CS544: Natural Language Processing

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The Dream

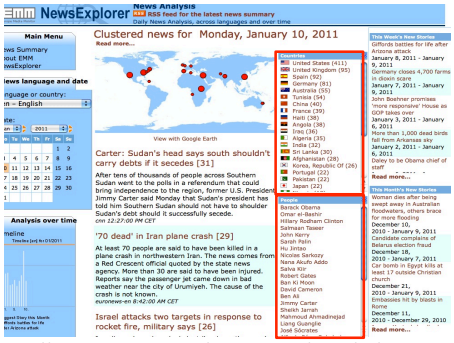
- It would be great if machines could
  - Process our emails
  - Translate languages accurately
  - Help us manage, summarize, and aggregate information
  - Understand phone conversation
  - Talk to us / listen to us
- But they cannot:
  - Language is complex, ambiguous, flexible, and subtle
  - Good solutions need linguistics and machine learning knowledge

What is NLP?

- Goal: intelligent processing of human language
  - Not just string and keyword matching
- End systems we want to build:
  - Less ambitious: spelling correction, name entity extractors
  - Ambitious: machine translation, information extraction, question answering, summarization …

Information Extraction

- Goal: build database entries from unstructured text
- Simple Task: Named Entity Extraction



http://emm.newsexplorer.eu/NewsExplorer/home/en/latest.html

Information Extraction

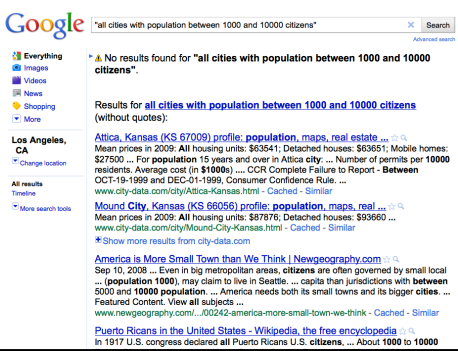
- Goal: build database entries from unstructured text
- Advanced: Multi-sentence template extraction

A **bomb** went off this morning near a **power tower** in **San Salvador** leaving a large part of the city without energy, but **no casualties** have been reported. According to unofficial sources, the bomb-allegedly detonated by **urban guerrilla commandos** **blew up** a power tower in the north western part of San Salvador at 0650.

Incident type:	bombing
Date:	March 11, 2010
Location:	San Salvador (city)
Perpetrator:	urban guerrilla commandos
Physical target:	power tower
Effect on physical target:	destroyed
Effect on human target:	no injury or death
Instrument:	bomb

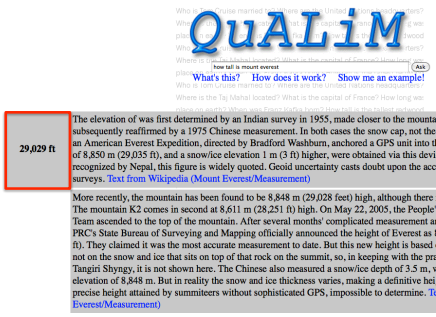
Information Retrieval

- Given a huge collection of text and a query
- Goal: find documents that are relevant to the query



Question Answering

- Find answers to general comprehension questions in a document collection



Text Summarization

Machine Translation

used Google Translate

Speech Processing

- Automatic Speech Recognition

"will you move the clinic there?"

- Performance: 5% for dictation, 50%+TV

Linguistics Levels of Analysis

- Phonology: sounds / letters / pronunciation
- Morphology: construction of words
- Syntax: structural relationships between words
- Semantics: meaning of strings (words, phrases)
- Discourse: relationships across different sentences
- Pragmatics: how we use language to communicate
- World Knowledge: facts about the world, common sense

MORPHOLOGY

Morphological Analysis

- *Morphology* studies the internal structure of words
- A *morpheme* is the smallest linguistic unit that has semantic meaning (Wikipedia)
- *Morphological Analysis* is the task of segmenting a word into its morphemes
  - carried => carry + ed (past tense)
  - disconnect => dis (not) + connect
- Challenging for morphologically rich languages like Finish and Turkish

SYNTACTIC TASKS

Part-of-Speech Tagging (POS)

- Annotate each word in a sentence with a part-of-speech tag

I	ate	the	spaghetti	with	meatballs.
Pro	V	Det	N	Prep	N

- Useful for syntactic parsing and word sense disambiguation
- English POS tagging 95% accurate

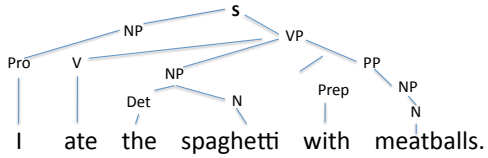
Phrase Chunking

- Find all non-recursive noun phrases (NPs) and verb phrases (VPs) in a sentence.

[NP I] [VP ate] [NP the spaghetti] [PP with] [NP meatballs] .

Syntactic Parsing

- Produce syntactic parse tree of a sentence

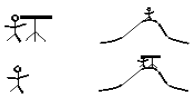


- Help figuring out questions like: *Who did what and when?*

More issues in Syntax

- Prepositional Attachment

  "I saw the man with the telescope"



Syntax does not tell us much about meaning

SEMANTIC TASKS

Word Sense Disambiguation

- Understand language! How?

I walked to the *bank* …

of the river.

to get money.

- Useful for machine translation, information retrieval

How to learn the meaning of words?

- From dictionaries, lexical repository like WordNet

bank -- *sloping land, especially the slope beside a body of water*
ex. "they pulled the canoe up on the bank"

bank – *a financial institution that accepts deposits and channels the money into lending activities*
ex. "he cashed a check at the bank"

- Automatically from the Web

Semantic Role Labeling

- For each clause, determine the semantic role played by each noun phrase that is an argument to the verb

agent patient source destination
John drove Mary from LA to San Diego.

Textual Entailment

- Determine whether one natural language sentence entails another

The glass is half empty.
The glass is half full.

Google bought Youtube.
Google acquired Youtube.

DISCOURSE, PRAGMATICS AND WORLD KNOWLEDGE

Anaphora Resolution

- Determine which phrases in a document refer to the same entity

"*George* woke up. *He* went to the kitchen."

" Peter put the *carrot* on the *plate* and ate *it*."

Pragmatics

- Studies how language is used to accomplish goals

What can we conclude from the following sentences?

"Could you please pass me the salt?"

" I am afraid I cannot do this"

World Knowledge

"George woke up. He went to the bathroom and started shaving. He took the car key and left."

WHERE WE STAND TODAY

What cannot NLP do today?

- Do general-purpose **text generation**
- Deliver **semantics**—either in theory or in practice
- Deliver **long/complex answers** by extracting, merging, and summarizing web info
- Handle extended **dialogues**
- **Read and learn** (extend own knowledge)
- Use **pragmatics** (style, emotion, user profile…)
- Provide significant contributions to a **theory of Language** (in Linguistics or Neurolinguistics) or of **Information** (in Signal Processing)

What can NLP do (robustly) today?

- Surface-level **preprocessing** (POS tagging, word segmentation, named entity extraction): 94%+ 90s–
- Shallow syntactic **parsing**: 92%+ for English 00s–
- **IE**: ~40% for well-behaved topics (MUC, ACE) 80s–
- **Speech**: ~80% large vocab; 20%+ open vocab, noisy input 80–90s
- **IR**: 40% (TREC) 80–90s
- **MT**: ~70% depending on what you measure 80s–
- **Summarization**: ? (~60% for extracts; DUC) 90–00s
- **QA**: ? (~60% for factoids; TREC) 00s–

CLASS DETAILS

What is in this Class?

- Some linguistic basics
  - structure of English
- Syntactic parsing
- Semantics
  - Word sense disambiguation
  - Semantic relations
- Applications:
  - Information Extraction
  - Machine Translation
  - Question Answering
  - Speech Recognition
  - Text Summarization

Class Requirements and Goals

- Class requirements:
  - Basic linguistics background
  - Basic probability and statistics
  - Decent coding skills
- Class goals:
  - Learn issues and techniques in NLP
  - Learn about applications that can benefit from NLP
  - Understand issues involved in processing natural language
  - Develop skills necessary to build NLP tools

Course Work

- Recommended Readings:
  - James Allen. *Natural Language Understanding (2nd ed)*, Addison Wesley, 1994.
  - Christopher Manning and Hinrich Schütze. *Foundations of Statistical Natural Language Processing*, MIT Press, 1999.
  - Daniel Jurafsky and James Martin. *Speech and Language Processing*, 2nd edi., Prentice Hall, 2008.
- Assignments:
  - 3 coding assignments
    - late submissions will not be accepted
    - brief 1-2 paged description
    - power point presentation
  - 1 final project

NLP AT USC: ISI AND ICT

Ph.D. Researchers and Topics

At ISI:

- David Chiang — parsing, statistical processing
- Ulf Hermjakob — parsing, QA, language learning
- Jerry Hobbs — semantics, ontologies, discourse
- Eduard Hovy — summarization, ontologies, NLG, MT
- Liang Huang — parsing, MT
- Kevin Knight — MT, NLG, encryption
- Zornitsa Kozareva — IE, text mining, lexical semantics
- Daniel Marcu — MT, QA, summarization, discourse
- Donald Metzler — IR
- (Patrick Pantel — clustering, ontologies, learning by reading)

At ICT:

- David DeVault — NL generation
- Andrew Gordon — cognitive science and language
- Anton Leuski — IR
- Kenji Sagae — parsing
- Bill Swartout — NLG
- David Traum — dialogue

At USC/EE:

- Shri Narayanan — speech recognition

NLP Projects at ISI