Introduction to Human Language Technologies

UPC

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FIB

Outline

1 Introduction
- What is Human Language Technology?
- Which is the general strategy for computing Human Language?
- Why is Human Language difficult to be processed?
- Examples of applications

2 Human Language Technology courses in MAI
- HLT branch
- IHL

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Definition

- HLT is the technology focused on the study of human language from a computational point of view.
- HLT comprises computational methods, resources and models specifically designed to deal with all kind of text:
  - list of words
  - question in natural language
  - document in electronic format (e.g., plain text, web page, sms, tweet, oral transcriptions)
  - **corpus**: collection of documents in electronic format

Definition

- HLT is a multidisciplinary area:
  - **Natural Language Processing (NLP)**
  - Computational Linguistics
  - Artificial Intelligence
  - Speech Processing
  - Cognitive Science, Psychology
  - Logic, Mathematics

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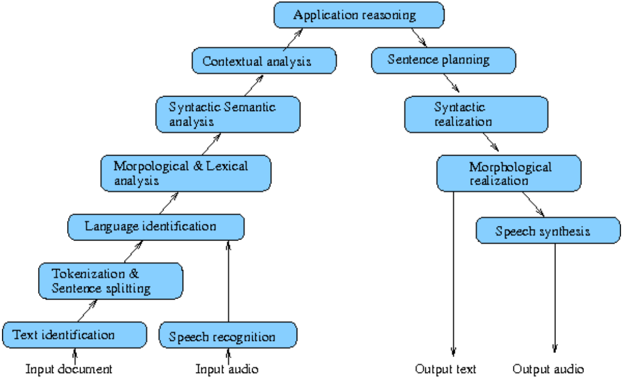
Definitions

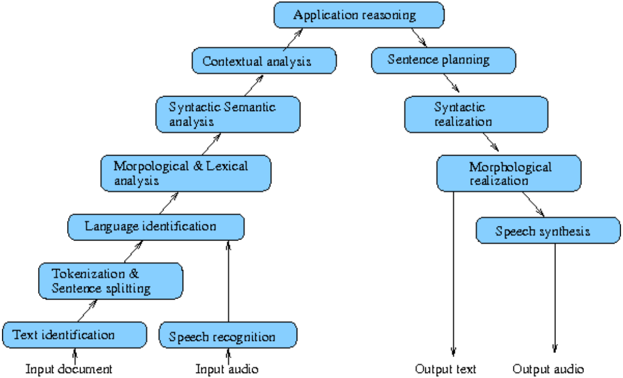
The general strategy follows the standard subareas of linguistics:

- Phonetics: sounds of human speech.
  E.g., *infrequent* → `/ɪnˈfrikwənt/`
- Morphology: structural formation of words.
  E.g., *in-frequent-ly*.
- Syntax: structural relations between words in sentences.
  E.g., *a determiner is followed by a common noun*.
- Semantics: meenings of words and their composition via syntax.
  E.g., *the president of USA is Donald Trump* →
  `president(USA, Donald_Trump)`
- Pragmatics: meaning in the context.
  E.g., **He** *is very well known in* **his country** [sarcasm]

General architecture



General architecture



- Branches: NL Understanding and NL Generation.
- Approaches: Knowledge-based *vs.* Statistical-based.
- Shallow methods (lexical overlap, pattern matching) *vs.* Deep methods (semantic analysis, logical inference)

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Problems

- World-knowledge
  - Representing world-knowledge is mandatory for understanding NL (AI-completeness)
    e.g., Yago - facts, OpenCyc - common sense
- Multilinguality
  - Different languages require different models and resources
  - Use of words from other languages
    `Estoy a full!` (non-standard Spanish text)
- Evaluation
  - Correctness/suitability of a translation/summary
- Variability
  - Different sentences refer to one meaning
    `Where can I get a map?`
    `I need a map`
    `need map` (non-standard text)
- Ambiguity
  - One sentence refers to different meanings
    `Esther said about Alice: ''I made her duck''`

Ambiguity

E.g., `Esther said about Alice: ''I made her duck''`

- `I cooked waterfowl for her`
- `I cooked the waterfowl she owned`
- `I created the duck she owns`
- `I caused her to quickly lower her head or body`
- `I turned her into waterfowl`

Word	Ambiguity	Alternatives
make	semantic	cook or create
her	syntactic	possessive or dative pronoun
	pragmatic	Esther or Alice
duck	synt-sem	noun or verb

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Examples of applications

- Document clustering
- Document classification (e.g. anti-spamming, email routing, sentiment polarity, language identification)
- Information Retrieval
- Text correction
- Plagiarism detection
- Information Extraction
- Automatic Summarization
- Question Answering
- Machine Translation
- Dialog Systems

...

Information Retrieval (IR)

- E.g.: Searchers (Google, Yahoo, ...)
- Given a corpus, $D = \{D_i\}$, and a user query (list of words), Q , provide $\hat{D} \subset D$ that better match Q.
- $sim(v(Q), v(D_i))$, where $v(X)$ represents X in a vector space
- What vector space seems better?
  - words? $Q =$"window", $D_i =$"...he closed the windows..."
  - lemmas? $Q =$"window", $D_i =$"...he closed Windows..."
  - compounds? $Q =$"Energie", $D_i =$"...Sonnenenergie..."

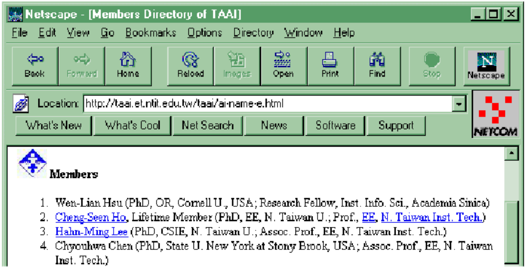
    ...
  - In-depth NLP seems not productive

Information Extraction (IE)

- E.g.: Enriching DBs or KBs with new content. Document collection indexing. Sentiment analysis.
- Extract the **relevant information** contained in text (entities, properties, relationships and events).
- Main subtasks:
  - Named Entity Recognition and Classification (NERC)
  - Slot Filling
  - Relationship Extraction
  - Event Extraction
- Depending on the specific task, more in-depth NLP is required (syntax, semantics, pragmatics, world-knowledge), as well as ML techniques.

Information Extraction (IE)

- Example 1: Member Name, Degree, School and Affiliation from WEB pages.


Netscape - [Members Directory of TAAI]
File Edit View Go Bookmarks Options Directory Window Help
Back Forward Home Reload Images Open Print Find Stop Netscape
Location:
What's New What's Cool Net Search News Software Support
NETCOM

Location: http://taai.et.ntit.edu.tw/taai/ai-name-e.html

Members

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Hahn-Ming Lee	PhD, CSIE, N. Taiwan U.	Prof.	EE,N. Taiwan Inst. Tech
...			

Information Extraction (IE)

- Example 2: incidents from free text (type of incident, perpetrator, target, date, location, effects, instrument).

> At 5pm on Thursday , a white Fiat van veered off the road and into a crowd outside the Plaça de Catalunya metro station in Barcelona. The van continued down Las Ramblas for more than 500 metres while crashing into pedestrians . 13 people have been killed . 100 people were injured and 15 are in serious condition . Las Ramblas attacker Younes Abouyaaqoub was killed in Subirats.

Information Extraction (IE)

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type of incident = crash

date = 17/8/2017

target = pedestrians

location = Las Ramblas (Barcelona)

perpetrator = Younes Abouyaaqoub

instrument = white Fiat van

effects = 13 people killed, 100 people injured, 15 people in serious condition

Automatic Summarization

- E.g.: Generate biographies, minutes of a meeting, abstracts or extracts of written documents
- Given a document or a corpus, generate an extract or an abstract consisting of the most relevant content.
- Abstractive methods:
  - Generate new text from the conceptual representation of the important information contained in the input text.
  - Require language understanding and generation
- Extractive methods:
  - Select the most important sentences in the input text and produce a summary.
  - The set of sentences should maximize overall importance and coherency and minimize the redundancy.
- How are *importance* and *redundancy* computed?
- Semantics and ML techniques help

Question Answering (QA)

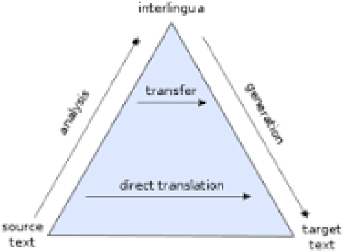
- E.g.: Questions answered by intelligent cars and rooms.
- Given a corpus, $D = \{D_i\}$, and a question, Q, extract the exact answer for Q from D.
  - Factoid QA: answers are exact facts

    E.g.: `Who was the president of the USA in 1987?`
  - Non-factoid QA: a definition, an explanation of how or why, a biography summary, ...

    E.g.: `Tell me what has been said so far in the meeting`
- Main subtasks:
  - Document indexing
  - Question processing (question type, question focus)
  - Answer extraction
- more in-depth NLP is required as well as ML techniques. Information extraction and Automatic Summarization help.

Machine Translation (MT)

- E.g.: Translation of written documents, help in human-human communication by mobile, online translation of broadcast news.
- Different MT models differ from the level of NLP they use:



- Transfer model is the most frequently used
- In general, the results are not comparable to human translation

Machine Translation (MT)

Examples of drawbacks: (with Google Translate)

- Working sentence by sentence: lack of context

```
ES: Ana no aprobó el examen.  Su amigo sí.
EN: Ana did not pass the exam.  Your friend yes.
ok:  Ana did not pass the exam.  Her friend did.
```

- Lack of world-knowledge: Named entities

```
ES: Disfrutar es el mejor nuevo restaurante de Europa
EN: Enjoy is the best new restaurant in Europe
ok:  Disfrutar is the best new restaurant in Europe
```

- Restricted domains: terminology

```
ES: El níscalo se cría bajo pinos
EN: The níscalo grows under pines
ok:  Red pine mushroom grows under pines

ES: Los níscalos se crían bajo pinos
EN: The chanterelles are raised under pines
ok:  Red pine mushrooms grow under pines
```

Dialog Systems

- E.g.: chatbots, dialog-driven QA in smart cars and rooms, health-care assistance
- Help users to achieve specific goals by means of natural language interaction
- Main subtasks:
  - Interpreting user intervention
  - Determining the next system's action considering the user intention (answer a question, ask for more info, suggest alternatives, ...)
  - Generating system's intervention
- High complexity: Natural language understanding and generation is required

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IHLT AHLT HLE

- **IHLT**: the foundations of NLP interpretation, focusing on possible simple applications (spelling correction, text classification, paraphrase detection, text anonymization, . . .)
- **AHLT**: more in-depth study of ML techniques for NLP interpretation (especially for syntactic and semantic parsing)
- **HLE**: review of complex applications of HLT (MT, IE, QA, Summ, Dialog)

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Content

	Topics	Examples of Applications
Session 1	Introduction (today)	
PART 1: Document Structure		
Session 2	XML parsers and Regular expr.	
	tokenization	Language identification
	sentence splitting	
PART 2: Words		
Session 3	Morphology	Spelling checkers
Session 4	PoS Tagging	
Session 5-6	Lexical semantics	Opinion detectors
	Word Sense Disambiguation	
PART 3: Sequences of Words		
Session 7	collocations	
	NERC	Anonymizers
PART 4: Sentences		
Session 8-9	Syntactic Parsing	Question classification for QA
Session 10	Compositional Semantics	Question reformulation for QA
PART 5: Sequences of Sentences		
Session 11	Coreference Resolution	Dialog
Session 12	Exercises and Project	
Session 13-14	Project presentations	

Evaluation procedure

- Final exam: all the content, exam period
- Lab sessions: groups of 2 students
  - Development of one project
  - Some deliverables of lab exercises
- Final mark = 50% Exam + 40% Project + 10% Lab deliverables