



Artificial Intelligence

3rd year, 1st semester

Natural Language Processing

“Science is what we understand well enough to explain to a computer; art is everything else.”— Donald E. Knuth



Language - a structured system of communication.

Structured system - has items, relations between them and (production) rules over them

Communication - there has to be a semantic association from that language to the outside of it

Intelligence uses and builds knowledge and language.

Sapir-Whorf and Neurolinguistics



Natural (human) languages vs Formal languages

(Full ?) Expressive power

Limited expressiveness

Personal interpretation

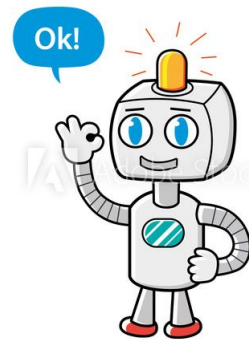
Unambiguous

Dynamic

Little dynamism

Easy to learn

Harder to learn

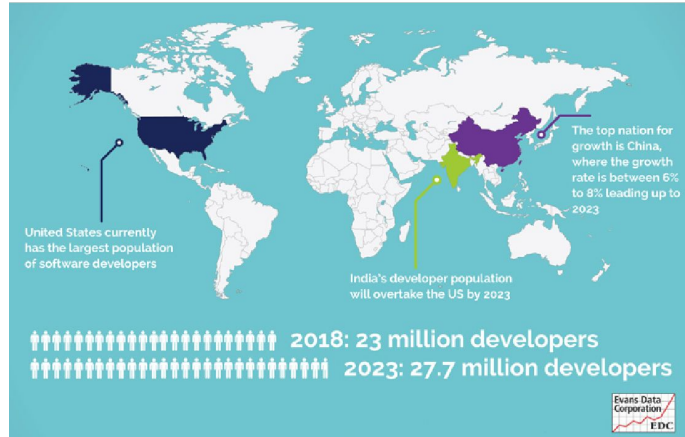




Does the computer need human language?

- Accessibility
- Access to resources
- Expressiveness

THE NUMBER OF SOFTWARE DEVELOPERS IN THE WORLD





Example: Virtual assistants

Apple's Siri



Amazon's Alexa



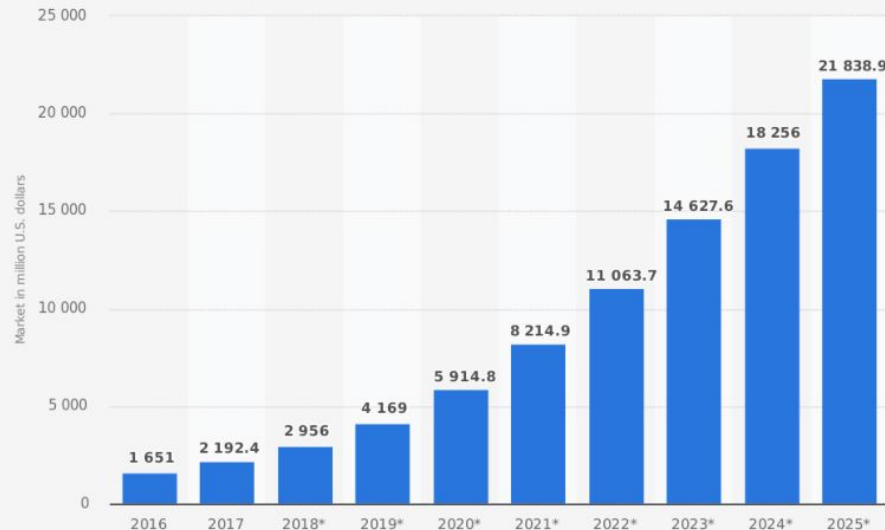
Microsoft's Cortana



Google's Assistant



Size of the enterprise virtual digital assistant (VDA) market worldwide from 2016 to 2025 (in million U.S. dollars)



Source
Tractica
© Statista 2018

Additional Information:
Worldwide; Tractica; 2016 to 4th quarter 2017



OK, now what?

We already know that:

- Language has items, relations between them and (production) rules over them
- There has to be a semantic association from that language to the outside of it
- Language has generous expressive power and is dynamic



Types of NLP

Text analysis: understand the meaning of a natural language message.

Text generation: convey a meaning in natural language.

Speech to text and text to speech.

Other multimodal applications: for example, sign language translation/transcription.



Text analysis: morphological level

Morphology: morpho = form

First step: developing a vocabulary

Recognize words as belonging to your language: is a dictionary enough?

Example





Why not 100%?

How many words are in “F.B.I.”?

Is “F.B.I.” a word?

How about “eccedentesiast”?



Text analysis: lexical level

Lexicology : lexicos = of words

How words are formed:

- Lemmas
- Suffixes and prefixes
- Syllables
- Morphemes
- Parts of speech

Further reading

How to split a word in syllables?



thermometer

an instrument for measuring temperature



thermal

relating to or caused by heat or changes in temperature



Thermos

a container which is used to keep hot drinks hot and cold drinks cold



How does a Part-Of-Speech tagger work?

1. Identify lexical tokens: The/students/are/learning/.
2. Identify lemmas: The/student-s/be-are/learn-ing/.
3. Use a lexicon and match unambiguous lemmas:
D-The/student-s/V-be-are/learn-ing/P-.
4. Use a language model to disambiguate the rest:

D	N	V	V	P	250
D	V	V	V	P	18
D	A	V	AV	P	5



Why not 100%?

“Time flies like an arrow.”

“Will, will Will will Will Will's will?”



Text analysis: syntactic level

Syntax: syn - together, taxis - arrange

Identify sentences/ discourse units.

Find the roles of words in a sentence.

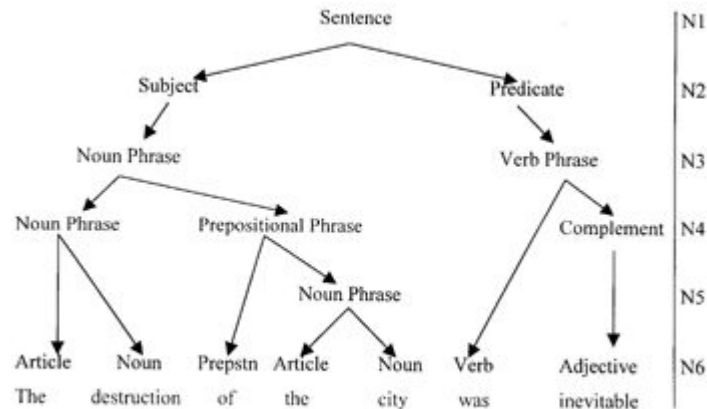
(subject, predicate, complement,...)

Find syntactic relations between words.

(Noun Phrase, Anaphora, direct object,...)

[Further reading](#)

[Example](#)





Why not 100%?

“Time flies like an arrow.”

“We saw her duck.”

“I saw the man on the hill with a telescope.”



Text analysis: semantic level

Semantic: semantikos - significant

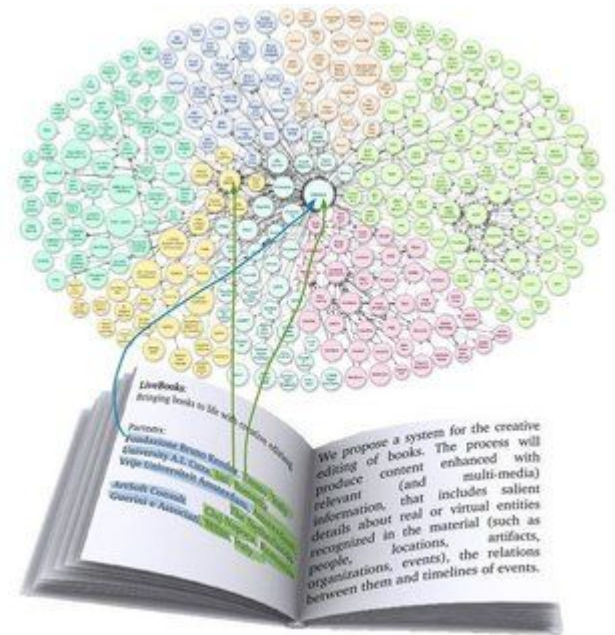
Associate meanings to words which have them.
(substantives, verbs, adjectives and adverbs)

Word Sense Disambiguation:

What are the possible senses of a word?

Is there a correct sense?

[Further reading](#)





Why not 100%?

“He’s mad.”

“You’re done.”

“We are far from each other.”



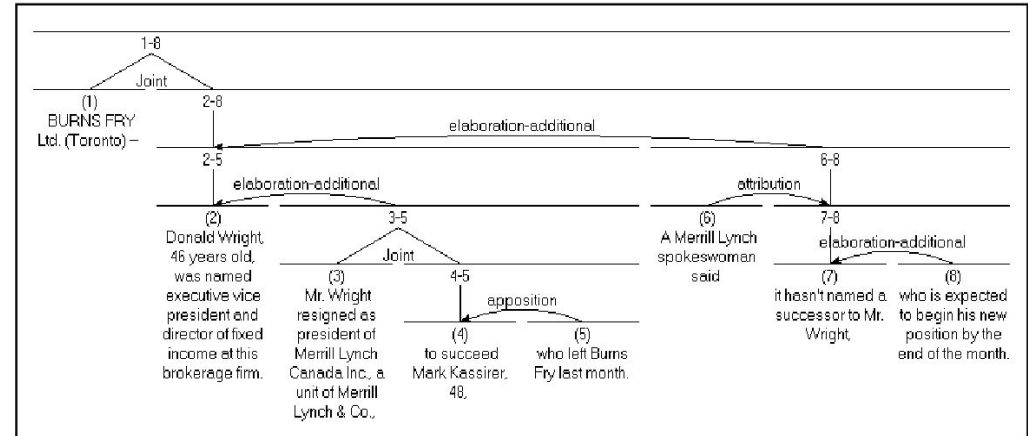
Text analysis: discourse level

Discourse: discursus - running around, going over something

What is the underlying structure of a text?

Several representations:

- [Rhetorical structure theory](#)
- [Centering theory](#)
- [Veins theory](#)





Text analysis: pragmatic level

Pragmatics: pragmatikos - fit for social activity

Context matters even for written text.

You have to identify the target of the message.

“Alexa, play a song.”

Punctuation matters:

“I like to eat my family and my cat”

Prosody: tone and intonation matters.

[Further reading](#)

«PRAGMATIC LINGUISTICS»





Text generation: I have knowledge, how do I communicate it?

Generally done by applying templates to knowledge.

I have ?x ?y.

Quantity	Type
20	apples

Often uses language models to determine most likely word to be used in the context.

have	possess	apples
180	5	frequency

Overview

Example systems: [RosaeNLG](#), [SimpleNLG](#)



Speech to text: what is that human speaking?

We use sounds, not words or letters.

Phonemes: sounds forming words.

I teach Artificial Intelligence.

aɪ ti:tʃ , a:tɪ'fɪʃ(ə)l ɪn'tɛlɪdʒəns.

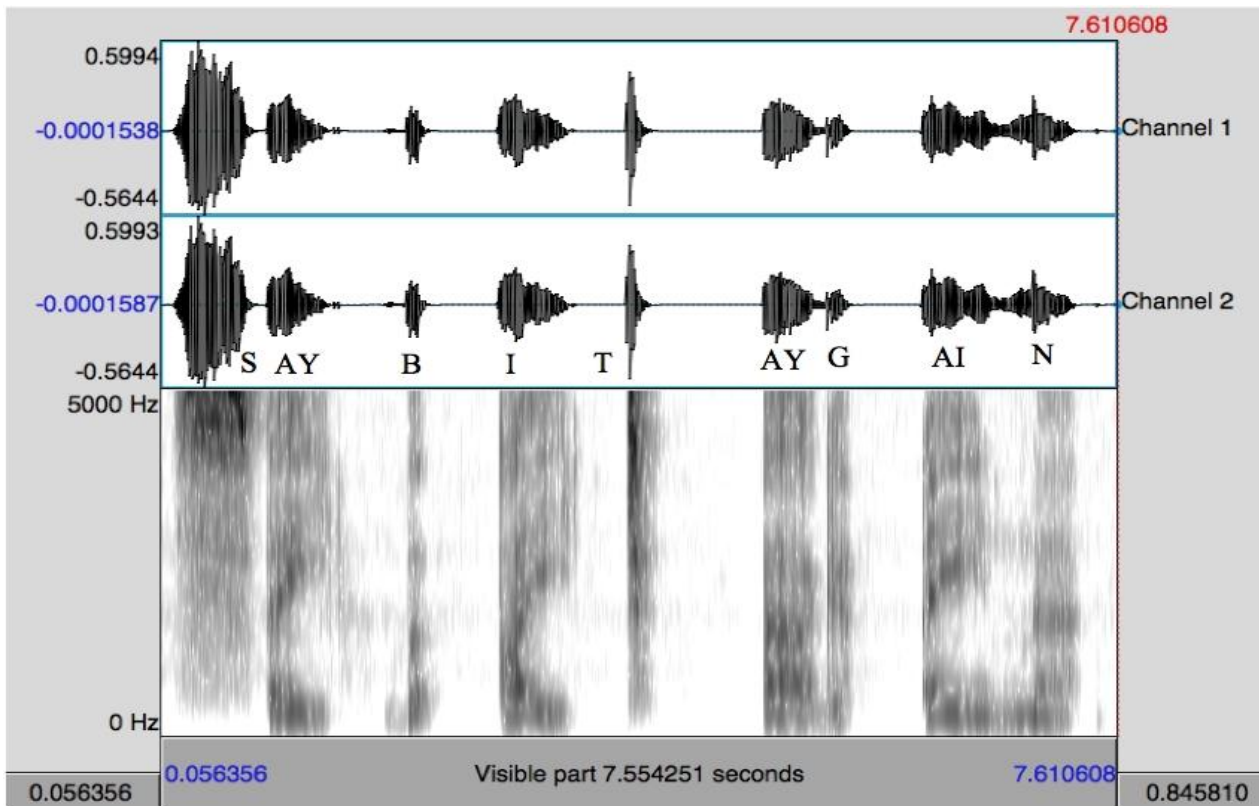
44 phonemes for English

[International Phonetic Alphabet](#)

[Phonetic keyboard](#)



Recognizing phonemes





Speech to text and reverse

Phonemes to words

r eh k ao g n ay z s p iy ch

"recognize speech"

r eh k ay n ay s b iy ch

"wreck a nice beach"

Language models

60k words - 216 trillion possible sets of 3 words

[IBM Watson STT](#)

[DeepSpeech](#)

[Google Assistant](#)



Multimodal NLP: how else can I communicate?

Using sign language:

[Google's MediaPipe](#)

[SignAll](#)

[Demo for Amazon Echo](#)

Lip reading

[DeepLipReading](#)

[Google's DeepMind](#)

[Demo](#)

Handwriting recognition



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NLP resources

<https://vlo.clarin.eu/?0>

<http://lremap.elra.info>

<https://www ldc.upenn.edu>

<https://gate.ac.uk>

<https://uima.apache.org>

<https://github.com/google-research/bert>