Coreference Resolution in NLP

What is Coreference Resolution?

- Coreference Resolution comes with NLP that tries to find all noun phrases refer to the same real-world entity.

- Suppose you have to find the pronouns in a sentence and replace them with relevant nouns. Coreference resolution can be used to do that.

- It finds and groups the words which refer to the same entities and replaces pronouns with noun phrases.

What is Coreference Resolution?

- Consider the following sentence.
- "I gave my laptop to Andrew because he told me that he needs it to do his assignment" Peter said.
- In Coreference Resolution first, it groups the words into several groups by considering entities. In this sentence the main entities are
- Andrew
- Peter
- Peter's Laptop

What is Coreference Resolution?

➢According to those entities, it can divide nouns and pronouns into

"I gave my laptop to Andrew because he told me that he needs it to do his assignment" Peter said.

After that, it replaces all the pronouns in the sentence with relevant nouns.

"Peter gave Peter's laptop to Andrew because Andrew told Peter that Andrew needs Peter's laptop to do Peter's assignment" Peter said.

What is Coreference Resolution?

▪ Consider the following sentence.

E.g.1 Narendra Modi, the prime minister of India communicate with common people through 'Man ki baat' program.

E.g.2 The music was so loud that it could not be enjoyed.

E.g. 3 Despite her difficulty, Swati went ahead to help him

Types of Coreference

➢ **Anaphora:** Refers to when a pronoun or other referring expression points back to a previous mention.

- For example, "Alice bought a new phone. She really likes it. The device has great features."

- In this example, the following anaphoric references occur:

- "She": This pronoun refers to "Alice", who is the person mentioned in the first sentence.

- "It": This pronoun refers to "phone", which is mentioned in the first sentence as well.

- "The device": This noun phrase also refers to "phone", continuing the reference from the first sentence.

➢ **Cataphora:** Refers to when a reference is made to a future mention.

➢ For example, in the sentence "Before she went to the store, Alice had already decided what to buy," "she" refers to "Alice" which is mentioned later.

Way to build a reference resolution system

➢ Rule based (Hobbs Algorithm)

➢Supervised algorithms (it's a classification task)

Hobb's Algorithm

- Simple syntax-based algorithm that on syntactic parser .

- Searches syntactic trees of current and preceding sentences in breadth-first, left-to-right manner.

- Stops when it finds matching NP.
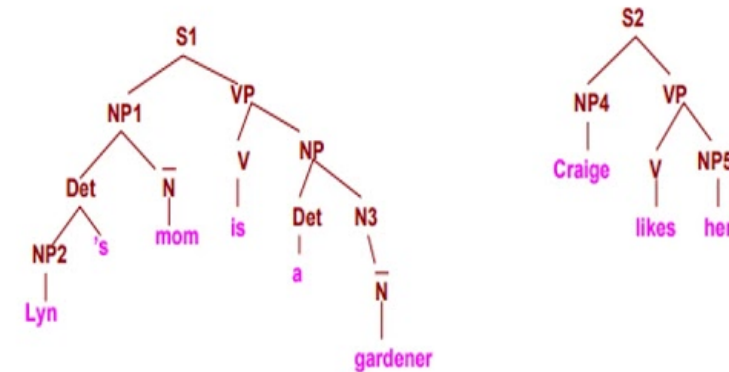
- Start search at NP5 in S2.
- Reject NP4 as no NP node between it and X (S2).
- What would have happened if the subject was *Craige's mom*?
- Move to S1. NP1 is first NP we encounter, so finish.
- Result: *Lyn's mom*

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Implementing coreference in Python

- Neural Coref library in Spacy can be used
- Hobbs algorithm code available in Github

- All anaphoric relations are not coreferential or vice versa.

E.g. We went to see a ==movie== last night. The ==tickets== were so expensive.

E.g. Narendra Modi or Modi is the prime minister of India.

When do we use Coreference Resolution?

- Coreference resolution is using in a variety of NLP tasks such as,

- Text summarization
- Information extraction (Named entity extraction)
- Sentiment analysis
- Machine translation
- Information Retrieval

Contextual Words and Phrases

- Contextual words and phrases refer to words or phrases whose meaning depends on the surrounding text or context. Understanding context is crucial for accurate language processing.

- Examples:

- Word Sense Disambiguation: In the sentences "He went to the bank to fish" and "He deposited money at the bank," understanding that "bank" refers to a riverbank in the first and a financial institution in the second is achieved through context.

- Phrase Understanding: In the phrase "the glass broke," the meaning of "glass" (as in a drinking container) is understood based on the context of "broke."

Importance of Context

- Meaning Disambiguation: Words can have different meanings based on context. For example, "bank" can refer to a financial institution or the side of a river. Understanding the surrounding text helps determine the correct meaning.

- Coherence and Flow: Context helps maintain the coherence and flow of sentences and paragraphs, allowing for a more natural understanding of the text.

Contextual Models:

➢ Word Embeddings: Traditional embeddings like Word2Vec or GloVe provide a static representation of words. Contextual embeddings go beyond this by considering the surrounding text.

➢ Transformers: Models like BERT (Bidirectional Encoder Representations from Transformers) and GPT (Generative Pre-trained Transformer) generate dynamic, context-sensitive representations of words.

➢ For example, BERT captures the meaning of a word in the context of its sentence, while GPT generates contextually appropriate continuations of text.

Homonyms in NLP

Homonyms

➢ Homonyms are words that are spelled or pronounced the same but have different meanings.

➢ They can be a challenge for NLP systems because they require distinguishing between different meanings based on context.

Types of Homonyms:

➢Homophones: Words that sound the same but have different meanings (e.g., "to," "too," and "two").

➢Homographs: Words that are spelled the same but have different meanings and possibly different pronunciations (e.g., "lead" as in to guide vs. "lead" as in the metal).

Challenges

➢ Disambiguation: Identifying the correct meaning of a homonym requires understanding the context in which it is used. For instance, distinguishing between "lead" (to guide) and "lead" (the metal) based on their usage in different sentences.

Handling Homonyms in NLP:

➢Contextual Embeddings: Modern models like BERT and GPT handle homonyms effectively by providing contextually relevant meanings. For example, BERT's attention mechanism helps disambiguate homonyms by considering surrounding words and phrases.

➢Word Sense Disambiguation (WSD): Algorithms designed to determine the correct sense of a word based on its context. These can be rule-based, statistical, or machine learning-based.

Applications and Implications of Homonyms

➢ Improved Communication: Accurate contextual understanding and homonym disambiguation are crucial for applications like machine translation, where misinterpreting homonyms can lead to incorrect translations.

➢ Enhanced Search and Retrieval: Contextual understanding improves search engines and information retrieval systems by returning more relevant results based on the nuanced meaning of queries.

➢ Natural Language Understanding: Better handling of context and homonyms leads to more sophisticated conversational agents and virtual assistants, improving their ability to understand and generate human-like responses.

Synsets, Hypernyms in NLP

Synsets

➢Definition: Synsets (short for "synonym sets") are groups of words or phrases that are considered synonymous in a particular context. Each synset represents a distinct concept or idea.

➢Purpose: Synsets are used to capture and represent the semantic relationships between words. They help in understanding that different words or phrases can convey similar meanings.

➢Example: In WordNet, a large lexical database of English, the word "car" might be grouped with "automobile," "motorcar," and "machine" in a synset. These words are considered synonyms within the context of the concept of a vehicle.

Hypernyms

➢Definition: Hypernyms are words that denote a broader category or a more general term in relation to other words. They represent a higher-level concept under which more specific terms (hyponyms) fall.

➢Purpose: Hypernyms help in organizing words into a hierarchical structure, which is useful for understanding the relationship between different concepts and for tasks like word sense disambiguation and semantic search.

➢Example: For the synset containing "car," the hypernym might be "vehicle." Here, "vehicle" is a more general term that includes "car," "truck," "bike," etc.

Relationships in WordNet

➢ In WordNet, which is a prominent lexical database for English, synsets and hypernyms are organized in a network. Here's how they relate:

➢ Synsets: Words are grouped into synsets based on their synonymous relationships. Each synset provides a definition and usage examples for the words it contains.

➢ Hypernyms: Synsets are linked to their hypernyms, forming a hierarchical structure. This helps in understanding the broader context of a word. For example, the synset for "car" might have a hypernym link to "vehicle," which in turn has hypernym links to "transport," and so on.

Practical Applications

➢ Word Sense Disambiguation: By understanding the synsets and hypernyms, NLP systems can better determine which sense of a word is being used in a given context.

➢ Semantic Search: Hypernyms can be used to broaden search queries by including related terms and concepts.

➢ Text Classification: Synsets help in categorizing text based on the concepts conveyed, which can improve the accuracy of text classification models.