Language and Communication

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Introduction

Natural Language Processing (NLP) is a key area in AI

It encompasses NLP proper as well as

Human-robot collaboration (HRC) and

Human-robot interaction (HRI)

There are major conferences dedicated to NLP (ACL) and major conferences (AAAI) have large NLP tracks.

Introduction

Common NLP tasks include:

- Information retrieval
- Document summarization
- Language translation

HRC tasks include:

- Communicating with your car

HRI tasks include:

- Chatting with an assistive technology robot

Communication

Before getting into the technical details of NLP, we will put NLP into perspective

Searle (remember the Chinese Room experiment) wrote a key book entitled Speech Acts.

Speech acts are about language as a tool.

Before that, people used to focus on language as sentences that can be assigned a truth value.

Communication

Much of language is about informing others, i.e. about sentences that are true or false.

However, there clearly is more.

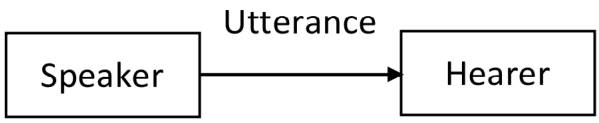
- **Acknowledgement**. In a phone conversation, one may say ”yes” “ehem” “right” and other words to acknowledge what the other person is saying. When texting, acknowledgement is oftentimes given through emoji's.
- **Commands**. When there is a strict hierarchy, such as in the military, commands are common. However, we see them by the side of road, such as “Do not litter.”
- **Promise**. People make promises such as, ”I’ll call you tomorrow.”
- **Question**. “Do you see the variety in speech acts?”

Communication

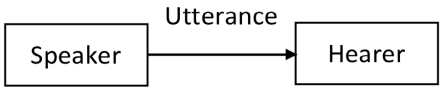
Even when informing someone, there are challenges.

Assume you wish to inform someone of some fact.

Consider this basic workflow in which you, the speaker, make an utterance to inform some hearer.



Communication

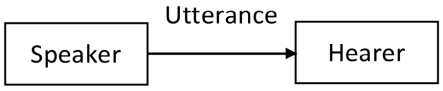


A sophisticated speaker chooses their words wisely.

Words they chose may depend on the following:

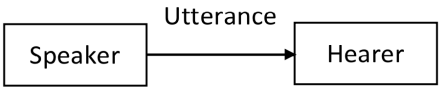
- Their own vocabulary
- The expected vocabulary of the hearer
- Concepts the speaker understands
- Expected concepts the hearer understands
- The belief system of the speaker
- The expected belief system of the hearer

Communication



Words that a speaker may chose may additionally depend on the:

- Situation
- Semantic and syntactic conventions
- The speaker's goals
- The speaker's rationality
- The expected rationality of the hearer



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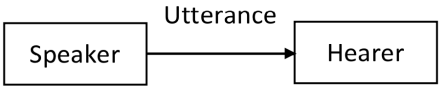
Let's take a more detailed look at the workflow diagram.

- Speaker *S* decides to inform the hearer *H* of some fact *P*
- *S* chooses their words wisely
- *S* utters words
- *H* perceives the words in a given context
- *H* infers possible meanings $P_1, \ldots P_n$ of the utterance
- *H* infers intended meaning P_i
- *H* incorporates P_i into their knowledge base

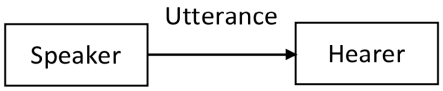


Communication

Let's now have a look at things that can go wrong.

- Speaker *S* decides to inform the hearer *H* of some fact *P*
  - *H* may already know *P*
  - *H* may not be interested in *P*
  - *S* may be insincere
- *S* chooses their words wisely
  - Or not
- S utters words
  - The words come out in the wrong way
  - There is background noise
  - *S* mutters

Communication



- *H* perceives the words in a given context
  - *H* misinterprets the context
  - *H*' is not the intended target of the utterance
- *H* infers possible meanings $P_1, \ldots P_n$ of the utterance
  - Based on context and *H's* background
  - The words chosen for the utterance itself is ambiguous
  - Even though *S* made an honest attempt to choose their words wisely, they didn't.
- *H* infers intended meaning P_i
  - Based on context, their own background and perhaps other cues.
- *H* incorporates P_i into their knowledge base
  - And then *H* forgets
  - Or *H* refuses

Challenges in NLP: Ambiguity

Natural language can be very ambiguous.

Examples:

- Squad helps dog bite victim
- Helicopter powered by human flies

Or the all-time favorite Groucho Marx adage:

- Time flies like an arrow – Fruit flies like banana.

Notice that processing (or realizing) the different meanings requires a serious amount of background knowledge, i.e. knowledge about the way the world works.

Challenges in NLP: Anaphora

Using pronouns to refer back to entities already introduced in the text

Simple example:

- After Mary proposed to John, they found a preacher and got married.
- For the honeymoon, they went to Hawaii

Example:

- Mary saw a ring through the window and asked John for it

Notice that in the first example, one needs to maintain a record of the conversation.

The second example, again, shows the need for background or common sense knowledge.

Challenges in NLP: Indexicality

Indexical sentences refer to utterance situation (place, time, S/H, etc.)

Examples:

- I am over here!
- Why did you do that?

To successfully process indexical sentences, one needs to collect and story meta-information, including:

- Who uttered the sentence.
- When and where it was uttered.
- Anyone else who is referred to in the utterance.

Challenges in NLP: Metonymy

Using one noun phrase to stand for another.

Examples:

- I've read Shakespeare
- Chrysler announced record profits

Here too, background knowledge is necessary.

Challenges in NLP: Metaphor

"Non-literal" usage of words and phrases.

Examples:

1. It is raining cats and dogs.
2. Life is a rollercoaster.
3. My big brother is a couch potato.
4. Laughter is the music of the soul.

Did I mention the use of background knowledge yet?

This is a bit different, some of the examples one just needs to have heard and processed before, such as 1 and 3.

Some metaphors can be processed by analogical reasoning, such as 2 and 4.

Winograd Schema Challenge

This is a challenge designed to test NLP processing and reasoning.

Example: “The city councilmen refused the demonstrators a permit because they [feared/advocated] violence.”

To solve a challenge, one needs to resolve anaphora.

The pronoun that needs to be resolved may refer to two parts of speech.

Based on which word in the bracket is chosen, a different part of speech is chosen.

However, resolving the ambiguity requires inference and common sense reasoning.

Example source: Terry Winograd. Understanding Natural Language. 1972