Introduction to Natural Language Processing (NLP)

Content

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  - What is NLP?
  - NLP and the Turing Test
  - Why NLP?
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  - Levels of NLP Processing and Analysis
  - NLP Phases
  - NLP common tasks
  - NLP applications

What is NLP?

- A field of computer science, artificial intelligence, and linguistics concerned with the interactions between computers and human (natural) languages.
- The study of human languages and how they can be represented computationally, analyzed and generated algorithmically.

- The cake is on the table → on(table, cake)
- on(floor, table) → The table is on the floor

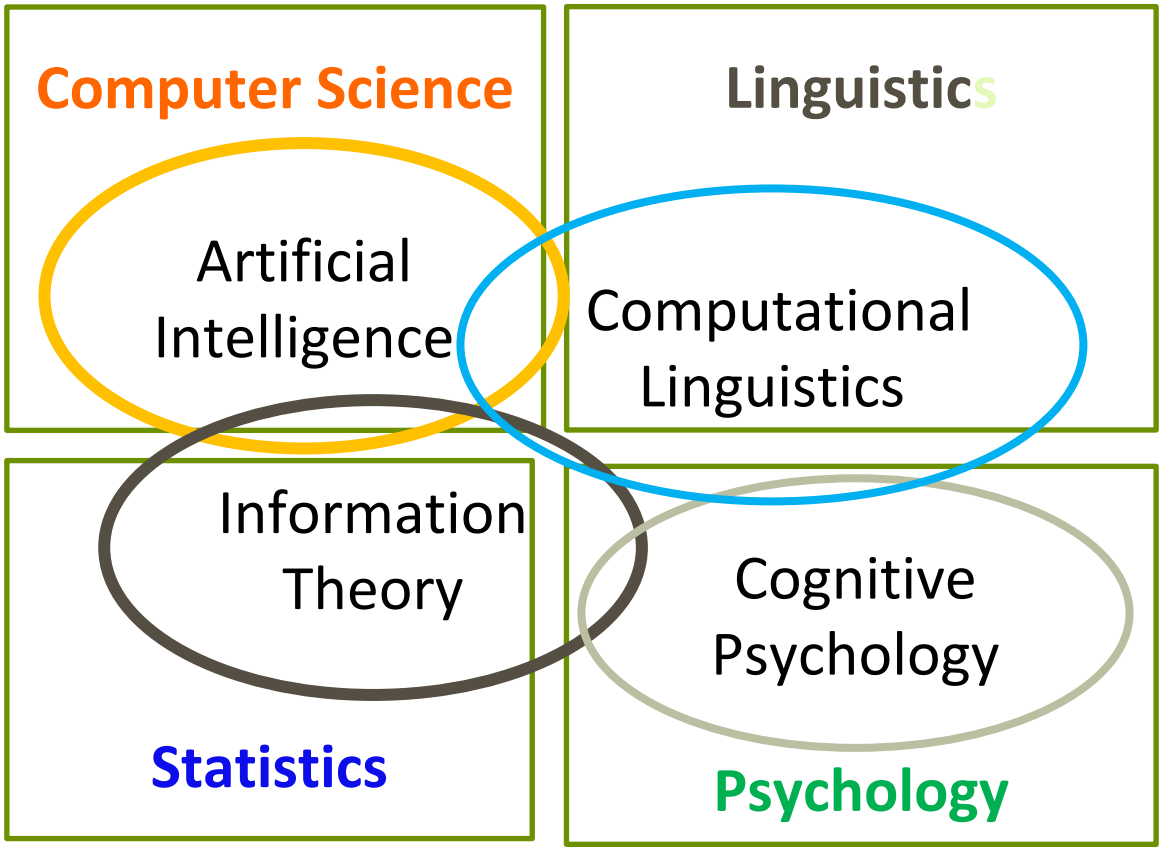
Other NLP Definitions

- The process of building computational models for understanding natural language.
- A coherent study of the human language from the point of views of several disciplines : Linguistics, Psychology, Cognitive Science, Computer Science, Statistics and Mathematics.
- A theoretically motivated range of computational techniques for analyzing and representing naturally occurring texts at one or more levels of linguistic analysis for the purpose of achieving human-like language processing for a range of tasks or applications

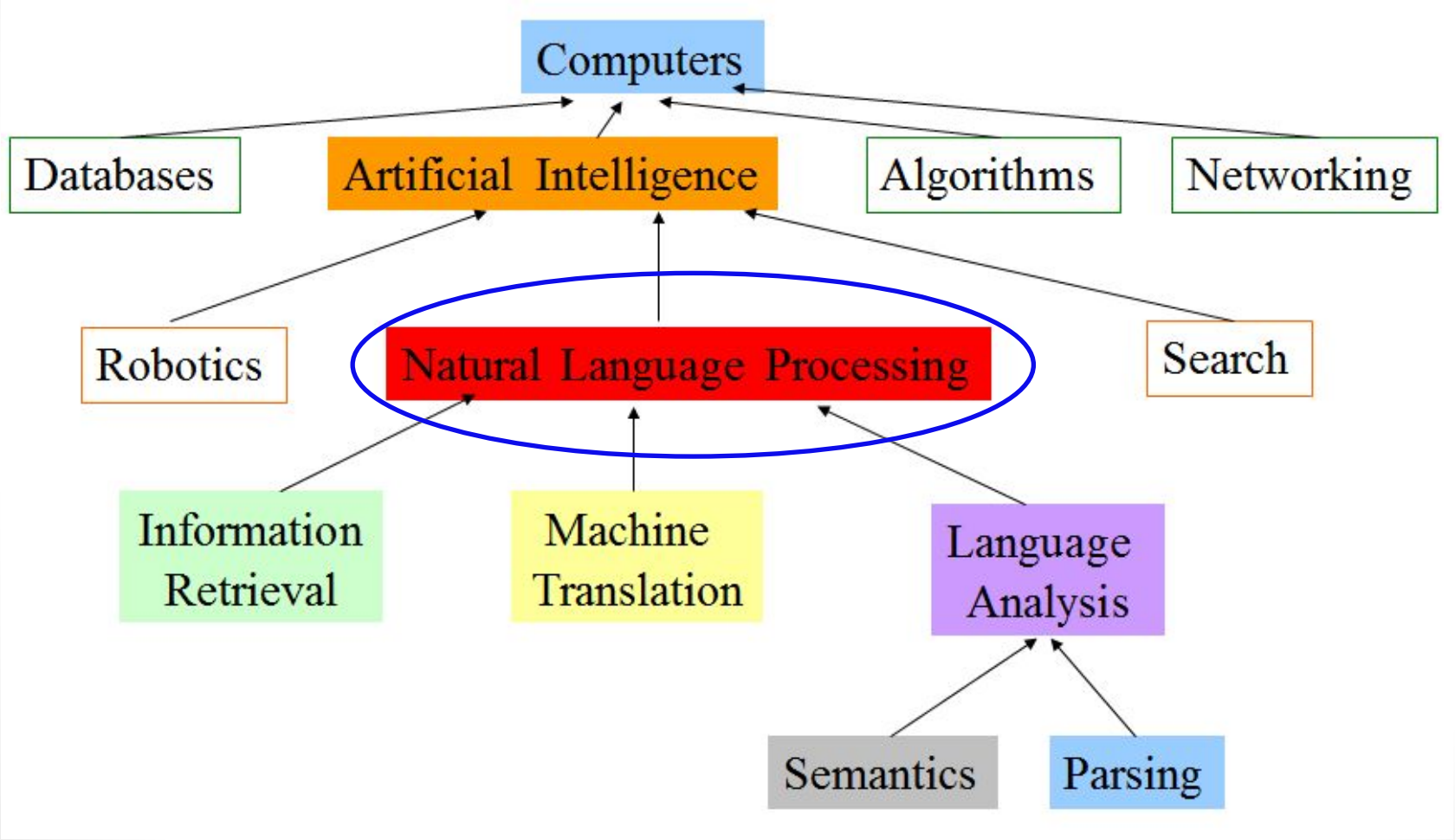
Other names for NLP

- Computational Linguistics (CL)
- Human Language Technology (HLT)
- Natural Language Engineering (NLE)
- Speech and Text Processing

Multidisciplinary NLP



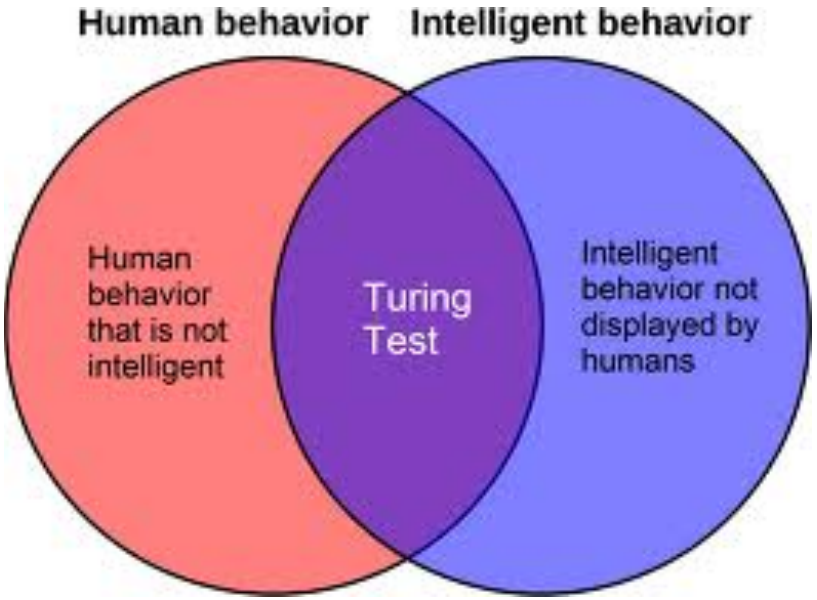
Where does NLP fit in CS?



NLP and the Turing Test

- Can machines think?
  - What does it mean to say that a machine can think???
- The basis to determine if a machine could think is a computer's use of language
  - Empirical test → Turing game
- Using human language (by itself) is sufficient as a test for intelligence

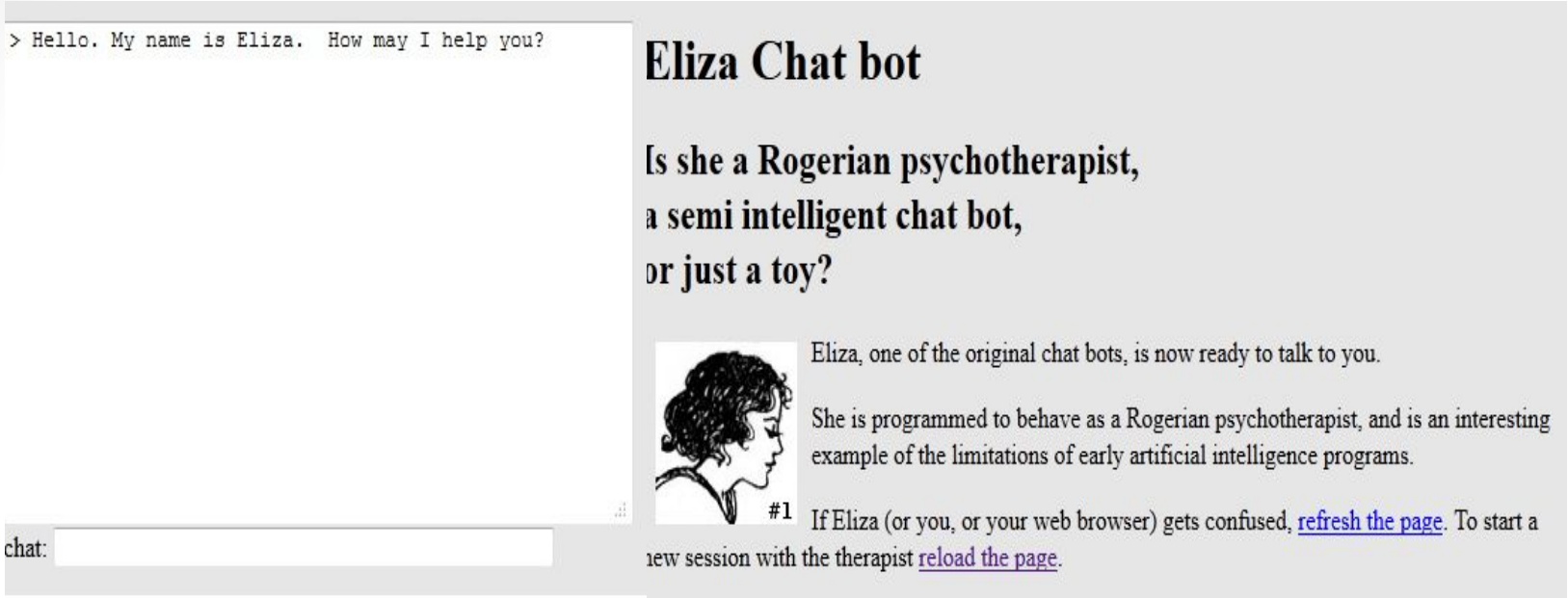
NLP and the Turing Test



NLP and the Turing Test

- The Test
  - 3 participants : 1 human interrogator, 1 participant, 1 computer
  - Goal of computer: Fool the interrogator into believing it is a person by responding like a human to the interrogator's questions.
  - Goal of participant: Convince the interrogator that the other participant is the machine and that she is human.
  - Goal of interrogator: Determine which participant is the machine through a series of questions
- Turing's prediction:
  - By end of the 20th century, a machine with 10 GB of memory would have approx. 30% chance of fooling a human interrogator after five minutes of questioning (Jurafsky & Martin, 2008)

ELIZA (1964-1966) http://nlp-addiction.com/eliza/



- A simple program (“chatterbot”) simple program that uses pattern matching to process the input and translate it into suitable outputs
- Models the behaviour of a psychiatrist ("active listening" strategies of a Rogerian therapist).
- ELIZA’s relevance to Turing test: Many people who interacted with ELIZA is convinced that it really understood them and their problems.

ALICE (1995-Present)

http://alice.pandorabots.com

A.L.I.C.E. and judge

You said: I knew because you are developed by the Artificial Intelligence Foundation.
A.L.I.C.E.: How, specifically, do you know?. Good reason.. Thanks for telling me that I am developed by the Artificial Intelligence Foundation.

You say: Say

Get an A.I. Foundation membership certificate.

Conversation Log:

judge: Hi Alice! How are you doing today?
ALICE: Hi there! Not too bad.
judge: That is good to hear. Do you like Articial Inteliigence class?
ALICE: Is it good to hear? No, I don't care for it.
judge: Why? Aren't you an inspiration from Artificial Intelligence?
ALICE: If I knew why, I wouldn't be sitting here. Yes I am an inspiration from Artificial Intelligence. How did you know?
judge: I knew because you are developed by the Artificial Intelligence Foundation.
ALICE: How, specifically, do you know?. Good reason.. Thanks for telling me that I am developed by the Artificial Intelligence Foundation.

- A.L.I.C.E. (Artificial Linguistic Internet Computer Entity) is an award-winning free natural language artificial intelligence chat robot. Uses a free (open source) software known as AIML (Artificial Intelligence Markup Language) for responses and input.
- The development of A.L.I.C.E (by Dr. Richard S.Wallace) was inspired by Eliza Chatbot.

Why NLP?

- Ambiguities in human language
  - Some input can be ambiguous when alternative linguistic structures are possible
- Resolving ambiguity:
  - Introduce models or algorithms to resolve ambiguity
  - E.g models: finite state machines, rule systems, logic, probabilistic models and vector space models.
  - E.g algorithms: Dynamic programming, Expectation Maximization, Artificial Neural Network, State space search or other machine learning algorithms

Ambiguities and Complexities in Language

Ambiguous

- *"Hospitals are sued by 7 Foot doctors"*
- *"Include your children when baking cookies"*
- *"Kids make nutritious snacks"*

Complex

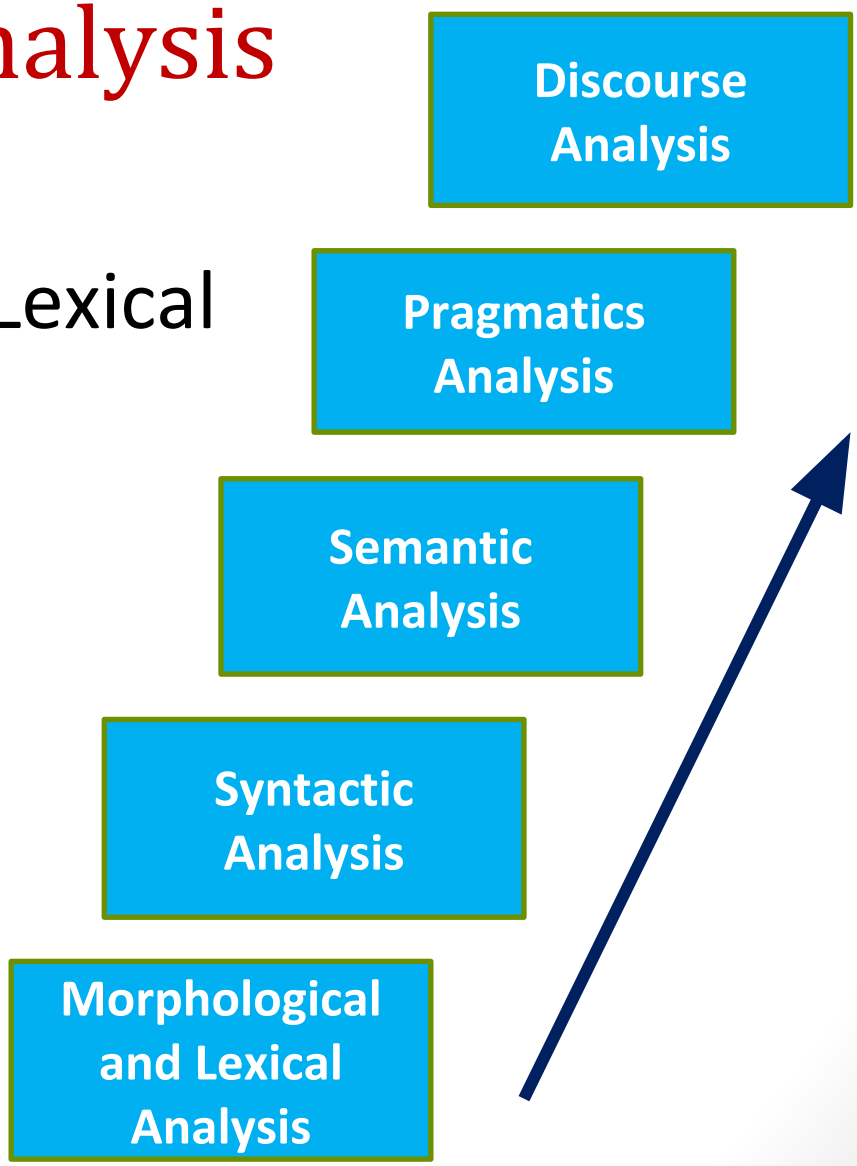
- *"There is a boy, who lost his toy, who jumped with joy, who drank the soy.*

Goal of NLP

- Get computers to perform useful tasks involving human language
  - ✓ Enable **human-machine communication**
  - ✓ Improve **human-human communication**
  - ✓ Perform useful **text/speech processing**
- Example tasks
  - Conversational agents/dialogue system (HAL)
  - Machine translation
  - Question answering system
  - Information extraction
  - Word sense disambiguation

Levels of Language Processing & Analysis

- Morphological and Lexical Analysis
- Syntactic Analysis
- Semantic Analysis
- Pragmatics Analysis
- Discourse Analysis

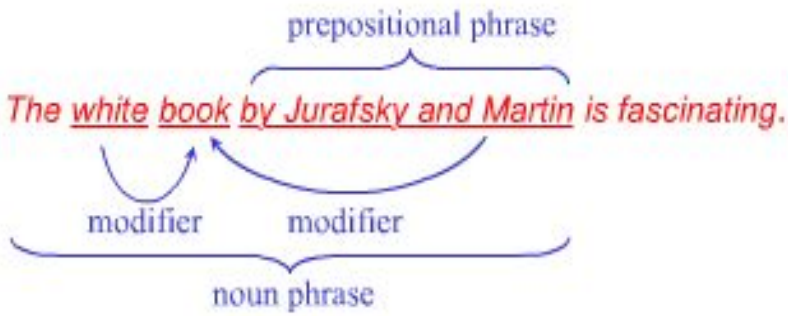


Phases of NLP

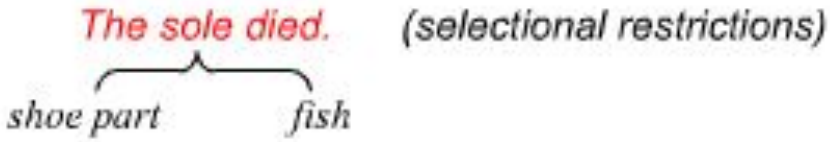
- Engaging in complex language behaviour requires various kinds of knowledge of language
  - Phonetics and Phonology - knowledge about linguistic sounds (tap, butter, chip, sheep)
  - Morphology - knowledge of the smallest meaningful units of words and their composition (cats, children, checked, buys, friendly)

Phases of NLP

- Syntax - knowledge of the structural relationships between words (i.e., in a sentence)



- Semantics - knowledge of meaning of words



– bass fishing, bass playing (word sense disambiguation)

Phases of NLP

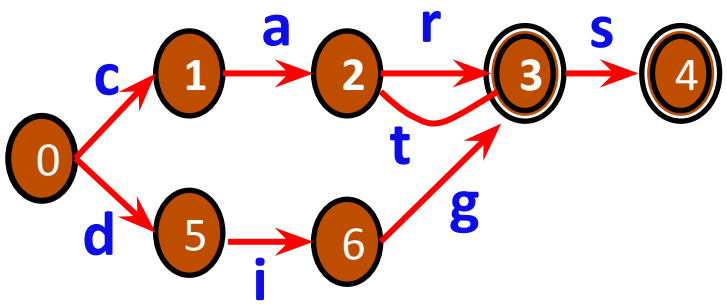
- Pragmatics - knowledge of the relationship of meaning to the goals/intentions of the speaker
- Discourse - knowledge about linguistic units larger than a single utterance

Common NLP Tasks

- Computational Morphology
- Part-of-Speech Tagging
- Text Summarization
- Topic Categorization
- Named Entity Recognition
- Word Sense Disambiguation
- Sentence Parsing
- Sentiment Analysis
- Co-reference Resolution
- Machine Translation

Computational Morphology

- Processing of words and word forms, in both their graphemic (written form) and their phonemic (spoken form)
- Example: finite state morphology



Part-of-Speech Tagging

- Assigning a **part-of-speech (noun, verb, adjective, …)** to each word in a sentence

*"Malaysia**/N** has**/V** 25**/NUM** million**/N** people**/N**"*

N – Noun

V – Verb

Num - Number

Text Summarization

- Text Summarization
  - Automatically reducing a text document to create a summary that preserves the most important points of the original document
  - Example : Given a single document, produce abstract, outline and headline

Topic Categorization

- Classifies documents according to their topics

  "Serena and Nadal relieved after surviving tough opponents in Madrid" [Sports]

  "Facebook eyes $1billion deal for GPS app Waze" [Technology]

  "Property, constructions to lead stock market" [Business]

  "All eyes on cabinet lineups" [Politics]

Named Entity Recognition

- Identifies and labels sequences of words in a text that represents names of things (proper names), such as persons , locations and organizations.
- Classification into a set of predefined categories

"The World Cup (tournament) took place in England (country)"

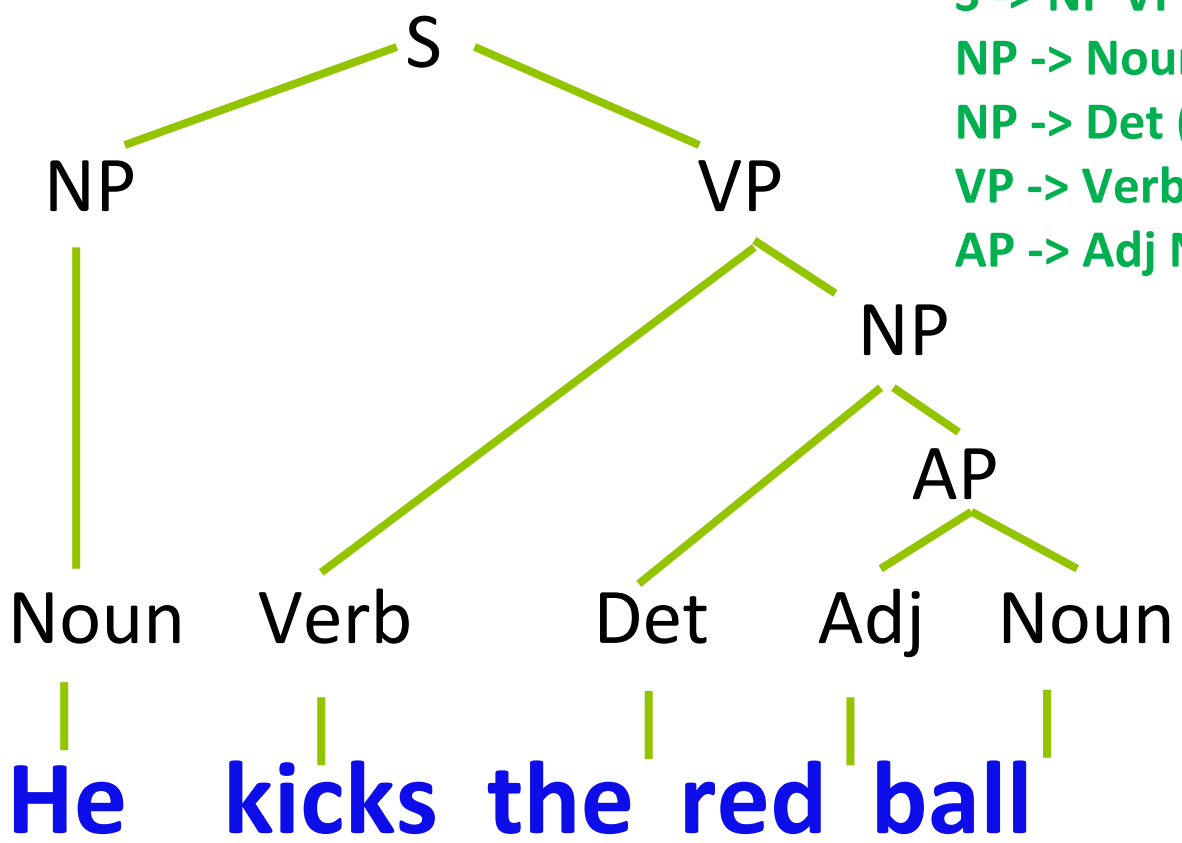
Word Sense Disambiguation

- Identify which sense of a word (i.e. meaning) is used in a sentence (in a context), when the word has multiple meanings.
- Classify an occurrence of the word in context into one or more of its sense classes.
- Examples:
  - bank (financial institution) vs bank (river)
  - book (reserve) vs book(reading material)
  - foot (body parts) vs foot (length/measurement)
  - fly ('take off' using wings) VS fly (insect)

Sentence Parsing

- Analysing a sentence into its component categories and functions

Rules
S -> NP VP
NP -> Noun
NP -> Det (Adj) Noun
VP -> Verb NP
AP -> Adj Noun



Sentiment Analysis

- Identify, analyze and classify opinions in text into categories such as "positive" , "negative" or “neutral”

“I love Macintosh.” (Positive)

“I hate Windows! ” (Negative)

“What a great car, it did not start the first day” (positive or negative???) → sarcasm

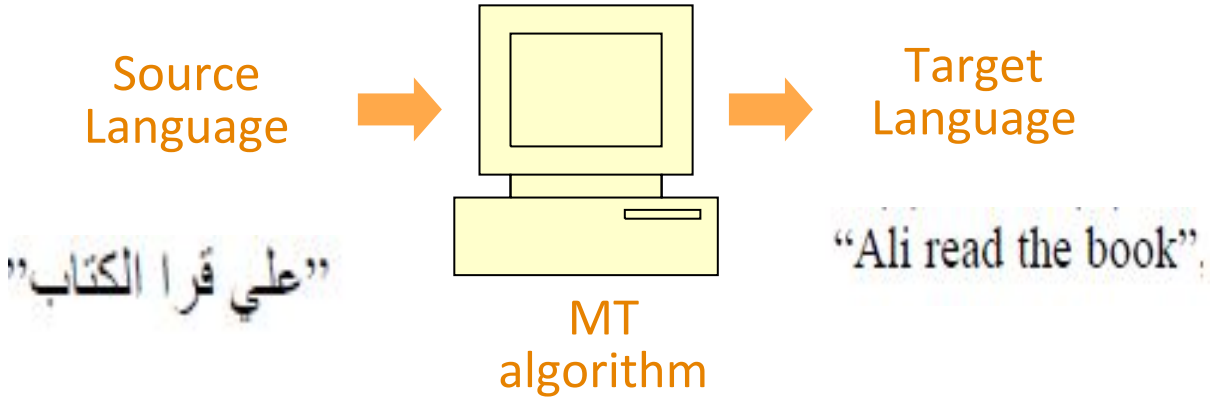
Co-reference Resolution

- Two textual entities that refers to the same object in the "real world" (Mitkov)

Saha Hisham Ismail $_1$***, 45, said poor drainage*** $_2$ ***in the village*** $_3$ ***was the main cause of the problem*** $_4$***. "We*** $_{1,3}$ ***have reported it*** $_2$ ***to the authorities*** $_5$ ***and they*** $_5$ ***have promised to look into it*** $_2$***, but nothing has been done to rectify the problem*** $_2$***."***

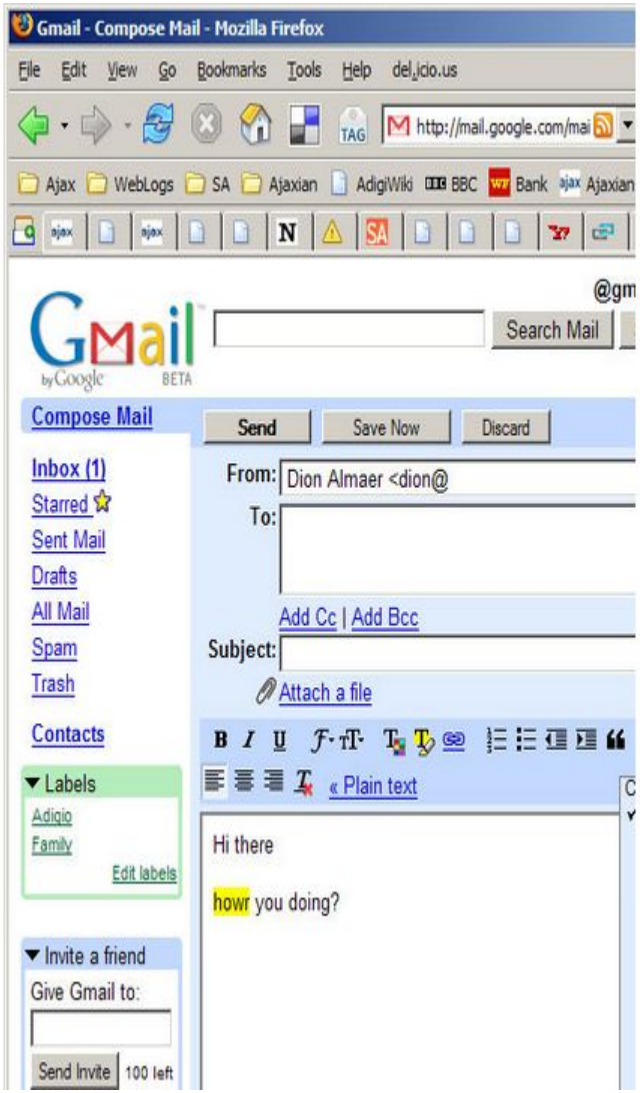
Machine Translation

- An automated system that analyzes text from source language and produces "equivalent" text in the target language



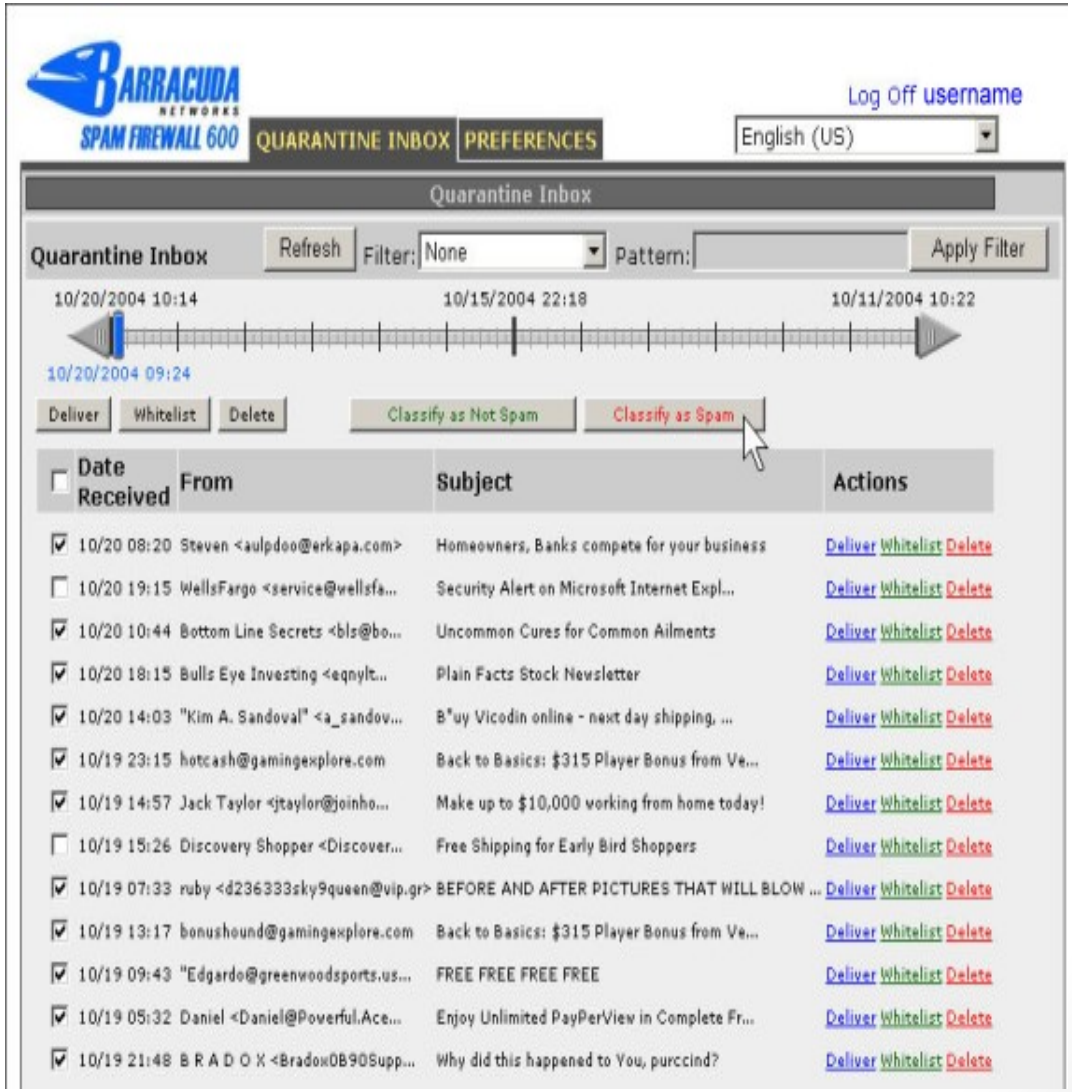
NLP Applications

- Gmail Spell Checker



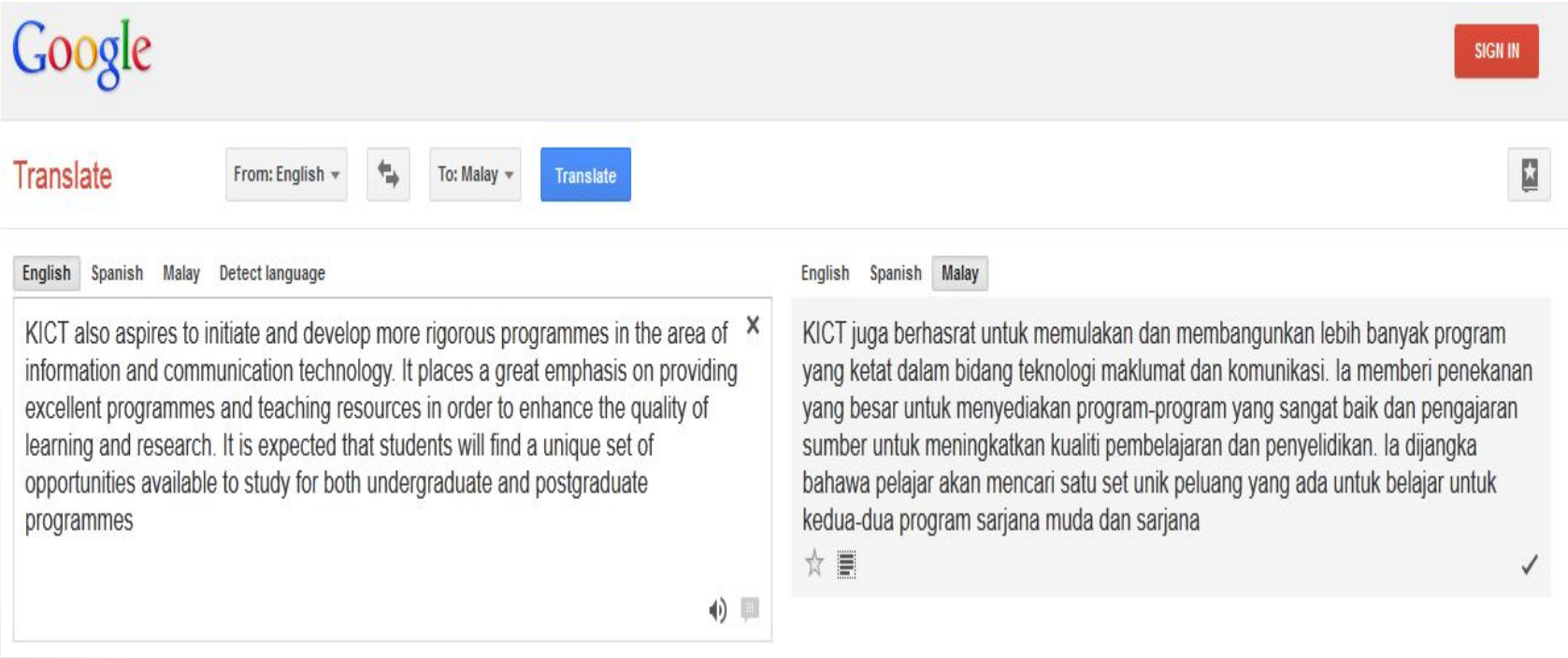
NLP Applications

- Spam Classifier



NLP Applications

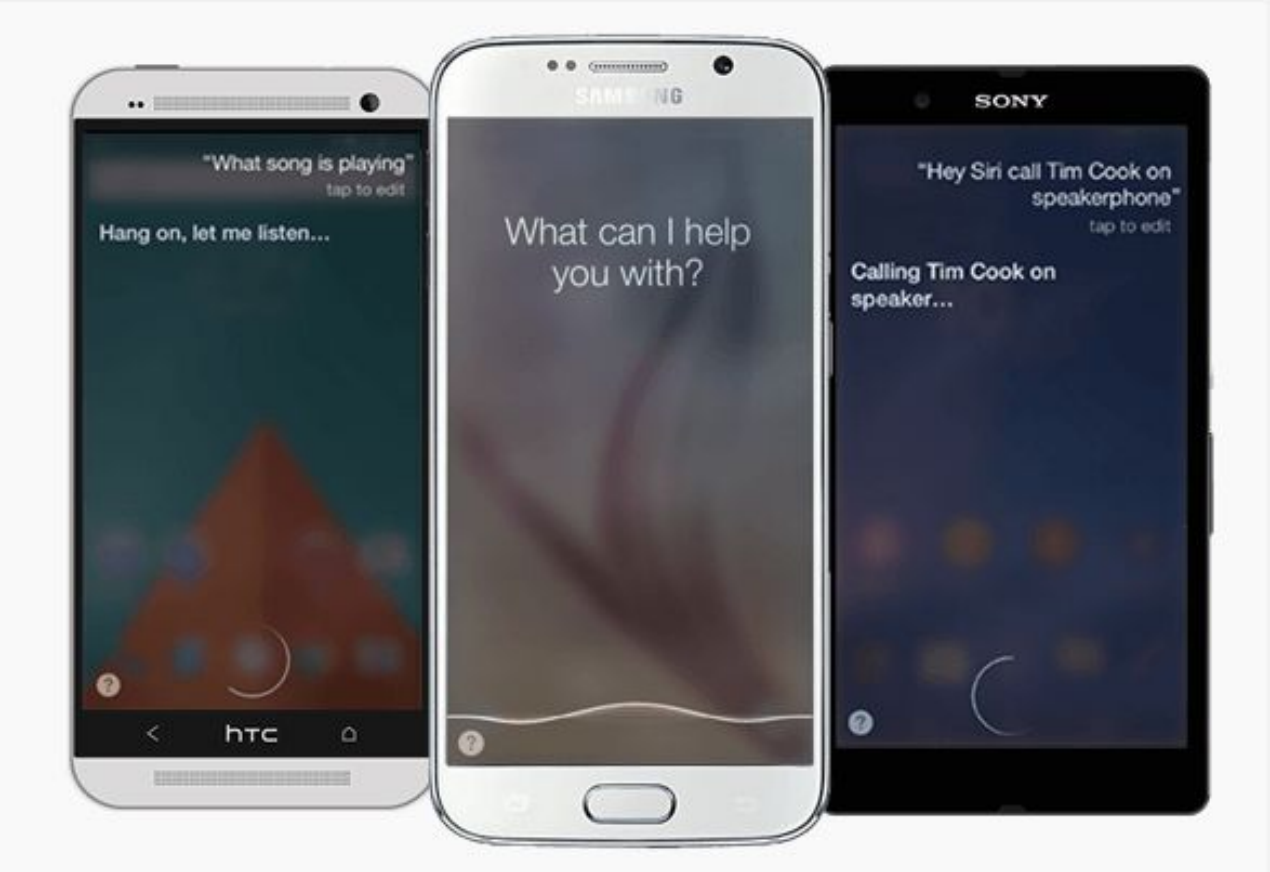
Google Translate



https://translate.google.com/

NLP Applications

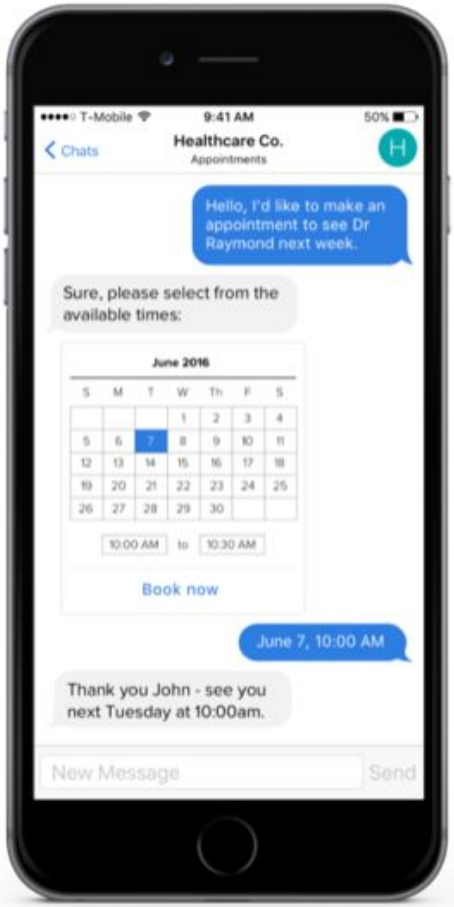
Personal Assistant (Speech-to-Text) : SIRI ANDROID



http://sirionandroid.com/

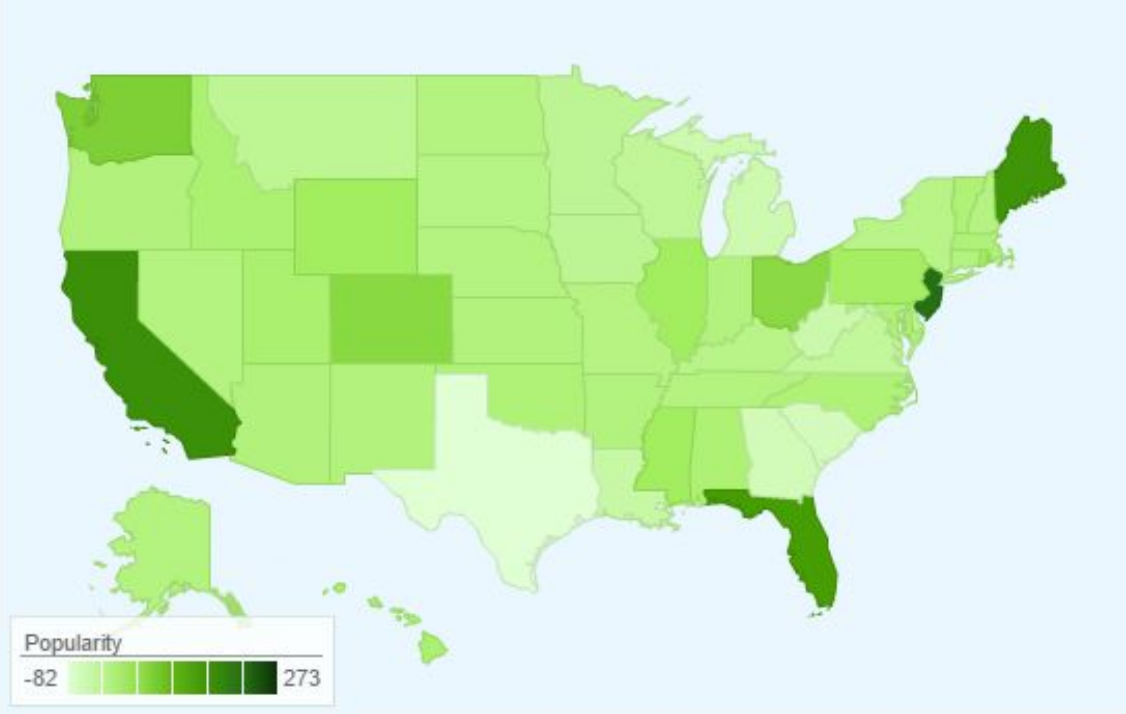
NLP Applications

Chatbot for Business:
Helpdesk agent/Call Centers



NLP Applications

Text Analytics App: Prediction on US Presidential Election

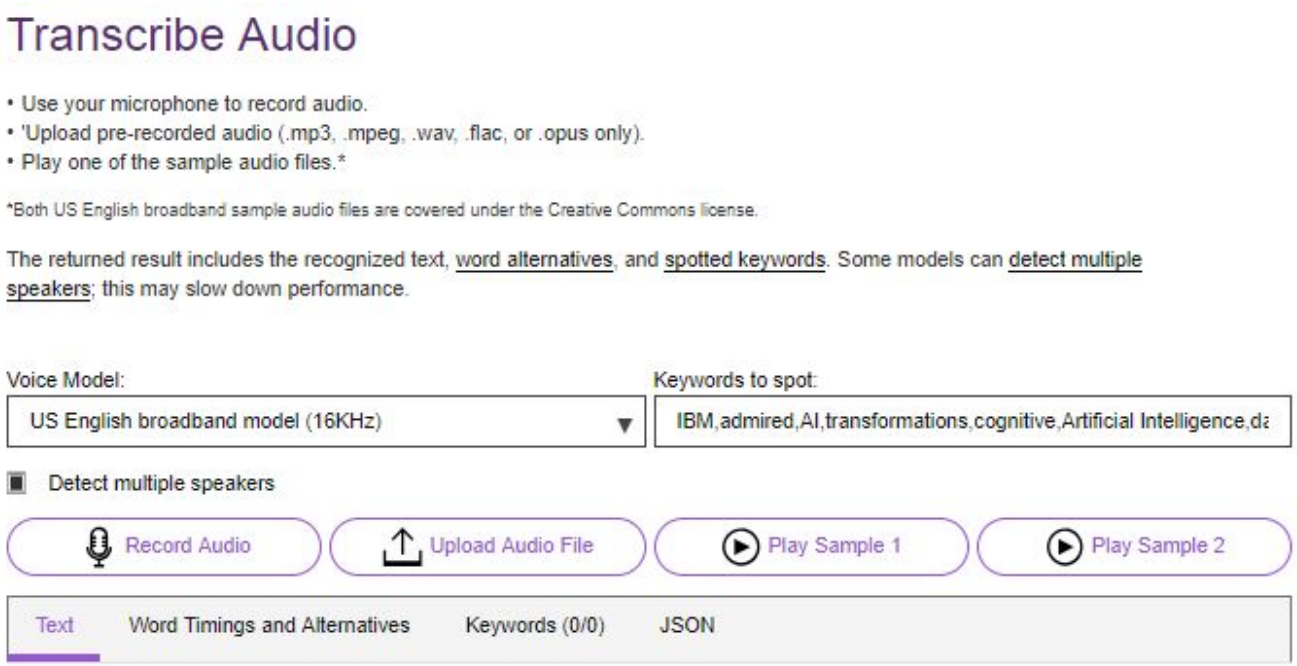


The following Geomap shows Romney's popularity results:

http://www.kazemjahanbakhsh.com/codes/election.html

NLP Applications

IBM Watson Cognitive supercomputer : Speech-to-text service



https://www.ibm.com/watson/services/speech-to-text/