



IT Systems Engineering | Universität Potsdam

# Natural Language Processing

*Introduction to Language Technology*

Potsdam, 12 April 2012

**Saeedeh Momtazi**

Information Systems Group

# Outline

- 1 Administrative Information
- 2 Introduction
- 3 NLP Applications
- 4 NLP Techniques
- 5 Linguistic Knowledge
- 6 Challenges
- 7 Course Materials

# Outline

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# NLP Course

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## ■ Lecture

- Thursdays 9:15-10:45
- Location: HS 3
- Credit Point: 3 LP

## ■ Assessment

- Regular attendance in the class
- Doing exercises
- Final exam

## ■ Contact

- Saeedeh Momtazi
  - Email: [saeedeh.momtazi@hpi.uni-potsdam.de](mailto:saeedeh.momtazi@hpi.uni-potsdam.de)
  - Office: A-1.7



## ■ Course Home Page

- [http://www.hpi.uni-potsdam.de/naumann/teaching/ss\\_12/natural\\_language\\_processing.html](http://www.hpi.uni-potsdam.de/naumann/teaching/ss_12/natural_language_processing.html)
  - Administrative information
  - Slides
  - Exercises

## ■ Mailing List

- Will be set later

# Outline

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# Different Types of Languages

7

- Natural languages
  - English
  - German
  - French
  - Spanish
  - ...
  
- Formal languages
  - Java
  - Python
  - LaTeX
  - ...
  
- Descriptive languages
  - Biology: DNA
  - Chemistry: chemical formulas
  - ...

# Natural Language

8

- A vocabulary consists of a set of words ( $w_i$ )
- A text is composed of a sequence of words from the vocabulary
- A language is constructed of a set of all possible texts

# Natural Language

9

## ■ Examples of Vocabularies

### □ English

- the
- and
- eat
- you
- book
- ...

### □ German

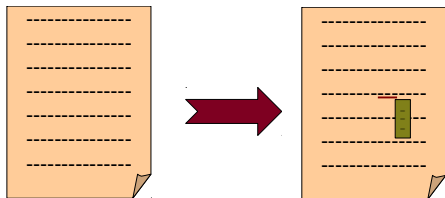
- das
- und
- essen
- du
- buch
- ...

# Outline

- 1 Administrative Information
- 2 Introduction
- 3 NLP Applications**
  - Text Technologies
  - Speech Technologies
- 4 NLP Techniques
- 5 Linguistic Knowledge
- 6 Challenges
- 7 Course Materials

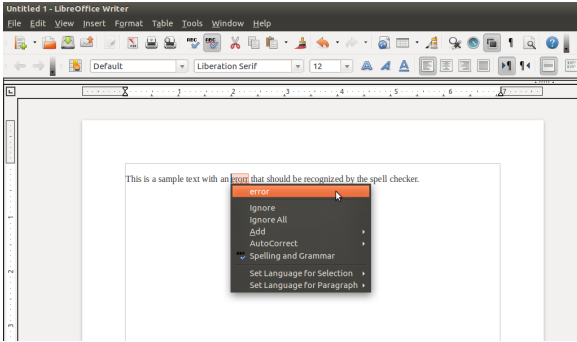
# Spell and Grammar Checking

- Checking the spelling and the grammar of a text, and suggesting correct alternatives for the errors



# Spell and Grammar Checking

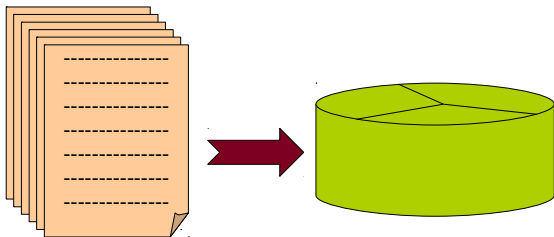
12





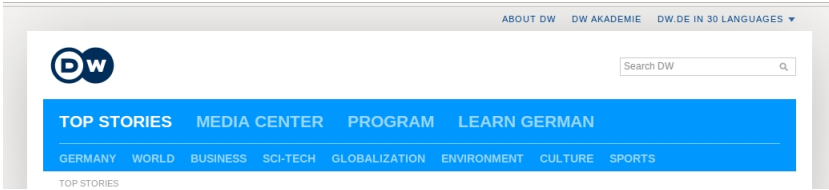
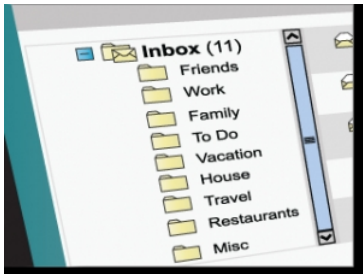
# Text Categorization

- Assigning each text to a category



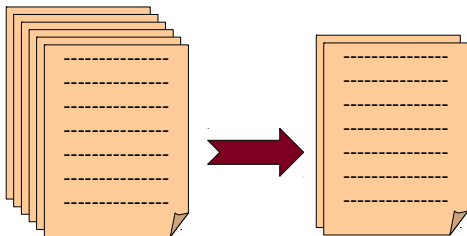
# Text Categorization

14



# Information Retrieval

- Finding relevant information to the user's query



# Information Retrieval

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The Google logo in its multi-colored font.

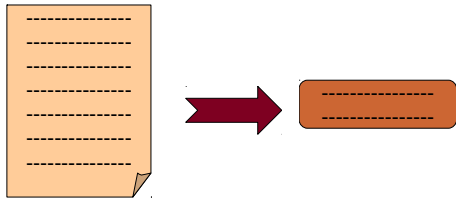
Google Search

I'm Feeling Lucky

The Bing logo in blue lowercase letters with a small orange dot above the 'i'.The Yahoo! logo in a purple, bold, serif font.

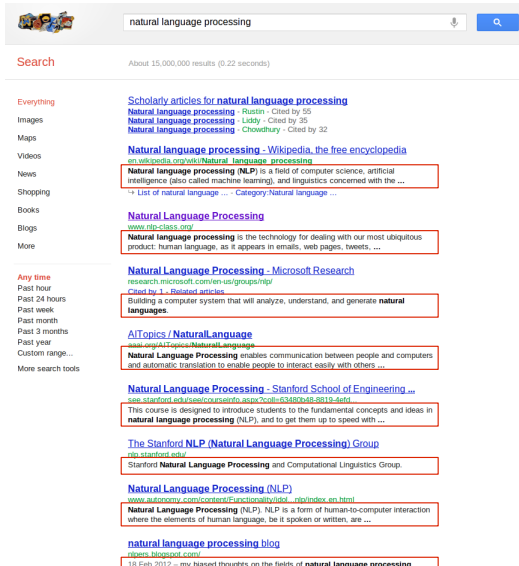
# Summarization

- Finding the most relevant part of a document based on the user's information need



# Summarization

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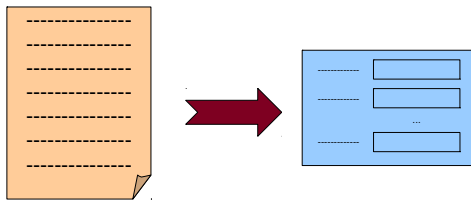


The screenshot shows a search engine interface with the query "natural language processing" entered in the search bar. The search results are categorized by type (Everything, Images, Maps, Videos, News, Shopping, Books, Blogs, More) and time (Any time, Past hour, Past 24 hours, Past week, Past month, Past 3 months, Past year, Custom range...). The results include:

- Scholarly articles for natural language processing**: A list of articles with authors and citation counts (e.g., Rustin - Cited by 55, Liddy - Cited by 35, Chowdhury - Cited by 32).
- Natural language processing - Wikipedia, the free encyclopedia**: A snippet describing NLP as a field of computer science, artificial intelligence, and linguistics.
- Natural Language Processing**: A snippet from www.nlp-class.org describing NLP as technology for dealing with human language in emails, web pages, tweets, etc.
- Natural Language Processing - Microsoft Research**: A snippet from research.microsoft.com describing a system that analyzes, understands, and generates natural languages.
- AITopics / NaturalLanguage**: A snippet from aaii.org describing NLP as enabling communication between people and computers.
- Natural Language Processing - Stanford School of Engineering**: A snippet from stanford.edu describing a course designed to introduce students to NLP concepts.
- The Stanford NLP (Natural Language Processing) Group**: A snippet from nlp.stanford.edu describing the group's focus on NLP and Computational Linguistics.
- Natural Language Processing (NLP)**: A snippet from www.autonomy.com describing NLP as a form of human-to-computer interaction.
- natural language processing blog**: A snippet from nlpers.blogspot.com dated Feb 18, 2012, discussing NLP fields.

# Information Extraction

- Extracting the important items of a text and structuring them







# Information Extraction

21

**Albert Einstein**

Wikipedia: The free encyclopedia

**Albert Einstein**

From Wikipedia, the free encyclopedia

**Albert Einstein** (German pronunciation: [ˈalbɛʁt ˈɛɪnʃtaɪn]; German: [ˈalbɛʁt ˈɛɪnʃtaɪn]; 14 March 1879 – 18 April 1955) was a German-born theoretical physicist, best known for his contributions to theoretical physics, and especially for his discovery of the law of the photo effect the beginning of his career. Einstein thought that Newtonian mechanics was no longer enough to describe the laws of nature and subsequent theory of gravitation in 1915. He published a paper on the general theory of relativity, one continued to deal with problems of SR. Einstein applied the general theory of relativity to model the structure of the universe as a whole.<sup>[?]</sup>

He was visiting the United States when Adolf Hitler came to power in 1933, and did not go back to Germany, where he had been a good recommendation that the U.S. begin similar research, the eventually led to what would become the Manhattan Project. Einstein was in a nuclear weapon. Einstein was affiliated with the Institute for Advanced Study in Princeton, New Jersey, until his death in 1955.

Einstein published more than 300 scientific papers along with over 100 non-scientific works.<sup>[?]</sup> His great intelligence and originality led

**Biography**

- 1. Biography
- 2. Early life and education
- 3. The photo effect and quantum theory
- 4. Special relativity
- 5. General relativity
- 6. The quantum theory of radiation
- 7. The Bohr model and quantum mechanics
- 8. The theory of statistical mechanics
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**Early life and education**

Albert Einstein was born in Ulm, in the Kingdom of Württemberg in the German Empire on 14 March 1879.<sup>[?]</sup> His father was Hermann A. Einstein, a Jewish engineer.<sup>[?]</sup>

The Einstein family were non-observant Jews; Albert attended a Catholic elementary school from the age of five for three years. Later, at 10 he is depicted by the Albert Einstein archives, and he excelled at the first school that he attended.<sup>[?]</sup>

His father once showed him a pocket calculator. Einstein realized that there must be something causing the needle to move, despite its being frictionless. He remembered to the Einstein family by his brother, and during weekly visits over the next five years he gave the boy an RSA. His father's company failed direct current (DC) lost the War of Currents to alternating current (AC). In search of business, the inventor claimed his invention and patented the electric organ and teaching method. He later wrote that the spirit of learning and a

<b>Albert Einstein</b>	
<b>Born</b>	14 March 1879 Ulm, Kingdom of Württemberg, German Empire
<b>Died</b>	18 April 1955 (aged 76) Princeton, New Jersey, United States
<b>Residence</b>	Germany, Italy, Switzerland, Austria, Belgium, United Kingdom, United States
<b>Citizenship</b>	Württemberg/Germany (1879–1906) Stateless (1896–1901) Switzerland (1901–1955) Austria (1911–1912) Germany (1914–1933) United States (1940–1955)
<b>Fields</b>	Physics
<b>Institutions</b>	Swiss Patent Office (Bem) University of Zurich Charles University in Prague ETH Zurich Prussian Academy of Sciences Kaiser Wilhelm Institute University of Leiden Institute for Advanced Study
<b>Alma mater</b>	ETH Zurich University of Zurich
<b>Doctoral advisor</b>	Alfred Kleiner
<b>Other academic advisors</b>	Heinrich Friedrich Weber
<b>Notable students</b>	Ernst G. Straus Nathan Rosen Leo Szilard Rakuzind Sidddiqi <sup>[?]</sup>
<b>Known for</b>	General relativity and special relativity Photoelectric effect Mass-energy equivalence Theory of Brownian Motion Einstein field equations E=mc <sup>2</sup> (mass-energy equivalence)

Albert Einstein

Wikipedia: The free encyclopedia

**Albert Einstein**

From Wikipedia, the free encyclopedia

**Albert Einstein** (German pronunciation: [ˈalbɛʁt ˈɛɪnʃtaɪn]; German: [ˈalbɛʁt ˈɛɪnʃtaɪn]; 14 March 1879 – 18 April 1955) was a German-born theoretical physicist, best known for his contributions to theoretical physics, and especially for his discovery of the law of the photo effect the beginning of his career. Einstein thought that Newtonian mechanics was no longer enough to describe the laws of nature and subsequent theory of gravitation in 1915. He published a paper on the general theory of relativity, one continued to deal with problems of SR. Einstein applied the general theory of relativity to model the structure of the universe as a whole.<sup>[?]</sup>

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which, after his father and his uncle founded elektrotechnische Fabrik Z. Einstein & Cie, a company that manufactured electrical equipment

only school education and he left Germany seven years later.<sup>[?]</sup> Although it has been thought that Einstein had early special abilities, this

as a letter for mathematics.<sup>[?]</sup> When Einstein was ten years old, his father changed to Swiss Patent, a junior Jewish medical student of

of Isaac Asser and Zurich University (which Einstein called the "Holy Bible Geometry Society").<sup>[?]</sup>

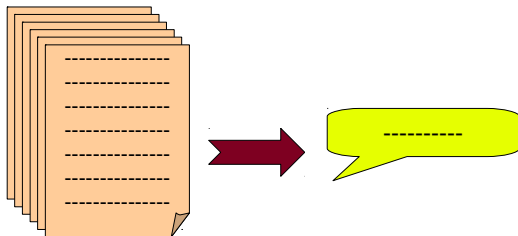
Paris, Einstein stayed in search to finish his studies at the Litzberg Gymnasium. His father intended for him to pursue classical engineering, but

in Paris, convincing the school to let him go by using a doctor's note.<sup>[?]</sup> It was during his time in Italy, one without formal schooling that

# Question Answering

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- Answering natural language questions asked by the user



# Question Answering

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# Question Answering

24



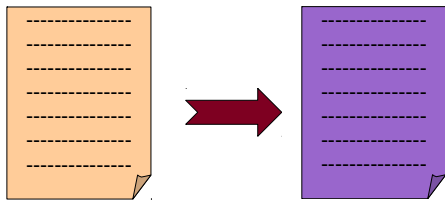
Crete

**HARRIET BOYD  
HAWES WAS  
THE FIRST WOMAN  
TO DISCOVER &  
EXCAVATE A  
MINOAN SETTLEMENT  
ON THIS ISLAND**

# Machine Translation

25

- Translating a text from one language to another language



# Machine Translation

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Translate

From: English - detected



To: German

Translate

English Spanish French

This is a sample sentence in English which is translated to German.

English Persian **German**

Dies ist ein Beispielsatz in englischer Sprache, die auf deutsch übersetzt wird.

Now! Click the words above to view alternate translations. [Dismiss](#)



Design IT. Create knowledge.

Willkommen beim HASSO-PLATTNER-INSTITUT, dem universitären Exzellenz-Center für IT-Systems Engineering

Flowplayer

HPI-TV-Berichte ansehen

4. conference 20-22 September 2012

IT-Gipfel

Aktuell



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flowplayer

HPI-TV-Geçerler ansehen

4. conference 20-22 September 2012

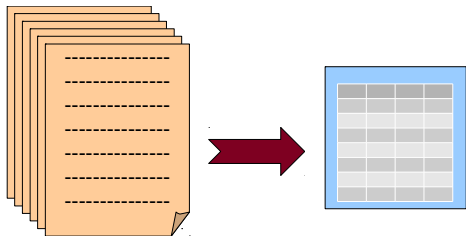
IT-Gipfel

Aktuell

# Data Fusion

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- Combining extracted information from several text files into a database or an ontology



# Data Fusion

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WIKIPEDIA  
The Free Encyclopedia

- Main page
- Featured content
- Current events
- Random article
- Donate to Wikipedia
- Interaction
- Help
- About Wikipedia
- Community portal
- Recent changes
- Contact Wikipedia
- Toolbox
- Postscript
- Languages
- Special pages
- Search
- Help
- Privacy policy
- Disclaimers
- Code of conduct
- Terms of use
- Mobile view
- Desktop view

Article Talk

## Jean Dujardin

From Wikipedia, the free encyclopedia

**Jean Edmond Dujardin** (French pronunciation: [d̥uːˈʁɑːˈd̥ɛː]; born 29 June 1972) is a French actor and comedian. He has worked regularly with director Michel Hazanavicius, starting in his 2005 117 spy parodies. His starting role in Hazanavicius' silent movie *The Artist*, playing actor George Valentin, received widespread acclaim. The role won him the Golden Globe Award for Best Actor in a Musical or Comedy, the BAFTA Award for Best Actor in a Leading Role, the Screen Actors Guild Award for Outstanding Performance by a Male Actor in a Leading Role, the Cannes Film Festival Best Actor Award, and the Academy Award for Best Actor. He is the first French actor to win the Academy Award for Best Actor.

- Contents** [hide]
- Early life
  - Career
  - Parodying
  - Film
  - Television
  - Music videos
  - References
  - External links

### Early life

Dujardin was born and raised in Rueil-Malmaison (Hauts-de-Seine, Île-de-France), a commune in the western suburbs of Paris, France.<sup>[c]</sup> After attending high school, he went to work for his parents' construction company.<sup>[c]</sup> Dujardin began contemplating a career in acting while serving his mandatory military service a few years later.<sup>[c]</sup>

### Career

			<p>Academy Award for Best Actor</p> <p>AACTA International Award for Best Actor</p> <p>BAFTA Award for Best Actor in a Leading Role</p> <p>Cannes Film Festival Best Actor Award<sup>[1]</sup></p> <p>Golden Globe Award for Best Actor – Motion Picture Musical or Comedy</p> <p>Hollywood Film Festival Spotlight Award</p> <p>Independent Spirit Award for Best Male Lead</p> <p>Las Vegas Film Critics Society Award for Best Actor</p> <p>London Film Critics Circle Award for Actor of the Year</p> <p>Phoenix Film Critics Society Award for Best Actor</p> <p>Santa Barbara International Film Festival <b>Cinema Vanguard Award</b></p> <p>Screen Actors Guild Award for Outstanding Performance by a Male Actor in a Leading Role</p> <p>Etoile d'Or Award for Best Actor</p> <p>Women Film Critics Circle Award for Best Screen Couple (with Bérénice Bejo)</p> <p>Nominated—Alliance of Women Film Journalists <b>EDA Award for Best Actor</b></p> <p>Nominated—Broadcast Film Critics Association Award for Best Actor</p> <p>Nominated—Central Ohio Film Critics Association Award for Best Actor</p> <p>Nominated—Crisis Award for Best Actor</p> <p>Nominated—Chicago Film Critics Association Award for Best Actor</p> <p>Nominated—Chlotrudis Award for Best Actor</p> <p>Nominated—Chlotrudis Award for Best Cast</p> <p>Nominated—Dallas–Fort Worth Film Critics Association Award for Best Actor (runner-up)</p> <p>Nominated—Detroit Film Critics Society Award for Best Actor</p> <p>Nominated—European Film Award for Best Actor</p> <p>Nominated—Houston Film Critics Society Award for Best Actor</p> <p>Nominated—National Society of Film Critics Award for Best Actor (second runner-up)</p> <p>Nominated—New York Film Critics Circle Award for Best Actor</p> <p>Nominated—Online Film Critics Society Award for Best Actor</p> <p>Nominated—San Diego Film Critics Society Award for Best Actor</p> <p>Nominated—Screen Actors Guild Award for Outstanding Performance by a Cast in a Motion Picture</p> <p>Nominated—St. Louis Gateway Film Critics Association Award for Best Actor</p>
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2011	<i>The Artist</i>	George Valentin
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Read Edit View history Search



Jean Dujardin in 2012 (Cannes Film Festival)

**Born:** Jean Edmond Dujardin  
19 June 1972 (age 39)  
Rueil-Malmaison, Hauts-de-Seine, Île-de-France, France

**Occupation:** Actor  
**Years active:** 2000–present  
**Genre:** actor

**Actor in a Leading Role**

**Demian Bichir**  
A Better Life

**George Clooney**  
The Descendants

**Jean Dujardin**  
The Artist

**Gary Oldman**  
Tinker Tailor Soldier Spy

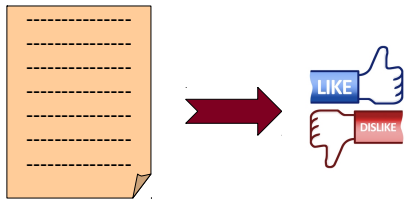
**Brad Pitt**  
Moneyball



# Sentiment Analysis

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- Identifying positive and negative opinions stated in a text



# Sentiment Analysis

HPI

Hasso Plattner Institut

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Home Berlin Hotels Flights Vacation Rentals Restaurants Things to Do Best of 2012 More Write a Review

Home > Berlin > Hotels > Berlin Hotels > The Ritz-Carlton, Berlin

## The Ritz-Carlton, Berlin

Professional Plaza 3, 10705 Berlin, Germany [Map](#) [Hotel amenities](#)

Ranked #7 of 152 hotels in Berlin

Travelers' Choice® 2012 Winner

Show the lowest price for this hotel\*

Show Prices

231 traveler photos

647 reviews from our community

See which reviews travelers prefer · 23 traveler tips

"A really great place to stay in Berlin"

"Great location and very comfortable hotel"

### "A Complete Letdown"

1 person found this review helpful

I originally selected this hotel over others in Berlin - including Hotel Adlon - due to its top 3 TripAdvisor ranking at the time. I ended with dismay but ever since then my position had been continually slipping ever downwards! I really had hoped that the recent upgrade from a good review count to the luxury property status and occasional bad experiences, which can happen even at the best properties. As I'd booked it through a third party agent I would advise using a price comparison site like as I got a better deal than if I'd booked it directly with the hotel) and paid in advance there was no way to return that.

Butler I searched into the full review, I will note that the best thing about this hotel is the breakfast. It is superb, and any criticism would only really come down to very personal taste and would be not picking anything in. I ordered for a wonderful selection of fresh hot, including breads, and cereals. Lots of different breads, rolls, and even bagels, and a toaster so one can toast sandwiches sandwiching one's wishes, there is also an equally large array of pastries/cakes to enjoy with the bread. There is a good selection of cold cuts, fish, high quality cheeses, as well as the usual American style hot buffet complete with condiments made to order. All of this isn't enough, either. American pancakes. French toast, and waffles can all be made to order (at no extra charge), in short, this is an exemplary hotel breakfast in both terms of quality and variety. The service was usually attentive with glasses regularly topped up, but once it started to get busy (around 9.30 onwards, especially at the weekend) one did notice a drop in attention to detail, as well as a general winking in the bar area. If you are going to stay here, make sure you have breakfast included as it is the major reasoning factor of this property!

Upon arrival, a hair caped doorman opened my taxi door, and neatly removed the luggage and welcomed me to the hotel. If only things had continued like this... The girl at the front desk was polite, but far from welcoming as the doorman had been. Things were wrong when we asked for my voucher; I explained that whilst I had booked through a third party I had e-mailed the hotel directly to confirm everything was as it should be and they had never mentioned the need for any voucher. She was very polite and went away to ask someone else, and still returned on the voucher. I advised that I could probably dig out an email once I had access to a computer and give it off to them. She still wasn't really satisfied, was a little huffy said that they would contact the travel agent for another copy. To add to this, I had been travelling since 4am that morning, whilst I did not expect the hotel to specifically know that, the front desk should always be very that most travellers will always be somewhat weary from their journey if it has not expired that or been checked out, but even contacted me if I had indeed needed to provide the voucher (which as it turned out I didn't).

A bell boy showed me up to my room and was extremely friendly and professional and showed me the various features of the room, how to operate touch-panel light switches etc. This was a thoughtful touch, and much appreciated. The room itself was a huge roomer I will discuss the rooms in more detail a little later) and the double glazing was far from top quality, and a hissing noise could be heard when the window did not seal fully on the 'fringed side'. I complained about this, and they advised someone would look at the window whilst I was out. I returned to the room and the problem was as before and there was no note explaining what had happened; I went to shower and get ready to go out, the bell containing the vanity kit was empty which I was not best pleased with. I spoke to the duty manager in my stay out and he assured me he would locate the issue with the window. I returned from shower, still no note and the hissing sound ever more apparent. I called the guest service department yet again (I am sure they were bored of my call) and they advised that someone had complained the noise to be solved. I am not someone who requires complex solutions, but it was a very particular noise and the room attendant was pretty good so I would be very particular.

The next day I returned and was offered a change of room, and a complimentary

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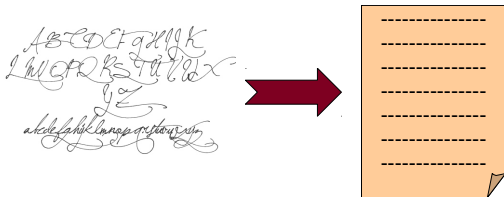
Value  
Location  
Sleep Quality

Cleanliness  
Service

# Optical Character Recognition

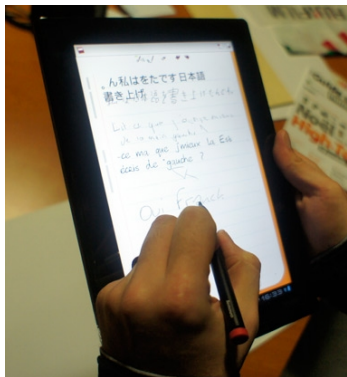
31

- Recognizing printed or handwritten texts and converting them to computer-readable texts



# Optical Character Recognition

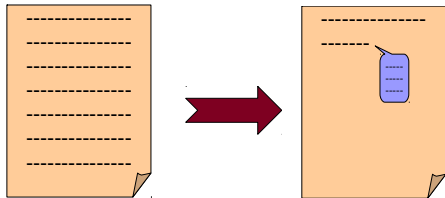
32



# Word Prediction

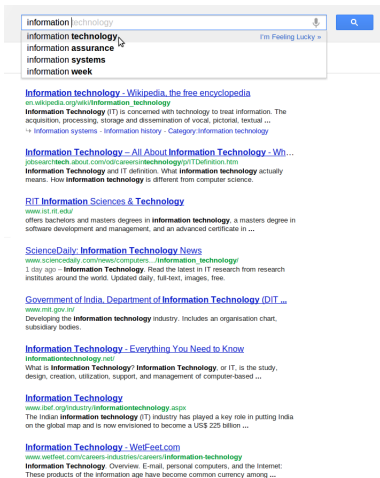
33

- Predicting the next word that is highly probable to be typed by the user



# Word Prediction

34



information | technology

- information **technology**
- information **assurance**
- information **systems**
- information **week**

[Information technology - Wikipedia, the free encyclopedia](#)  
 en.wikipedia.org/wiki/Information\_technology  
**Information Technology** (IT) is concerned with technology to treat information. The acquisition, processing, storage and dissemination of vocal, pictorial, textual ...  
 -> Information systems - Information history - Category:Information technology

[Information Technology - All About Information Technology - Wh...](#)  
 jobsearchtech.about.com/od/careersintechnology/p/ITDefinition.htm  
**Information Technology** and IT definition. What **information technology** actually means. How **information technology** is different from computer science.

[RIT Information Sciences & Technology](#)  
 www.rit.edu  
 offers bachelors and masters degrees in **information technology**, a masters degree in software development and management, and an advanced certificate in ...

[ScienceDaily: Information Technology News](#)  
 www.sciencedaily.com/news/computers.../information\_technology/  
 1 day ago - **Information Technology**: Read the latest in IT research from research institutes around the world. Updated daily. Full-text, images, free.

[Government of India, Department of Information Technology \(DIT ...](#)  
 www.mit.gov.in  
 Developing the **information technology** industry. Includes an organisation chart, subsidiary bodies.

[Information Technology - Everything You Need to Know](#)  
 informationstechnology.net  
 What is **Information Technology**? **Information Technology**, or IT, is the study, design, creation, utilization, support, and management of computer-based ...

[Information Technology](#)  
 www.ibef.org/industry/informationtechnology.aspx  
 The Indian **information technology** (IT) industry has played a key role in putting India on the global map and is now envisioned to become a US\$ 225 billion ...

[Information Technology - WetFeet.com](#)  
 www.wetfeet.com/careers-industries/careers/information-technology  
**Information Technology** Overview. E-mail, personal computers, and the Internet: These products of the information age have become common currency among ...

# Outline

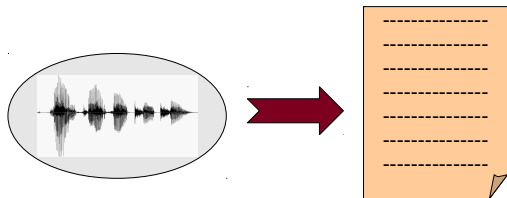
35

- 1 Administrative Information
- 2 Introduction
- 3 NLP Applications**
  - Text Technologies
  - Speech Technologies**
- 4 NLP Techniques
- 5 Linguistic Knowledge
- 6 Challenges
- 7 Course Materials

# Speech Recognition

36

- Recognizing a spoken language and transforming it into a text





# Speech Recognition

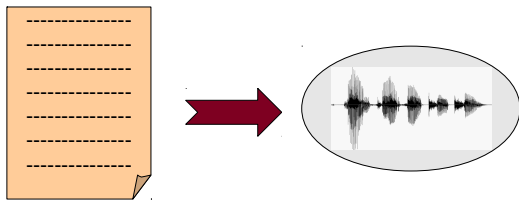
37



# Speech Synthesis

38


- Producing a spoken language from a text



# Speech Synthesis

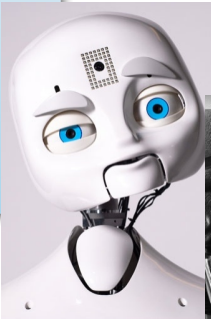
39

Text-to-Speech TRANSLATOR **addcast**  
CONNECTING VOICES COMMUNICATION



1. Enter Text: (250 character limit, 50 character limit for Asian language)  
I'm your father, Luke

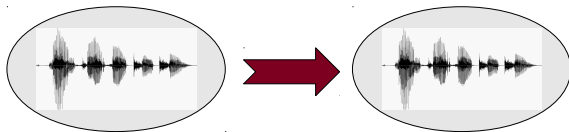
2. Translate From: English To: Spanish  
Voice: Alberto (Lat Am)



# Spoken Dialog Systems

40

- Running a dialog between the user and the system



# Spoken Dialog Systems

41



Computer, show me the shortest route to TSMC, HsinChu City



# Applications' Levels

42

- Easy (mostly solved)
  - Spell and grammar checking
  - Spam detection
  
- Intermediate (good progress)
  - Information retrieval
  - Sentiment analysis
  - Machine translation
  - Information extraction
  
- Difficult (still hard)
  - Question answering
  - Summarization
  - Dialog system

# Outline

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- 1 Administrative Information
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# Part Of Speech Tagging

44

*"I saw the man on the roof."*

*"I<sub>[PRON]</sub> saw<sub>[V]</sub> the<sub>[DET]</sub> man<sub>[N]</sub> on<sub>[PREP]</sub> the<sub>[DET]</sub> roof<sub>[N]</sub>."*

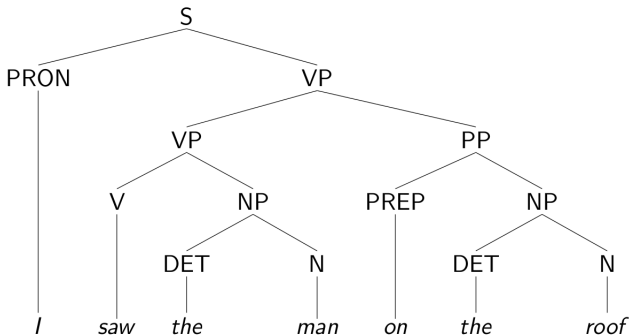
[PRON]	Pronoun
[PREP]	Preposition
[DET]	Determiner
[V]	Verb
[N]	Noun



# Parsing

45

*"I saw the man on the roof."*



# Named Entity Recognition

46

*“Steven Paul Jobs, co-founder of Apple Inc, was born in California.”*

*“Steven Paul Jobs, co-founder of Apple Inc, was born in California.”*  
*Person Organization Location*

# Word Sense Disambiguation

47

“Jim flew his *plane* to Texas.”



“Alice destroys the item with a *plane*.”



# Semantic Role Labeling

48

“John *grills* a fish on an open fire.”

Cook  
 Food  
 Heating-Instrument

“John *grills* a fish on an open fire .”  
 Cook                  Food                  Heating-Instrument

# Outline

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# Linguistic Knowledge

50

- Phonetics and Phonology
- Morphology
- Syntax
- Semantics
- Pragmatics
- Discourse

# Phonetics and Phonology

51

- The study of linguistic sounds and their relations to words

b	b	l	l	sh	ʃ	a	æ	oh	oʊ
p	p	r	r	zh	ʒ	ah	aː	oa	o
d	d	m	m	th	θ	ay	e	u	u
t	t	n	n	h	h	e	ɛ	uh	ʌ
f	f	s	s	w	w	ee	i	oo	u
v	v	z	z	y	j	i	i	oi	ɔj
g	g	ch	tʃ	ng	ŋ	iy	aɪ	ow	aʊ
k	k	j	dʒ			o	ɑ		

# Morphology

52

- The study of internal structures of words and how they can be modified
- Parsing complex words into their components

*unbelievable*  
*un+believ+able*

prefix: *un*  
root: *believe*  
suffix: *able*

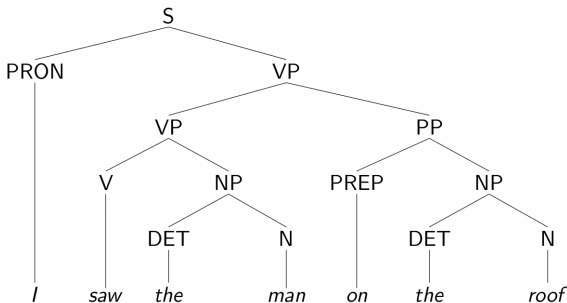


# Syntax

53

- The study of the structural relationships between words in a sentence

*I saw the man on the roof.*



# Semantics

54

- The study of the meaning of words, and how these combine to form the meanings of sentences
- Realizing lexical relations among words

Hyponymy (is a)      *dog & animal*

Meronymy (part of)      *arm & body*

Synonymy      *fall & autumn*

Antonymy      *tall & short*

# Pragmatics

55

- The study of how language is used to accomplish goals, and the influence of context on meaning
- Understanding the aspects of a language which depends on situation and world knowledge

*Do you know what time it is?*

# Discourse

- The study of linguistic units larger than a single utterance

*John reads a book. He borrowed it from his friend.*

# Outline

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- 1 Administrative Information
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# Challenges

58

## ■ Different words/sentences express the same meaning

- The third season of the year
  - *Fall*
  - *Autumn*
- Book delivery time
  - *When will my book arrive?*
  - *When will I receive my book?*

Paraphrasing

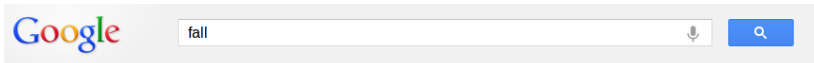
## ■ One word/sentence can have different meanings

- *Fall*
  - The third season of the year
  - Moving down towards the ground or towards a lower position
- *The door is open.*
  - Expressing a fact
  - A request to close the door

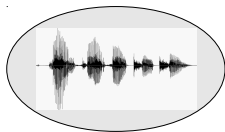
Ambiguity

# Challenges

59



- Moving down?
- The third season of the year?
  - What about *autumn*?



*Computers can recognize speech*

*Computers can wreck a nice peach*



# Morphology

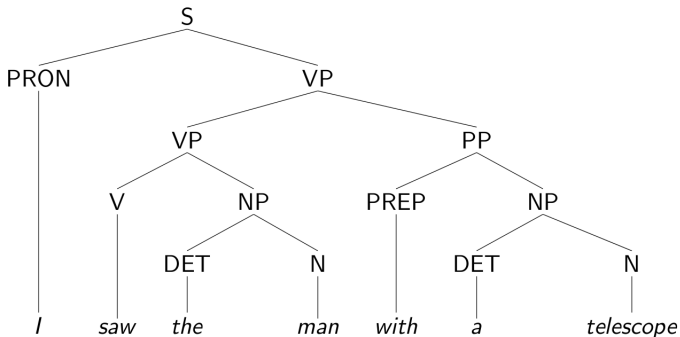
61

*Unionize*

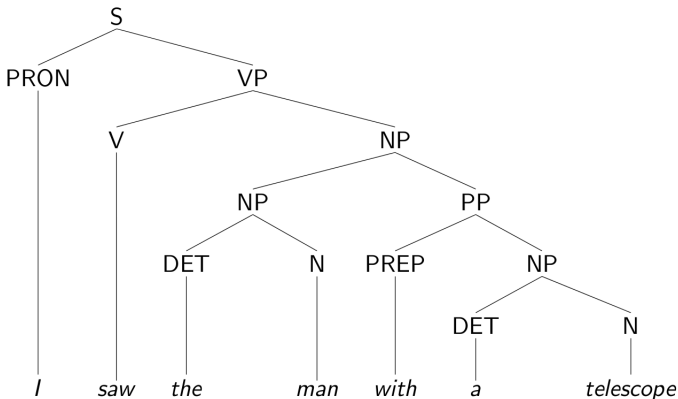
Union + ize

Un + ion + ize

*I saw the man with a telescope.*



*I saw the man with a telescope.*



The astronomer loves the **star**.

Movie Star (Celebrity)

Sky Star

*Every man loves a woman.*

$\forall x : (\text{man}(x) \rightarrow \exists y : (\text{woman}(y) \ \& \ \text{love}(x, y)))$

$\exists y : (\text{woman}(y) \ \& \ \forall x : (\text{man}(x) \rightarrow \text{love}(x, y)))$

*Can you give me the salt?*

Would you please give me the salt?

Do you have the ability to give me the salt?

*Alice understands that you like your mother, but **she** ...*

Alice

Your Mother

# Ambiguity

68

I made her duck.





# Outline

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# Topics

70

- Introduction
  - Introduction to Language Technology
  - Language Modeling
  
- Machine Learning for NLP
  
- NLP Techniques
  
- NLP Applications

# Topics

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- Introduction
  
- Machine Learning for NLP
  - Learning Techniques
  - Classification Algorithms
  - Clustering Algorithms
  
- NLP Techniques
  
- NLP Applications

# Topics

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- Introduction
- Machine Learning for NLP
- NLP Techniques
  - Part Of Speech Tagging
  - Parsing
  - Named Entity Recognition
  - Word Relations
  - Word Sense Disambiguation
  - Semantic Role Labeling
- NLP Applications

# Topics

73

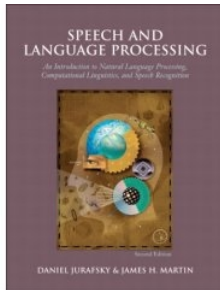
- Introduction
- Machine Learning for NLP
- NLP Techniques
- NLP Applications
  - Text Categorization
  - Information Retrieval
  - Information Extraction
  - Question Answering
  - Sentiment Analysis
  - Summarization
  - Machine Translation

## SPEECH AND LANGUAGE PROCESSING

An Introduction to Natural Language Processing,  
Computational Linguistics, and Speech Recognition

by Daniel Jurafsky and James H. Martin

Second Edition



# Relevance Journal & Conference

75

## ■ Journal

- Computational Linguistics

## ■ Conferences

- ACL: Association for Computational Linguistics
  - NAACL: North American Chapter
  - EACL: European Chapter
- HLT: Human Language Technology
- EMNLP: Empirical Methods on Natural Language Processing
- CoLing: Computational Linguistics
- LREC: Language Resources and Evaluation