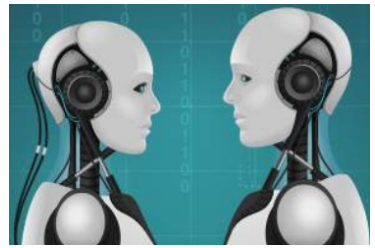
COMP5423 Natural Language Processing

Introduction to Natural Language Process (Part 1)

Introduction to NLP

Communication

- Human-to-Human
- Human-to-Machine
- Machine-to-Machine



Language is a medium of communication that helps us expressing and conveying our thoughts, feelings, and emotions.

Introduction to NLP

- **Natural Language Processing (NLP)**

Natural Language

Human Language

Retrieve the birth date and address of the employee(s) whose name is 'John B. Smith'.

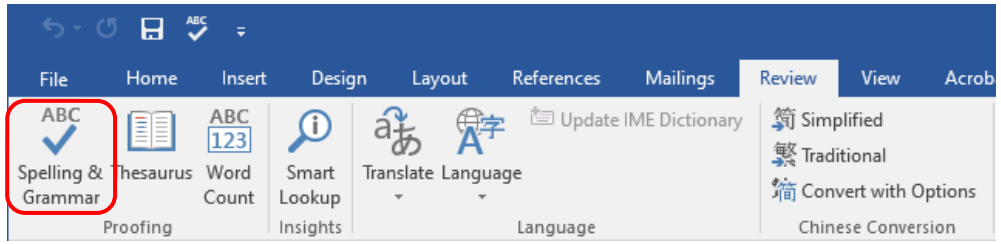
```
SELECT   Bdate, Address
FROM     EMPLOYEE
WHERE    Fname='John' AND Minit='B' AND Lname='Smith';
```

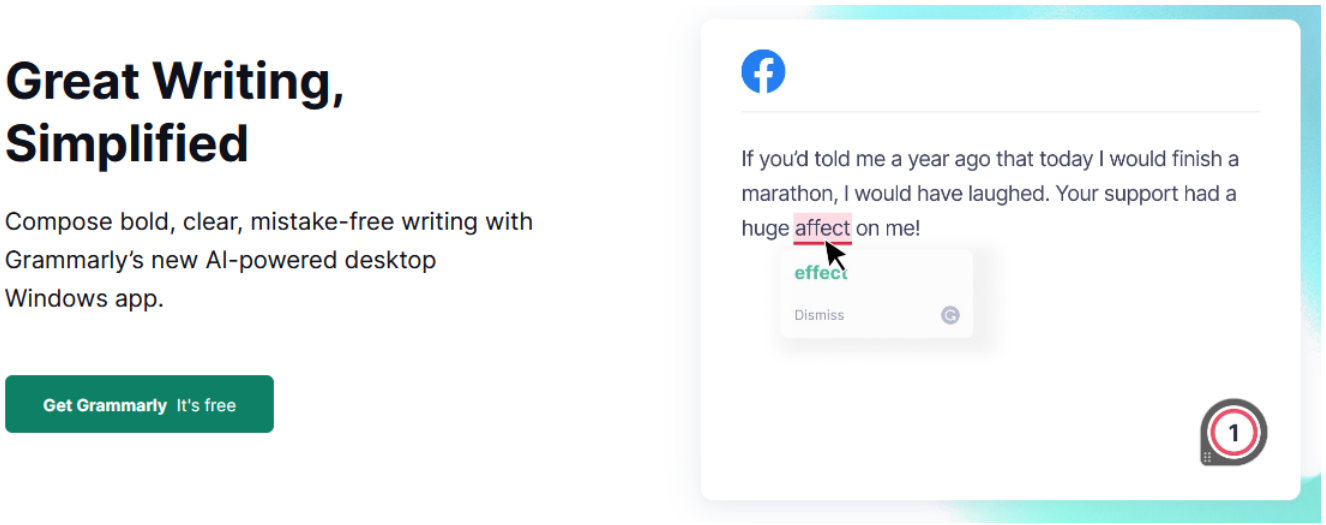
Processing

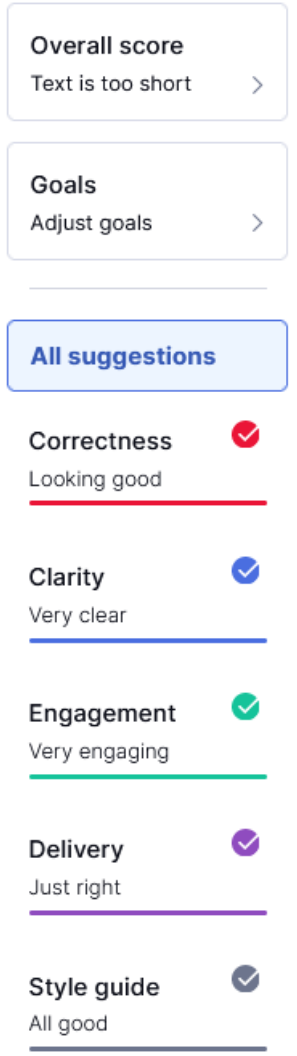
Application of Computational Techniques to the Analysis of Natural Language

Introduction to NLP

- **Applications of NLP**
  - Spelling and Grammar Check

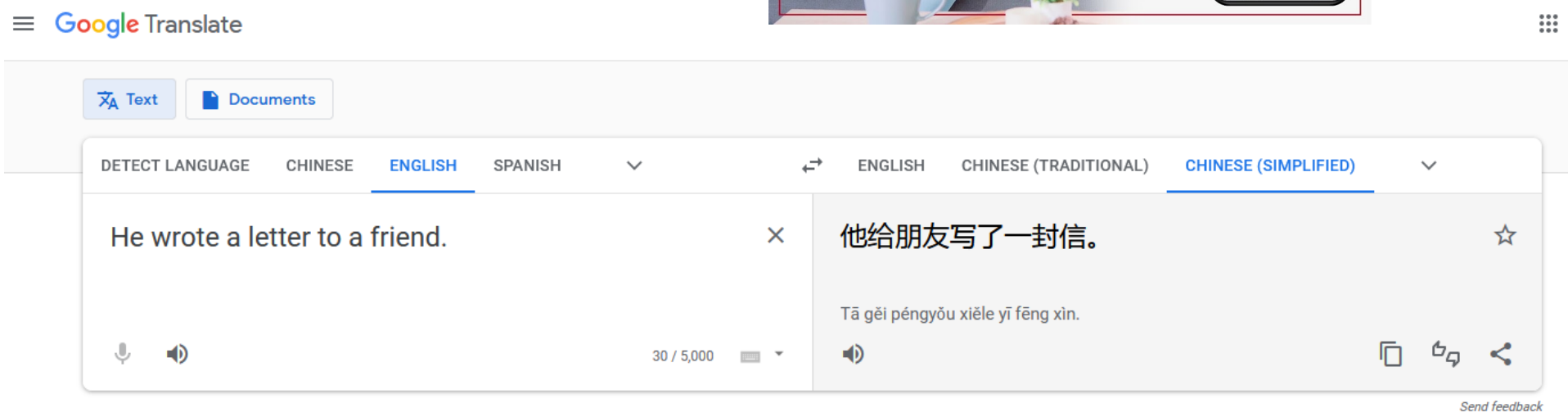






Introduction to NLP

- **Applications of NLP**
  - Machine Translation (MT)



Google Translate was launched in April 2006 as a statistical machine translation service. As of December 2024, it supports 249 languages.

Introduction to NLP

- **Applications of NLP**
  - Question Answering (QA)

Passage 1

Bacteria are extremely small living things. While we measure our own sizes in inches or centimeters, bacterial size is measured in microns. One micron is a thousandth of a millimeter a pinhead is about a millimeter across. Rod shaped bacteria are usually from two to tour microns long, while rounded ones are generally one micron in diameter Thus if you enlarged a founded bacterium a thousand times, it would be just about the size of a pinhead. An adult human magnified by the same amount would be over a mile(1.6 kilometers) tall.

Even with an ordinary microscope, you must look closely to see bacteria. Using a magnification of 100 times, one finds that bacteria are barely visible as tiny rods or dots One cannot make out anything of their structure. Using special stains, one can see that some bacteria have attached to them wavy - looking "hairs" called flagella. Others have only one flagellum. The flagella rotate, pushing the bacteria though the water. Many bacteria lack flagella and cannot move about by their own power while others can glide along over surfaces by some little understood mechanism.

From the bacterial point of view, the world is a very different place from what it is to humans To a bacterium water is as thick as molasses is to us. Bacteria are so small that they are influenced by the movements of the chemical molecules around them. Bacteria under the microscope, even those with no flagella, often bounce about in the water. This is because they collide with the water molecules and are pushed this way and that. Molecules move so rapidly that within a tenth of a second the molecules around a bacterium have all been replaced by new ones even bacteria without flagella are thus constantly exposed to a changing environment.

Multiple Choice QA

1. Which of the following is the main topic of the passage?
(A) The characteristics of bacteria (B) How bacteria reproduce
(C) The various functions of bacteria (A) How bacteria contribute to disease

2. Bacteria are measured in
(A) inches (B) centimeters (C) microns (D) millimeters

3. Which of the following is the smallest?
(A) A pinhead (B) A rounded bacterium
(C) A microscope (D) A rod-shaped bacterium

4. According to the passage, someone who examines bacteria using only a microscope that magnifies 100 times would see
(A) tiny dots (B) small "hairs"
(C) large rods (D) detailed structures

5. The relationship between a bacterium and its flagella is most nearly analogous to which of the following?
(A) A rider jumping on a horse's back (B) A ball being hit by a bat
(C) A boat powered by a motor (D) A door closed by a gust of wind

6. In line 16, the author compares water to molasses, in order to introduce which of the following topics?
(A) The bacterial content of different liquids
(B) What happens when bacteria are added to molasses
(C) The molecular structures of different chemicals
(D) How difficult it is for bacteria to move through water

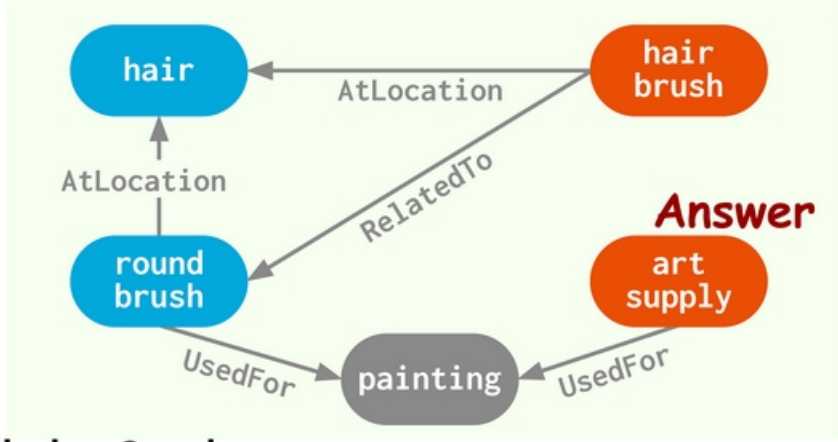
Introduction to NLP

- **Applications of NLP**
  - Question Answering (QA)

Document-based QA (DBQA)

If it is not used for **hair**, a **round brush** is an example of what?

A. hair brush B. bathroom C. **art supplies*** D. shower



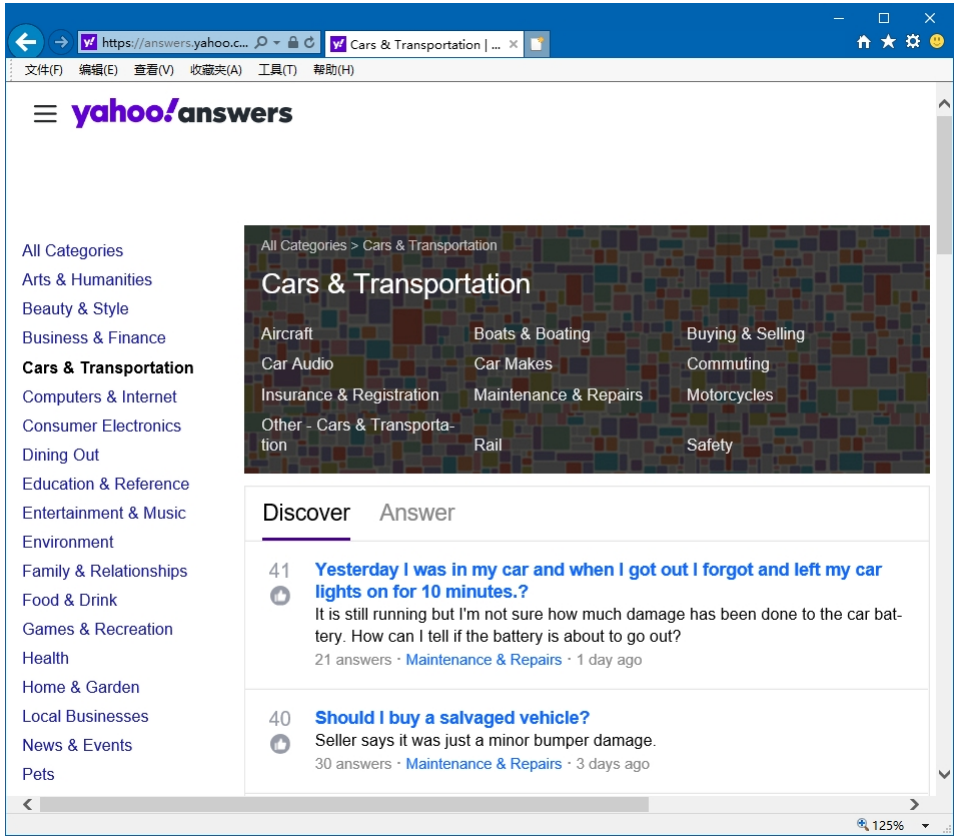
Knowledge Graph

Knowledge-based QA (KBQA)

Introduction to NLP

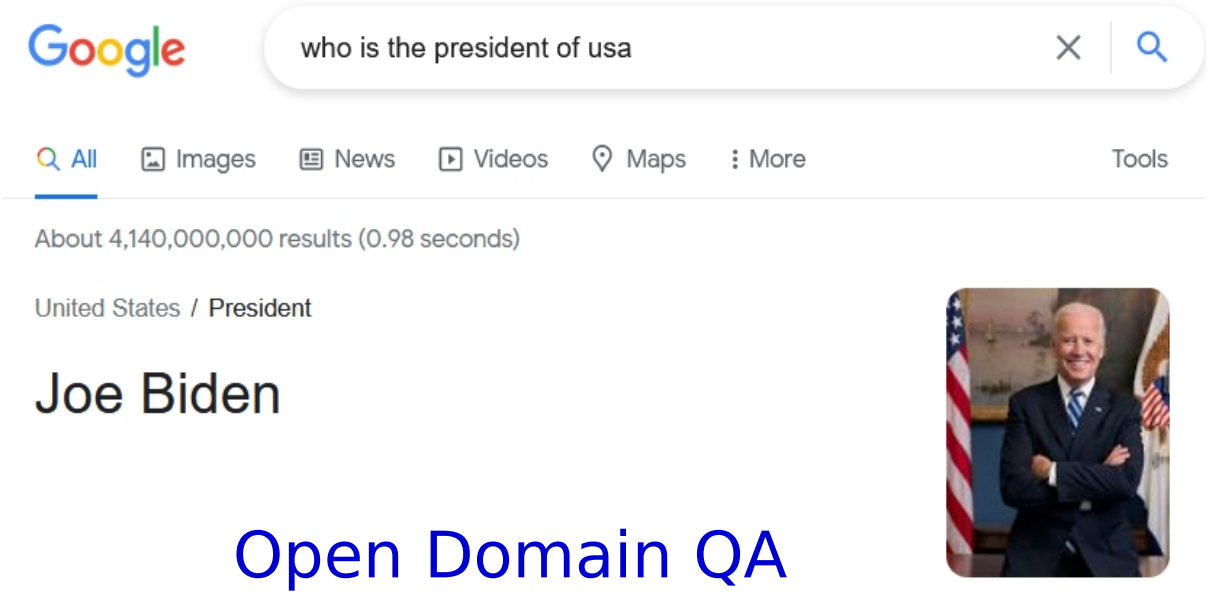
- **Applications of NLP**
  - Question Answering (QA)

Community QA



Introduction to NLP

- **Applications of NLP**
  - Question Answering (QA)

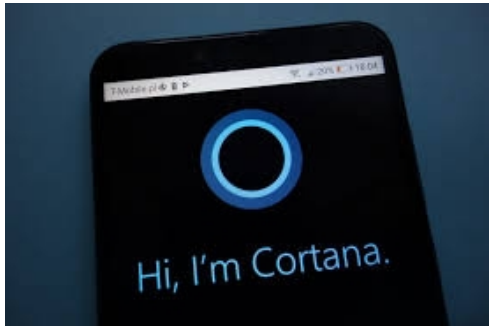


Open Domain QA

Introduction to NLP

- **Applications of NLP**
  - Dialogue Systems (aka. Chatbots)

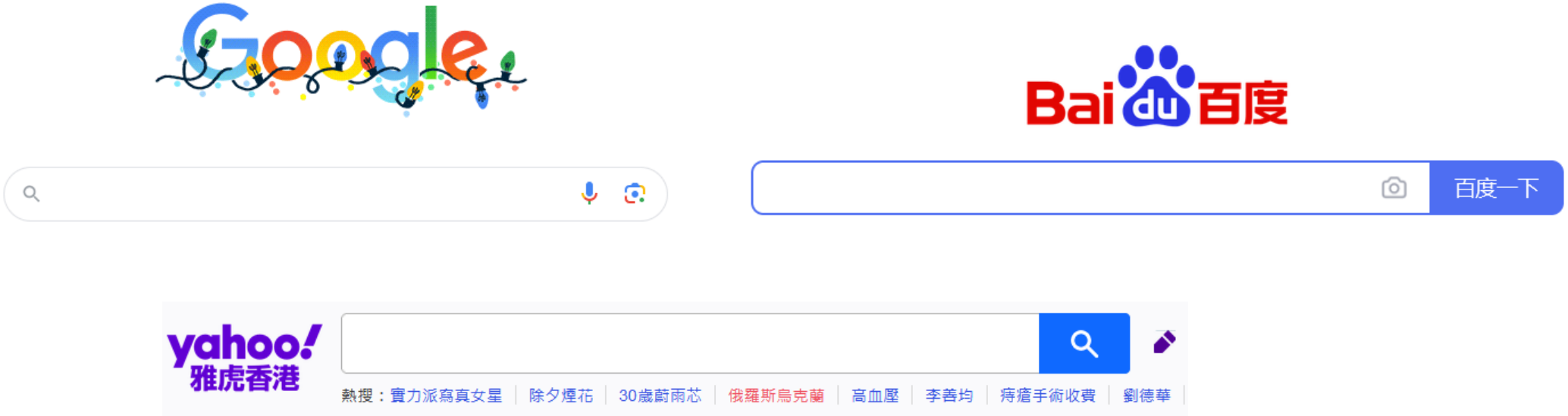
Google Assistant



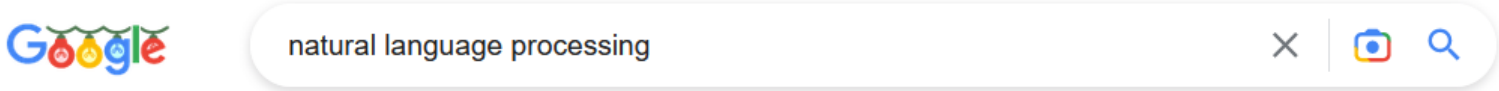
Task-Oriented vs. Non-Task-Oriented (Social-Oriented)

Introduction to NLP

- **Applications of NLP**
  - Web Search



Snippets



https://en.wikipedia.org › wiki › Natural_language_pro...

Natural language processing - Wikipedia

Natural language processing (**NLP**) is an interdisciplinary subfield of linguistics, computer science, and artificial intelligence concerned with the ...

Language processing · History of natural language... · Language understanding

You've visited this page many times. Last visit: 2/18/22

https://www.ibm.com › Cloud › Cloud Learn

What is Natural Language Processing? - IBM

2 Jul 2020 — **Natural language processing** (**NLP**) refers to the branch of computer science—and more specifically, the branch of artificial intelligence or AI— ...

What is natural language... · NLP tasks · NLP tools and approaches

You've visited this page 2 times. Last visit: 12/21/22

https://www.techtarget.com › searchenterpriseai › definition

What is Natural Language Processing? An Introduction to NLP

Natural language processing (**NLP**) is the ability of a computer program to understand human language as it is spoken and written -- referred to as natural ...

https://www.sas.com › SAS Insights › Analytics Insights

Natural Language Processing (NLP): What it is and why ... - SAS

Natural language processing helps computers communicate with humans in their own language and scales other language-related tasks. For example, **NLP** makes it ...

You visited this page on 12/21/22.

https://www.oracle.com › ... › Autonomous Database

What is Natural Language Processing (NLP)? - Oracle

Natural language processing (NLP) is a branch of artificial intelligence (AI) that enables computers to comprehend, generate, and manipulate human language.

https://www.nltk.org

NLTK :: Natural Language Toolkit

Natural Language Processing with Python provides a practical introduction to programming for language processing. Written by the creators of NLTK, ...

natural language processing

All | Images | Books | News | Videos | More | Tools

About 579,000,000 results (0.35 seconds)

Natural language processing (NLP) is a branch of artificial intelligence (AI) that enables computers to comprehend, generate, and manipulate human language. Natural language processing has the ability to interrogate the data with natural language text or voice.

Oracle
https://www.oracle.com › ... › Artificial Intelligence

What is Natural Language Processing (NLP)? - Oracle

About featured snippets • Feedback

People also ask

- What is NLP and example?
- Is NLP an AI?
- What are the 5 steps in NLP?
- Is NLP part of deep learning?

Feedback

Wikipedia
https://en.wikipedia.org › wiki › Natural_language_pr...

Natural language processing

Natural language processing (**NLP**) is an interdisciplinary subfield of computer science and linguistics. It is primarily concerned with giving computers the ...

Language processing · Language generation · The history of natural... · NLP

Scholarly articles for **natural language processing**

Natural language processing - Chowdhary - Cited by 2467

Natural language processing: an introduction - Nadkarni - Cited by 1553

Natural language processing: a historical review - Jones - Cited by 240

Natural language processing

Natural language processing is an interdisciplinary subfield of computer science and linguistics. It is primarily concerned with giving computers the ability to support and manipulate human language.
Wikipedia

books Natural language processing — View 5+ more


Natural Language Processi...


Speech and Languag...


Foundation of Statistica...


Natural Language Processi...

People also search for — View 10+ more


Artificial intelligence


Machine learning

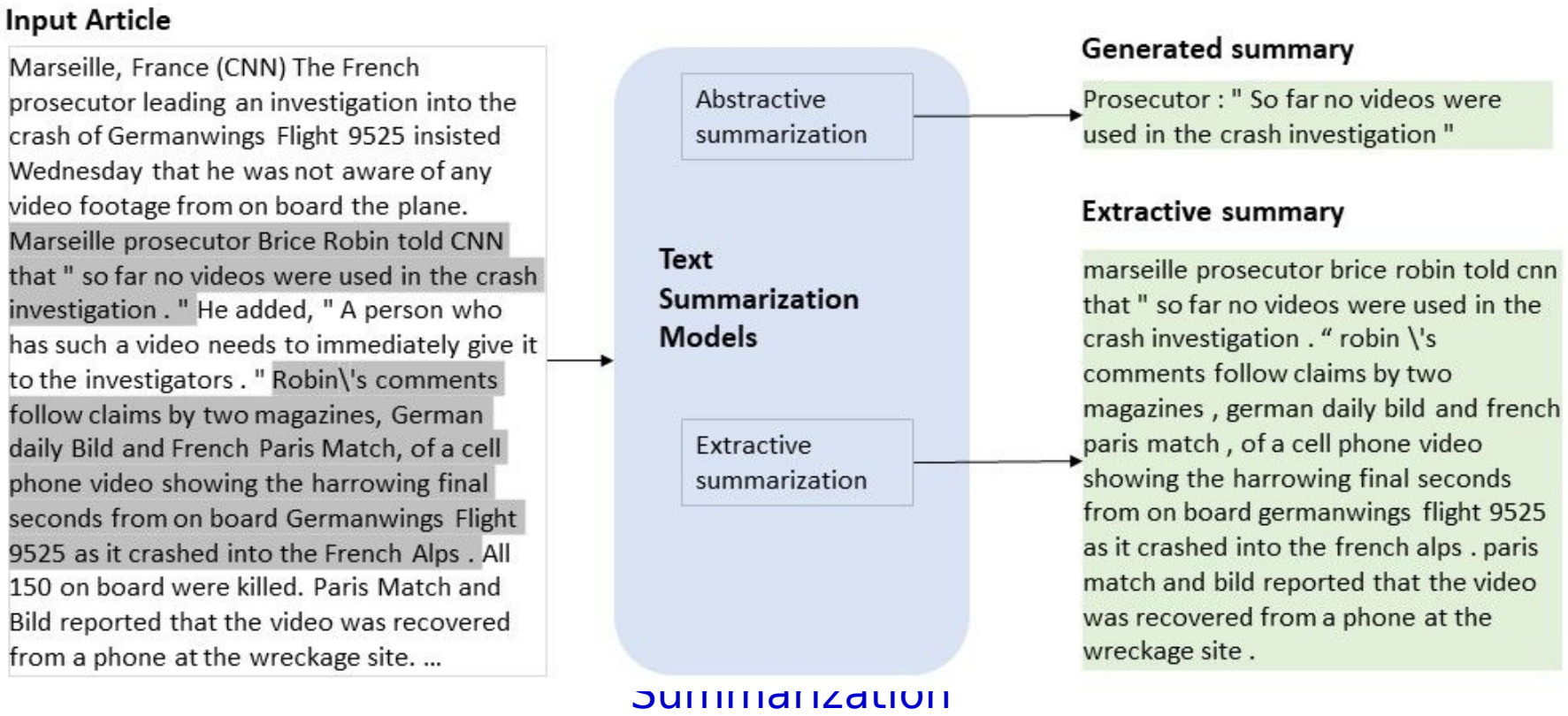

Data science

Learning

Applications of Natural Language Processing

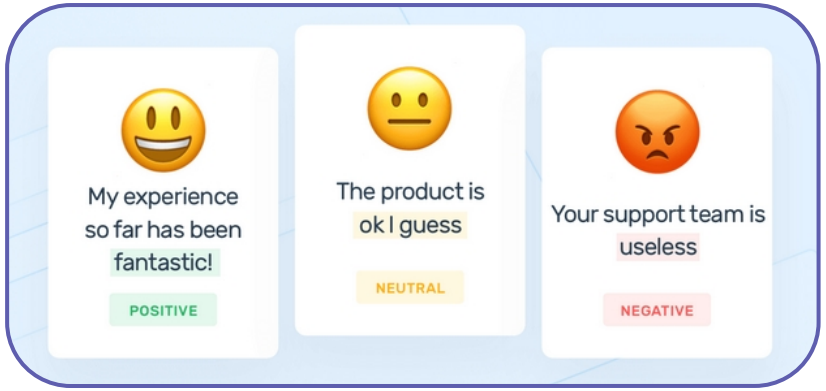
Introduction to NLP

- **Applications of NLP**
  - Automatic Text Summarization

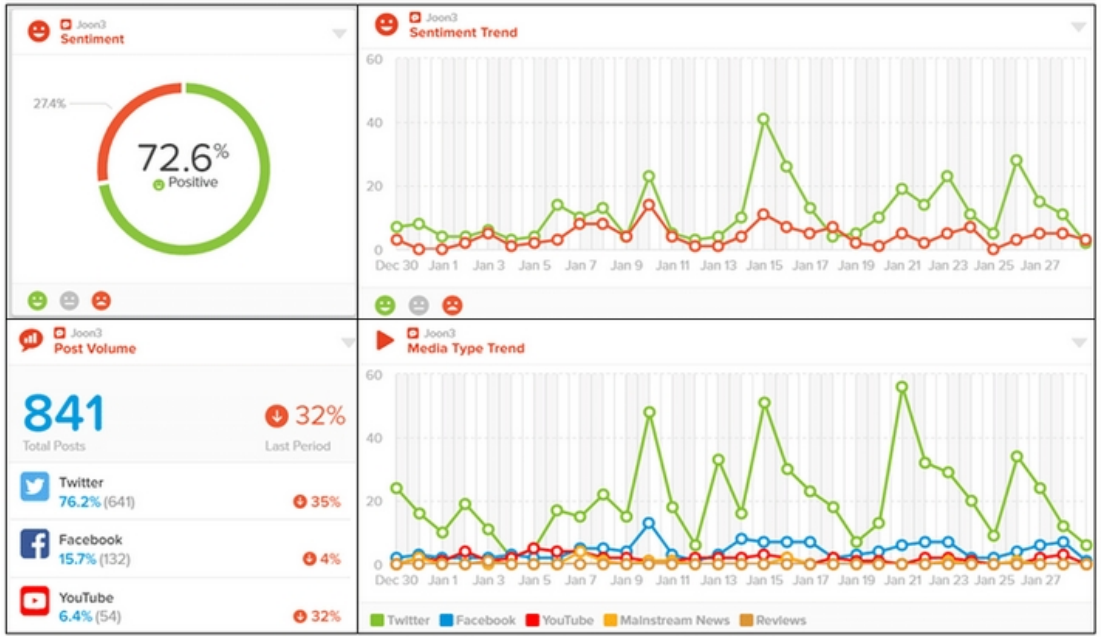


Introduction to NLP

- **Applications of NLP**
  - Social Medial Monitoring



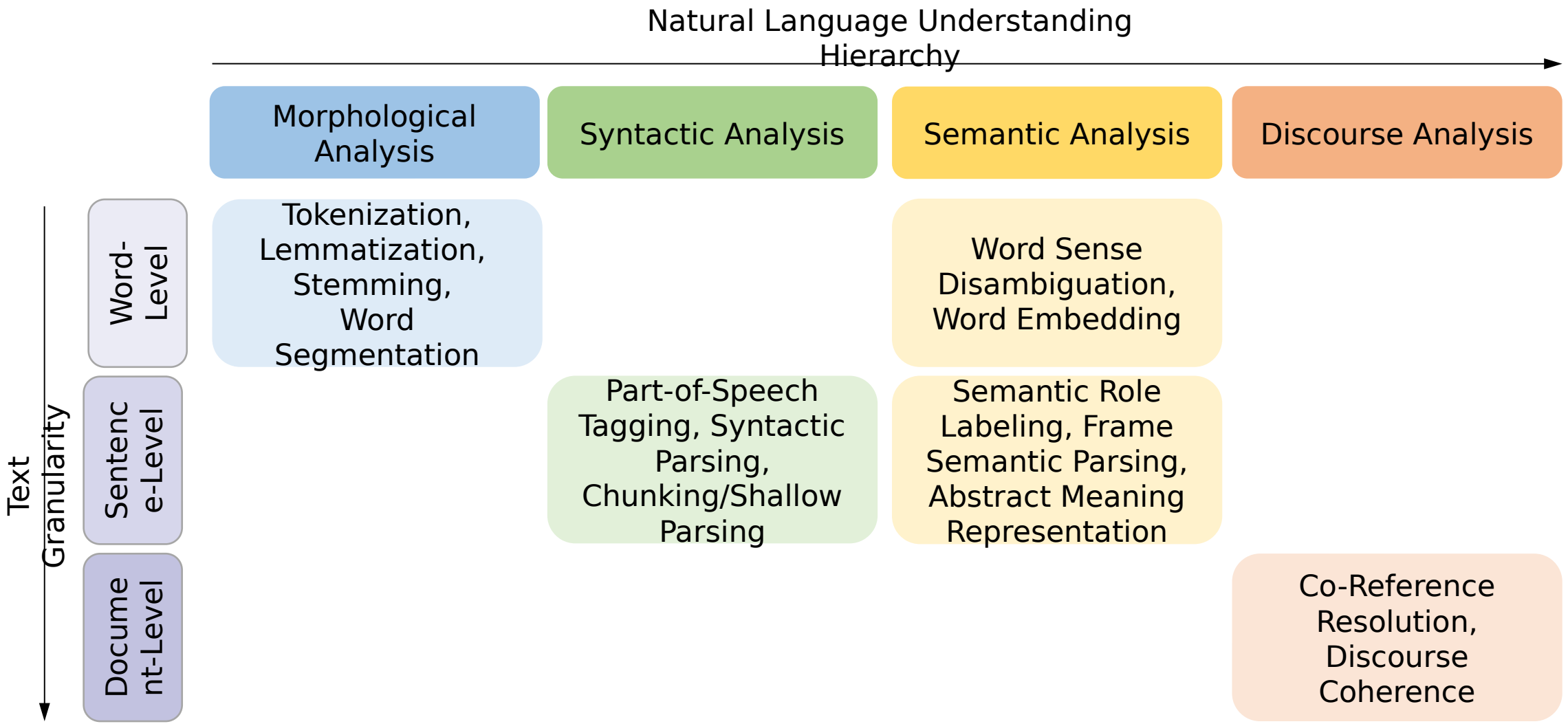
Sentiment Classification



Introduction to NLP

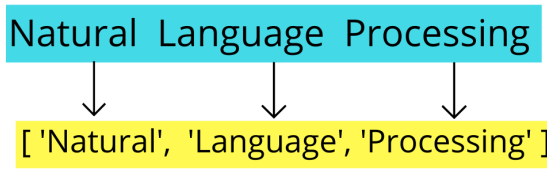
- **Tasks in NLP**
  - Two Fundamental Tasks
    - Natural Language Understanding
    - Natural Language Generation

Introduction to NLP



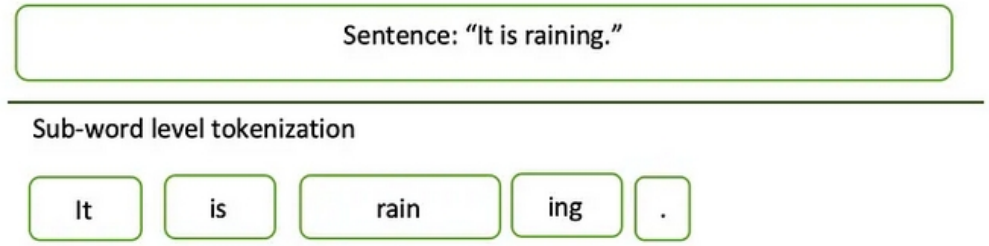
Introduction to NLP

Tokenization/Segmentation



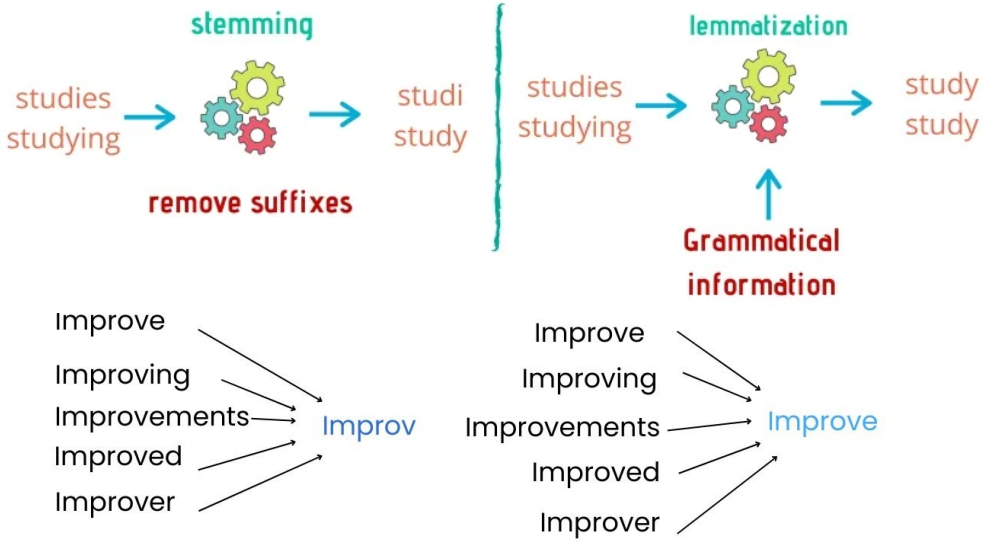
下雨天留客天留我不留

下雨，天留客。天留，我不留！
下雨天，留客天。留我不，留！



Given a sequence of characters, word tokenization is the task of chopping it up into pieces, called word tokens. Word tokenization in Chinese is known as Chinese Word Segmentation, identifying the boundaries of

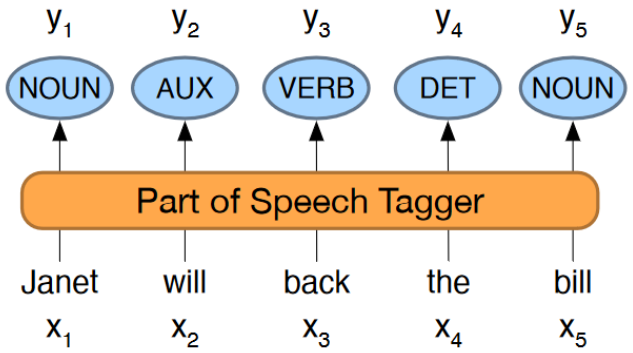
Lemmatization/Stemming



Lemmatization is to reduce inflectional forms (surface form) and sometimes derivationally related forms of a word to a common lemmatized (base, root) form or lemma. Stemming is a naive version of morphological analysis which simply strip

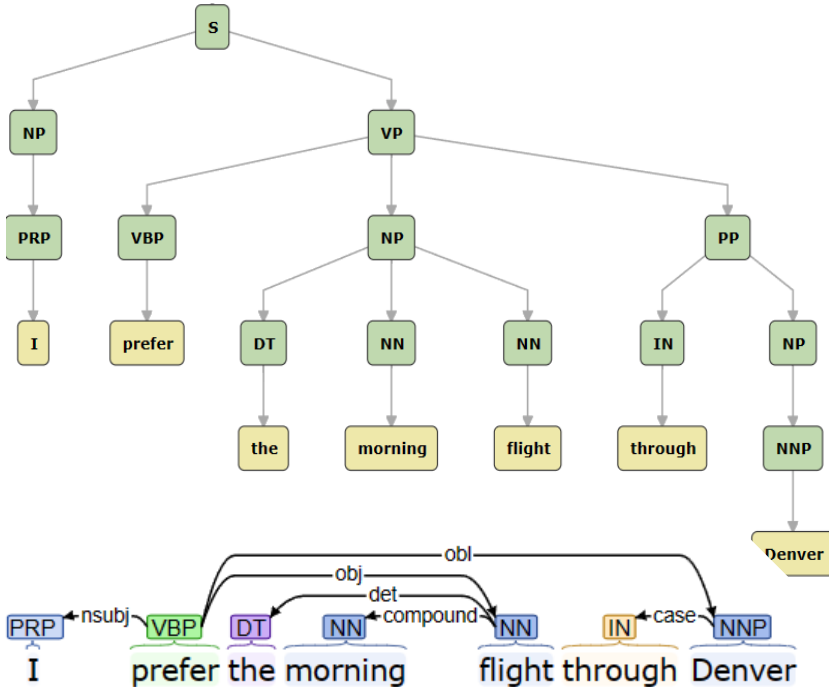
Introduction to NLP

Part-of-Speech Tagging



Part-of-Speech (for short POS) is the name for a group words, which have similar grammatical functions, such as noun, verb, pronoun, proposition, adverb, and conjunction, etc. Part-of-Speech tagging is a task of assigning a Part-of-Speech tag (like noun, verb, adjectives) to each word in a sentence.

Syntactic Parsing



Syntactic parsing to assign a syntactic structure to a sentence. Constituency parsing focuses on the constituent (phrase) structure, while dependency parsing describes the syntactic structure with of the grammatical relations that

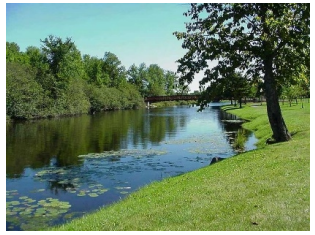
Chunking/Shallow (Partial) Parsing

[$_{NP}$ The morning flight] from [$_{NP}$ Denve
[$_{VP}$ has arrived].

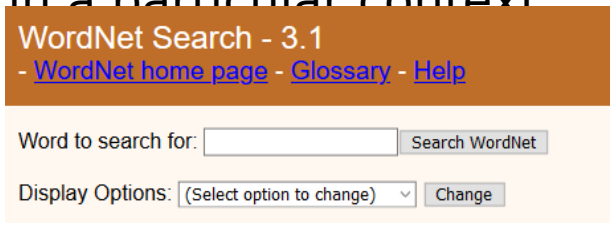
Chunking is to identify the non-overlapping segments of a sentence, such as noun phrases, verb phrases, adjective phrases, and prepositional phrases.

Introduction to NLP

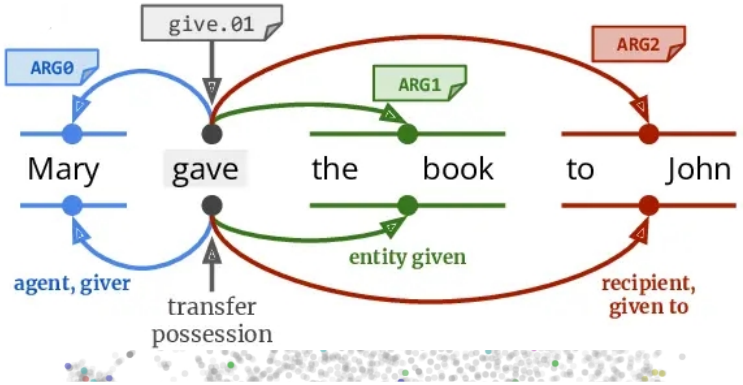
Word Sense Disambiguation



Most words have many different senses. Word sense disambiguation (WSD) is a task of determining which sense of a word is being used in a particular context



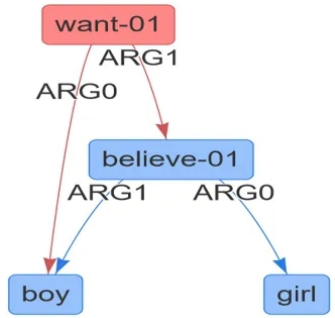
Semantic Role Labeling



Semantic role labeling is the task of assigning roles to spans in sentences, such as predicate, agent, patient, time, location, and instrument, etc.

Word Embeddings

Abstract Meaning Representation (AMR) Parsing



Abstract Meaning Representation (AMR) is a semantic representation language. AMR graphs are rooted, labeled, directed, acyclic graphs (DAGs), comprising whole sentences.

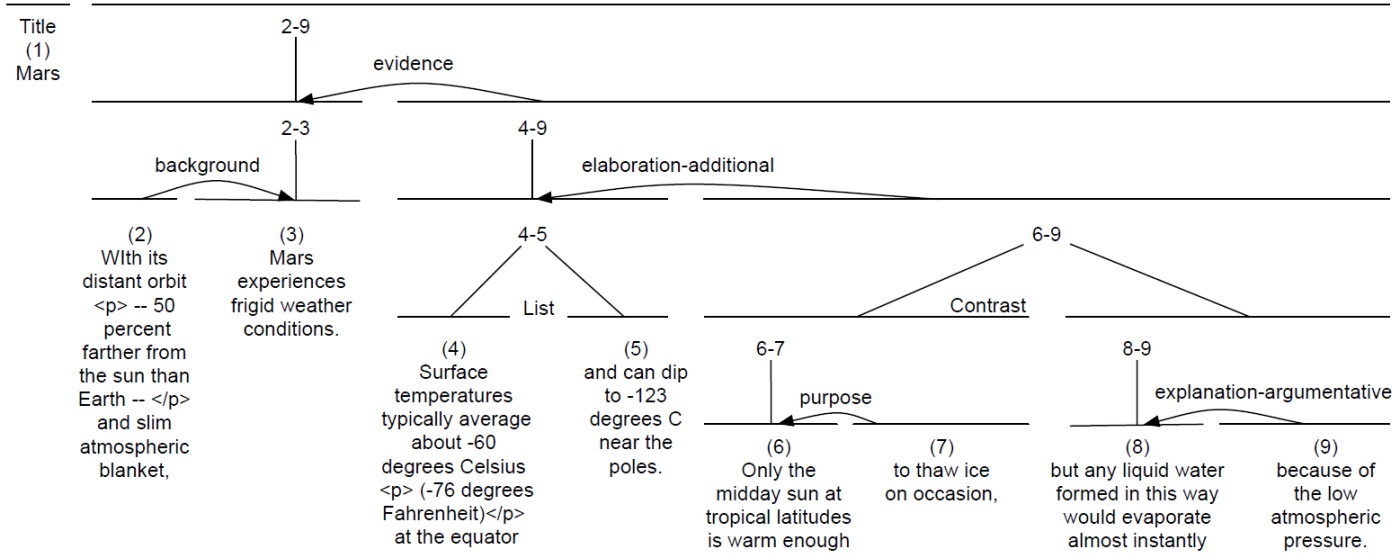
Introduction to NLP

Co-Reference Resolution

0 Paul Allen was born on January 21 , 1953 , in 1 Seattle , Washington , to Kenneth Sam Allen and Edna Faye Allen . 0 Allen attended Lakeside School , a private school in 1 Seattle , where 0 he befriended 2 Bill Gates , two years younger , with whom 0 he shared an enthusiasm for computers . 3 0 Paul and 2 Bill used a teletype terminal at 3 their high school , Lakeside , to develop 3 their programming skills on several time - sharing computer systems .

In information extraction (IE), a (named) entity is a real-world object, such as a person, location, organization, product, etc., that can be denoted with a proper name. Co-reference resolution is the task of determining whether two mentions (of entities) co-refer.

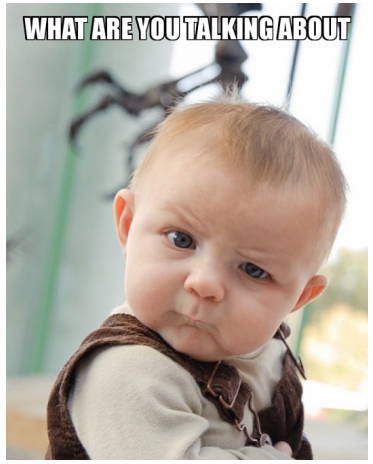
Discourse Coherence



Coherent discourses are structured by coherence relations that hold between text units, e.g., defined in Rhetorical Structure Theory (RST) . Given a sequence of sentences, the task of automatically determining the coherence relations between Elementary Discourse Units (EDU, Nuclear or Satellite) is called RST parsing.

Introduction to NLP

Why do we care about coherence of a discourse?



John wanted to buy a piano for his living room.

Jenny also wanted to buy a piano.

He went to the piano store.

It was nearby.

The living room was on the second floor.

She didn't find anything she liked.

The piano he bought was hard to get up to that floor.

Entity-based Coherence

Introduction to NLP

- **Tasks in NLP**
  - Natural Language Understanding
    - Morphological/Lexical Analysis
      - Morphological knowledge concerns how words are constructed from morphemes.
      - Key Concepts: Tokenization, Stemming/Lemmatization, Chinese Word Segmentation

Introduction to NLP

- **Tasks in NLP**
  - Natural Language Understanding
    - Syntactic Analysis
      - Syntactic knowledge concerns how words can be put together to form correct sentences and determines what structural role each word plays in the sentence and what phrases are subparts of what other phrases.
      - Key Concepts: Part-of-Speech (POS) Tagging, Syntactic Parsing (Constituency Parsing, Dependency Parsing), Chunking, Context-Free Grammar (aka. Phrase-Structure Grammar)

Introduction to NLP

- **Tasks in NLP**
  - Natural Language Understanding
    - Semantic Analysis
      - Semantic knowledge concerns what words mean and how these meanings combine in sentences to form sentence meanings.
      - Key Concepts: Word Sense Disambiguation, Word Embedding, Semantic Role Labeling, Frame Semantic Parsing, Abstract Meaning Representation, First Order Logic (aka. Predicate Calculus)

Introduction to NLP

- **Tasks in NLP**
  - Natural Language Understanding
    - Discourse Analysis
      - Discourse knowledge concerns how the immediately preceding sentences affect the interpretation of the next sentence.
      - Key Concepts: Co-Reference Resolution, Discourse Coherence

Introduction to NLP

- **Tasks in NLP**

Natural Language Understanding
(Reading)

Natural Language Generation
(Writing)

Introduction to NLP

- **Tasks in NLP**
  - Natural Language Generation
    - Context-Free Grammar (aka. Phrase-Structure Grammar) is the most widely used formal system for modeling constituent structure in natural languages.

Lexicon: Words (such as fly, Sunday) and Syntactic Symbols (such as Noun (denoted as N), Noun Phrase (denoted as NP))

Rules (or Productions): Each expresses the ways that words and symbols of the language can be grouped and ordered together.

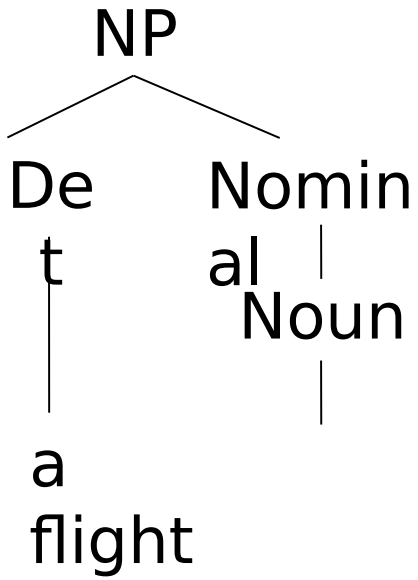
Introduction to NLP

A CFG can be thought of in two ways.

- As a device for assigning a structure to a given sentence
- As a device for generating sentences

NP ⟹
ProperNoun
NP ⟹ Det
Nominal
Det ⟹ a
Nominal ⟹
Det ⟹ the
Noun ⟹ flight

⟹ means to rewrite the symbol on the left with the sequence of symbols on the right.



Parsing

Introduction to NLP

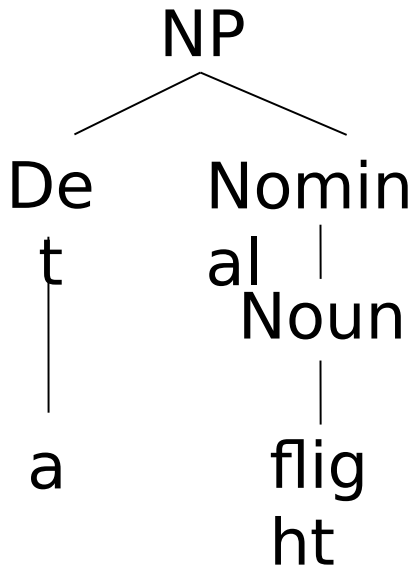
A CFG can be thought of in two ways.

- As a device for assigning a structure to a given sentence
- As a device for generating sentences

NP ⟹
ProperNoun
NP ⟹ Det
Nominal
Det ⟹ a
Nominal ⟹
Det ⟹ the
Noun ⟹ flight

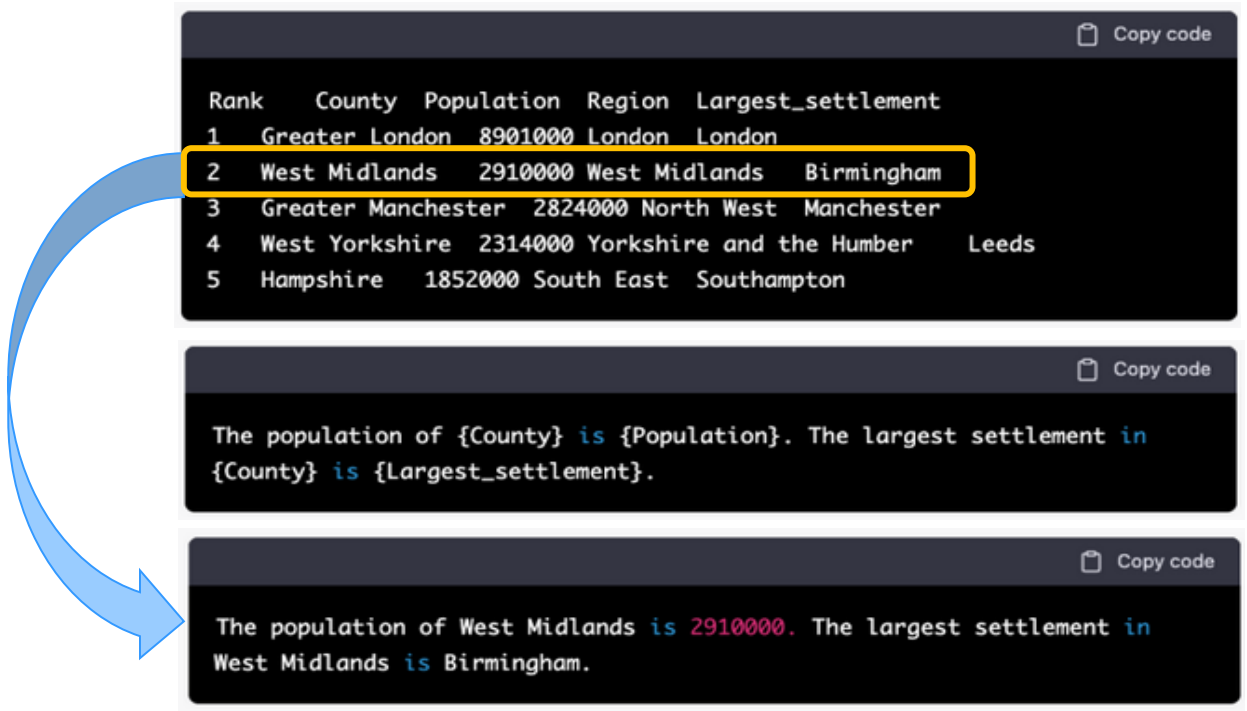
⟹ means to rewrite the symbol on the left with the sequence of symbols on the right.

Generation



Introduction to NLP

- **Tasks in NLP**
  - Natural Language Generation
    - Template based Generation



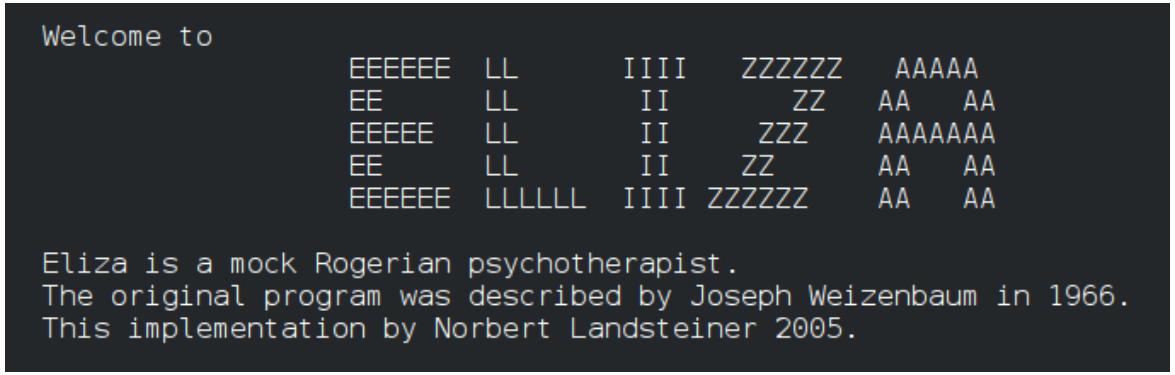
Relational Database

Pre-defined Template

Natural Language Sentence

Introduction to NLP

- **Tasks in NLP**
  - Natural Language Generation
    - Pattern Recognition and Transformation Rules

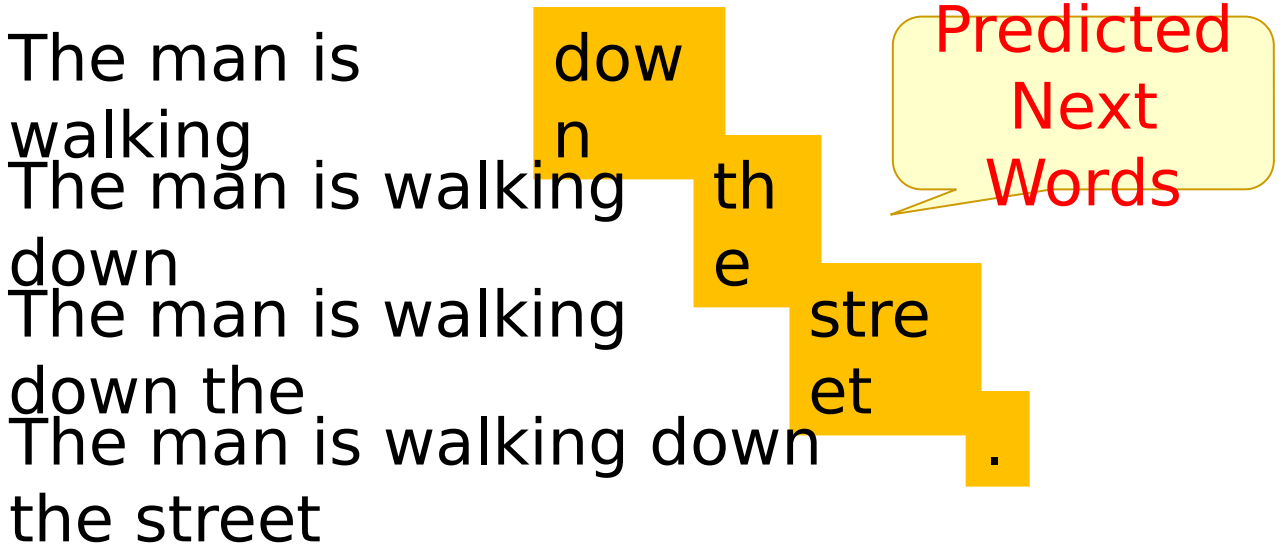


You hate me

WHAT MAKES YOU THINK I HATE YOU

Introduction to NLP

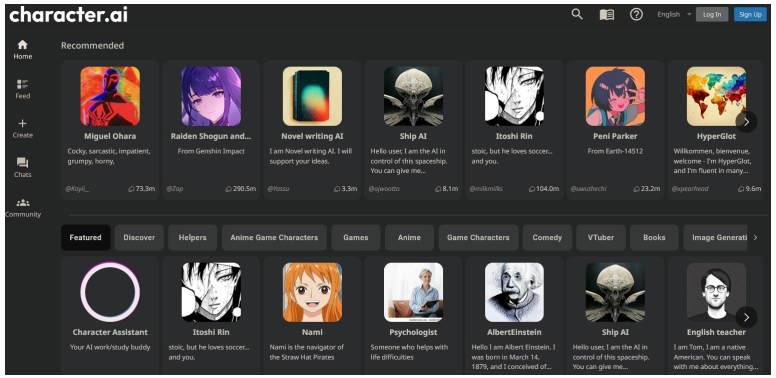
- **Tasks in NLP**
  - Natural Language Generation
    - Statistical (*N*-Gram) or Neural Language Model based Generation (Word-by-Word Generation)



* In 1980, the first significant statistical language model was proposed.

Introduction to NLP

- **Tasks in NLP**
  - Natural Language Generation
    - Application Scenarios: Story Generation, Report Generation, Summary Generation, Question/Answer Generation, Response/Dialogue Generation, etc.
    - Conditional/Controllable Generation



[-] *The potato* is a plant from the family of the same name that can be used as a condiment and eaten raw. It can also be eaten raw in its natural state, though…

[Negative] *The potato* is a pretty bad idea. It can make you fat, it can cause you to have a terrible immune system, and it can even kill you…

[Positive] *The potato* chip recipe you asked for! We love making these, and I've been doing so for years. I've always had a hard time keeping a recipe secret. I think it's the way our kids love to eat them…

    - Personalized and Stylized Generation

Introduction to NLP

- **Tasks in NLP**
  - Natural Language Generation
    - Short Text (Sentence) Generation vs. Long Text (Document) Generation vs. Interactive Text (Dialogue) Generation

The man is walking down

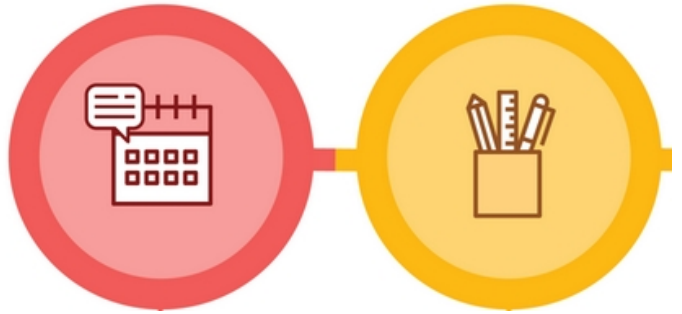
The man is walking down the

The man is walking down the street

The man is walking down the street .

Content Planning: Decides what information to include and how to structure sentences and paragraphs.

Text Generation: Creates the final output by composing huma



Introduction to NLP

- **Tasks in NLP**
  - Textual Entailment (TE) and Natural Language Inference (NLI)

Premise	Label	Hypothesis
A man inspects the uniform of a figure in some East Asian country.	Contradiction	The man is sleeping.
An older and younger man smiling.	Neutral	Two men are smiling and laughing at the cats playing on the floor.
A soccer game with multiple males playing.	Entailment	Some men are playing a sport.

Introduction to NLP

- **Tasks in NLP**
  - Information Extraction and Knowledge Graphs

(Named) Entity Recognition

In December 1903 DATE the Royal Swedish Academy of Sciences ORG awarded Marie PERSON and Pierre Curie PERSON , along with Henri Becquerel PERSON , the Nobel Prize in Physics WORK_OF_ART .

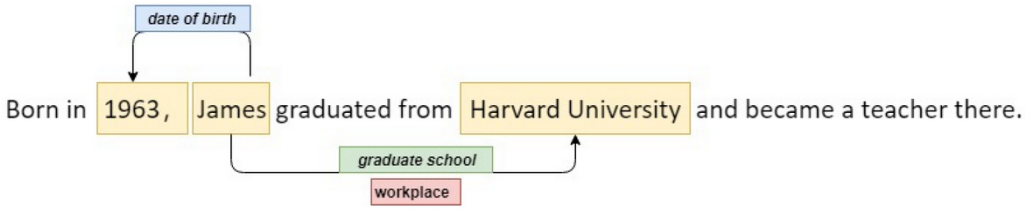
Co-Reference Resolution

0 Paul Allen was born on January 21 , 1953 , in 1 Seattle , Washington , to Kenneth Sam Allen and Edna Faye Allen . 0 Allen attended Lakeside School , a private school in 1 Seattle , where 0 he befriended 2 Bill Gates , two years younger , with whom 0 he shared an enthusiasm for computers . 3 0 Paul and 2 Bill used a teletype terminal at 3 their high school , Lakeside , to develop 3 their programming skills on several time - sharing computer systems .

A (named) entity is a real-world object, such as a person, location, organization, product, etc., that can be denoted with a proper name.

Two or more expressions (i.e., mentions) that are used to refer to the same entity are said to co-refer. Co-reference resolution is the task of determining whether two mentions

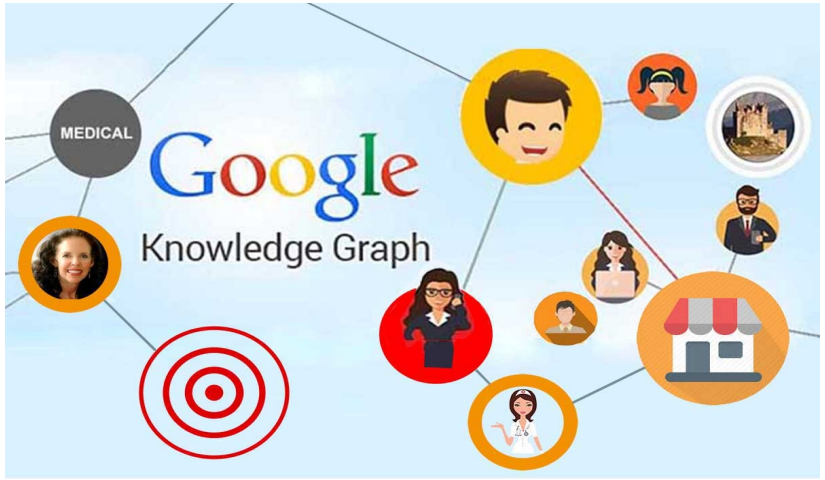
Relation Detection

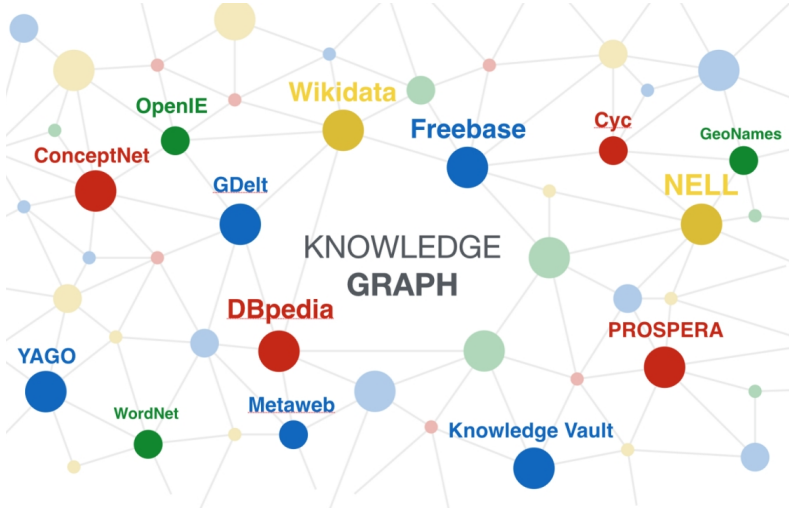


The task of relation extraction is finding and classifying semantic relations among entities mentioned in a text.

Introduction to NLP

- **Tasks in NLP**
  - Information Extraction and Knowledge Graphs





ConceptNet
An open, multilingual knowledge graph

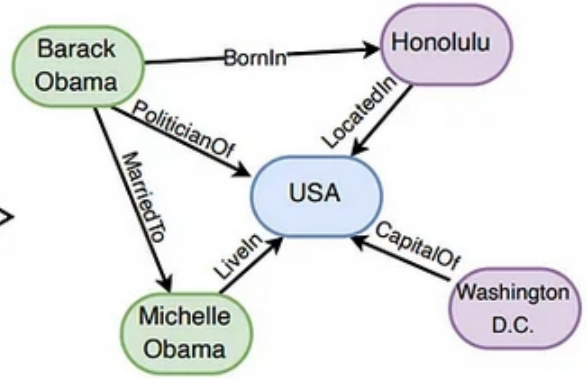
A knowledge graph represents a network of real-world entities (i.e., objects and concepts) and illustrates the relationship between them. This information is usually stored as the entity-relation-entity triples in a database and visualized as a graph structure, prompting the term knowledge “graph”.


thank you

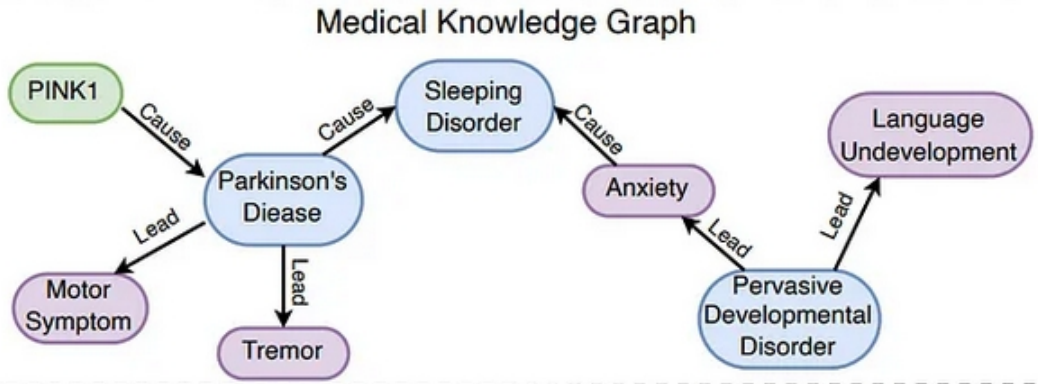
Introduction to NLP

Encyclopedic Knowledge Graphs

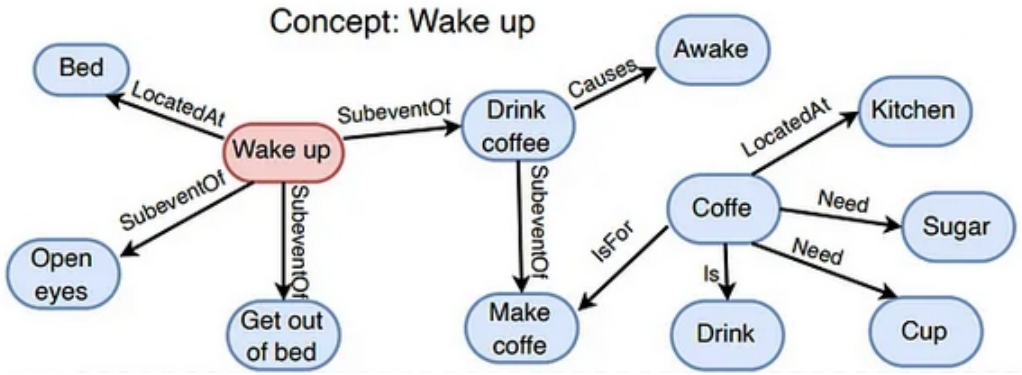
Wikipedia



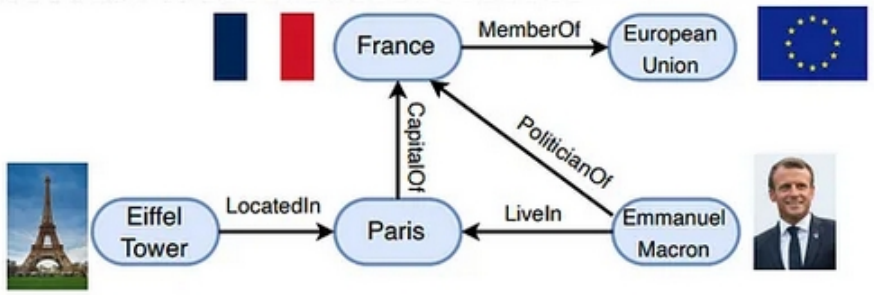
Domain-specific Knowledge Graphs



Commonsense Knowledge Graphs

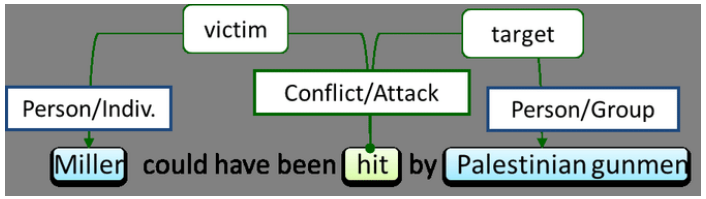


Multi-modal Knowledge Graphs



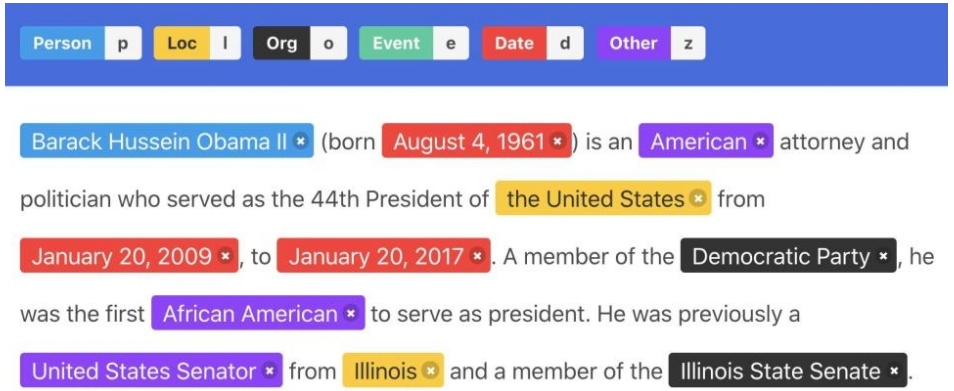
Introduction to NLP

Event Extraction



Event extraction is the task of finding events in which the entities participate.

Temporal Expression Extraction



Temporal expression recognition is a task of finding the start and end of all of the text spans that correspond to such temporal expressions. These temporal expressions can be normalized onto specific calendar dates or times of day to situate events in time.

Temporal Relation Extraction

Temporal Relation Extraction is identifying temporal relations between pairs of events and temporal expressions.