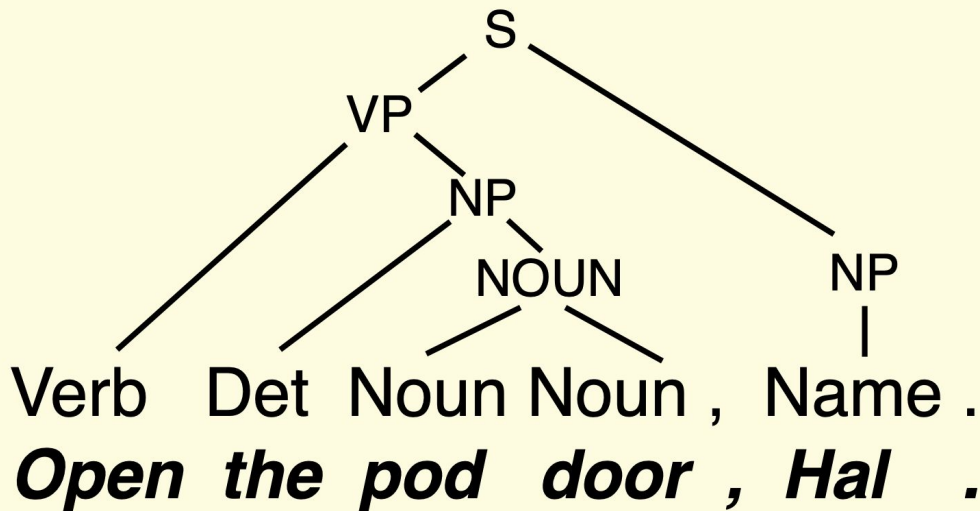
- Tokenization
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- **Semantic analysis**
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- Semantic analysis is the process of extracting the meaning of a text by analyzing the relationships between words and phrases in a sentence.
- It involves identifying the underlying concepts and ideas conveyed by the text and representing them in a structured form, such as a knowledge graph or ontology.
- Semantic analysis is used in various natural language processing applications, including question answering, information retrieval, and chatbots, to enable more accurate and intelligent responses.

Common NLP tasks

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$\exists x \exists y (\text{pod_door}(x) \ \& \ \text{Hal}(y)$
 $\& \ \text{request}(\text{open}(x, y)))$



Common NLP tasks

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We need a **meaning representation language**.

“Shallow” semantic analysis: **Template-filling**
(Information Extraction)

Named-Entity Extraction: Organizations, Locations, Dates,...
Event Extraction

“Deep” semantic analysis: (Variants of) **formal logic**
 $\exists x \exists y (\text{pod_door}(x) \& \text{Hal}(y) \& \text{request}(\text{open}(x, y)))$

We also distinguish between
Lexical semantics (the meaning of words) and
Compositional semantics (the meaning of sentences)

Common NLP tasks

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More than a decade ago, **Carl Lewis** stood on the threshold of what was to become the greatest athletics career in history. **He** had just broken two of the legendary Jesse Owens' college records, but never believed **he** would become a corporate icon, the focus of hundreds of millions of dollars in advertising. **His** sport was still nominally amateur. Eighteen Olympic and World Championship gold medals and **21 world records later, Lewis has** become the richest man in the history of track and field -- a multi-millionaire.

Who is Carl Lewis?
Did Carl Lewis break any world records?
(and how do you know that?)

Common NLP tasks

- Tokenization
- POS tagging
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- Syntactic parsing
- Semantic analysis
- **Coreference resolution**
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- Coreference resolution is the task of identifying all the expressions (e.g., pronouns, names) in a text that refer to the same entity, and linking them together.
- It is a crucial task in natural language processing as it enables a system to maintain a consistent representation of entities throughout a document, enabling more accurate information extraction and text understanding.

Common NLP tasks

- Tokenization
- POS tagging
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- **Named Entity Recognition (NER)**
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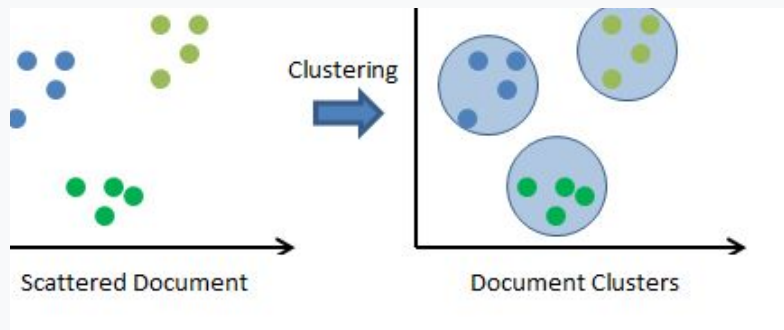
Named entity recognition (NER) is the process of identifying and categorizing named entities in a text, such as people, organizations, locations, and dates.

When **Sebastian Thrun** PERSON started at **Google** ORG in **2007** DATE, few people outside of the company took him seriously. "I can tell you very senior CEOs of major **American** NORP car companies would shake my hand and turn away because I wasn't worth talking to," said **Thrun** PERSON, now the co-founder and CEO of online higher education startup Udacity, in an interview with **Recode** ORG **earlier this week** DATE.

A little **less than a decade later** DATE, dozens of self-driving startups have cropped up while automakers around the world clamor, wallet in hand, to secure their place in the fast-moving world of fully automated transportation.

Common NLP tasks

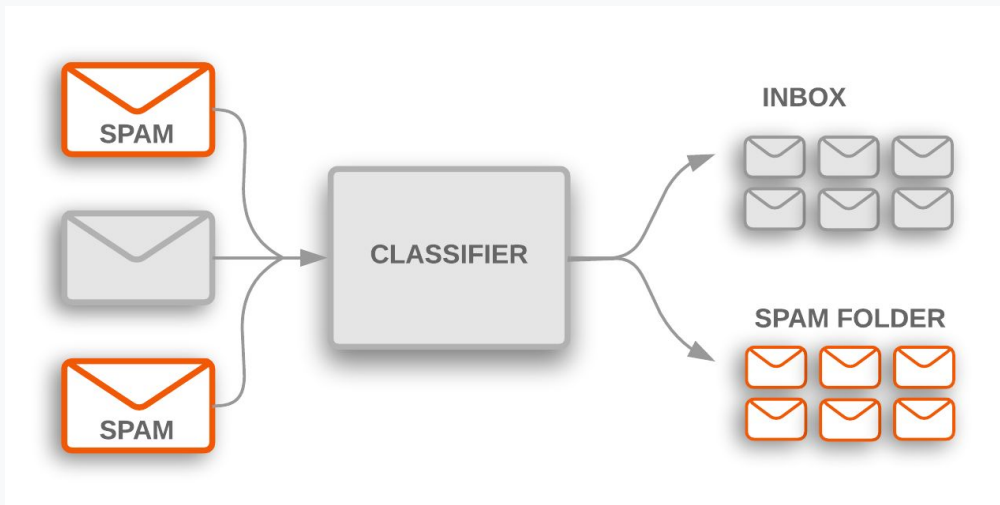
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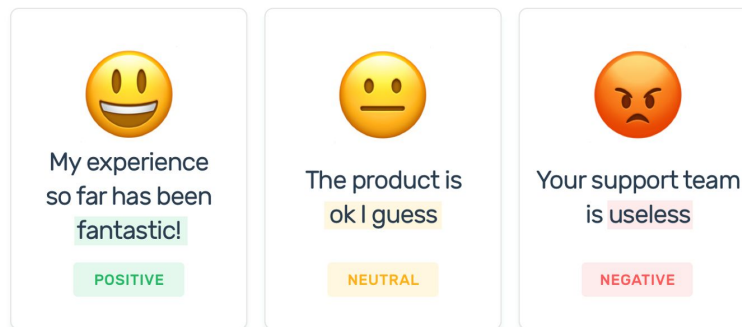
- Text representation is the process of converting unstructured text data into a structured format that can be used for natural language processing tasks.
- It involves selecting a suitable representation scheme, such as bag-of-words, word embeddings, or topic models, to capture the key features and characteristics of the text data in a numerical form that can be processed by machine learning algorithms.

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Sentiment Analysis



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Input Article

Marseille, France (CNN) The French prosecutor leading an investigation into the crash of Germanwings Flight 9525 insisted Wednesday that he was not aware of any video footage from on board the plane. Marseille prosecutor Brice Robin told CNN that "so far no videos were used in the crash investigation." He added, "A person who has such a video needs to immediately give it to the investigators." Robin's comments follow claims by two magazines, German daily Bild and French Paris Match, of a cell phone video showing the harrowing final seconds from on board Germanwings Flight 9525 as it crashed into the French Alps. All 150 on board were killed. Paris Match and Bild reported that the video was recovered from a phone at the wreckage site. ...

Abstractive summarization

Text Summarization Models

Extractive summarization

Generated summary

Prosecutor : " So far no videos were used in the crash investigation "

Extractive summary

marseille prosecutor brice robin told cnn that " so far no videos were used in the crash investigation . " robin 's comments follow claims by two magazines , german daily bild and french paris match , of a cell phone video showing the harrowing final seconds from on board germanwings flight 9525 as it crashed into the french alps . paris match and bild reported that the video was recovered from a phone at the wreckage site .

Sentence having the right answer

'context': 'Beyoncé Giselle Knowles-Carter (/bi:ˈjɒnsər/ bee-YON-say) (born September 4, 1981) is an American singer, songwriter, record producer and actress. Born and raised in Houston, Texas, she performed in various singing and dancing competitions as a child, and rose to fame in the late 1990s as lead singer of R&B girl-group Destiny's Child. Managed by her father, Mathew Knowles, the group became one of the world's best-selling girl groups of all time. Their hiatus saw the release of Beyoncé's debut album, Dangerously in Love (2003), which established her as a solo artist worldwide, earned five Grammy Awards and featured the Billboard Hot 100 number-one singles "Crazy in Love" and "Baby Boy".',
'text': 'in the late 1990s'
'question': 'When did Beyonce start becoming popular?'

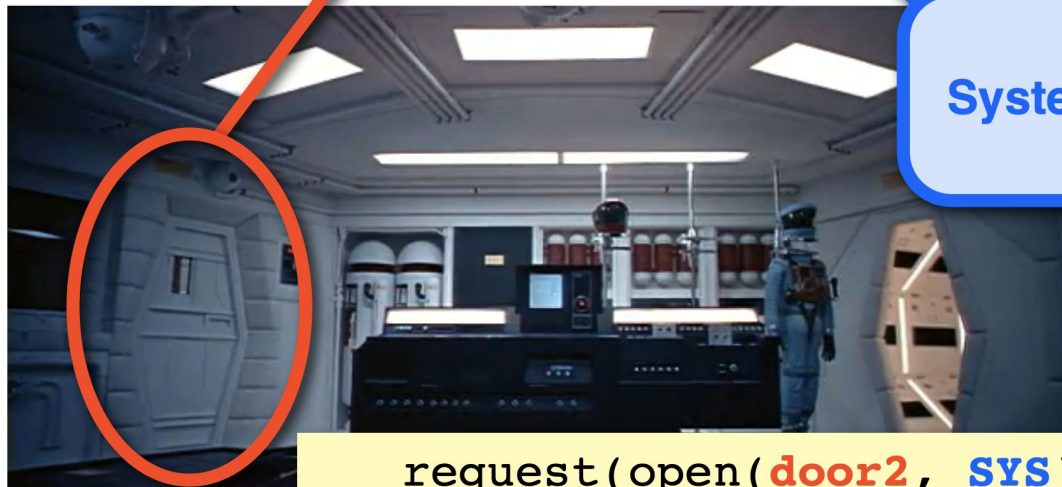
Exact Answer

Common NLP tasks

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Multimodal NLP: mapping from language to the world

$\exists x \exists y (\text{pod_door}(x) \ \& \ \text{Hal}(y) \ \& \ \text{request}(\text{open}(x, y)))$

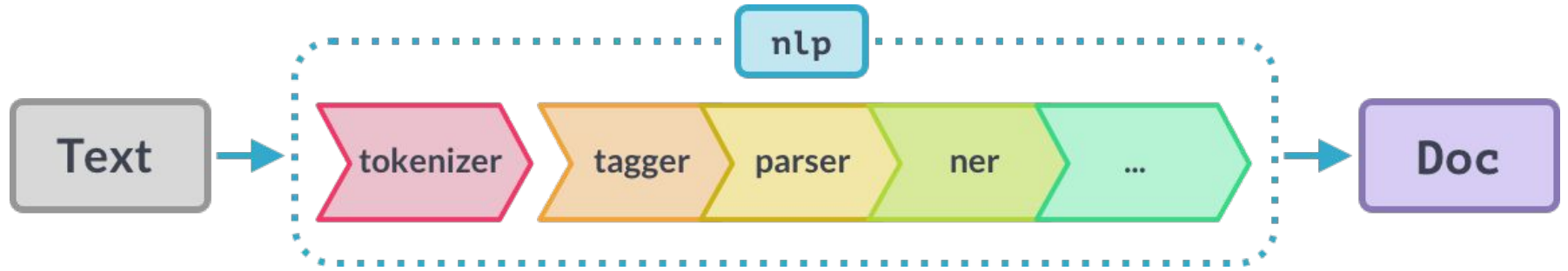


$\text{request}(\text{open}(\text{door2}, \text{SYS}))$

spaCy Package

spaCy is an open-source library used for natural language processing in python. It is extremely popular for processing a large amount of unstructured data generated at a vast scale in the industry and generate useful and meaningful insights from the data.

spaCy NLP Pipeline



Let's code

[Colab](#)

Assignment

[Colab](#)

Thank you.

Appendix