

Adv. Natural Language Processing

Lecture 1

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Goals of this subject

- Understanding the challenges of NLP
- Learn about NLP problems and their solution
- Learn general purpose methods
- Be able to read modern research in NLP



Disclaimer

I am not inventing the wheel in this class

You are welcome to watch videos, read those if you feel more comfortable with that

We will change things based on experience, so please be **patient**.



Course Outlines

- Introduction + representing words (word vectors)
- Language models, feed-forward networks, back-propagation
- Tagging, HMMs, Viterbi
- Log-linear models for tagging
- PCFGs, CKY
- Log-linear models for parsing, Lexicalized parsing, dependency parsing
- Globally normalized log-linear models (structured perceptron, CRFs)
- Semantic parsing



Recommended books

Speech and Language Processing: An Introduction to Natural Language Processing:

By James H. Martin and Daniel Jurafsky

Ontology Based Interpretation of Natural Language:

By Cimiano, Christina and John

Reference Book:

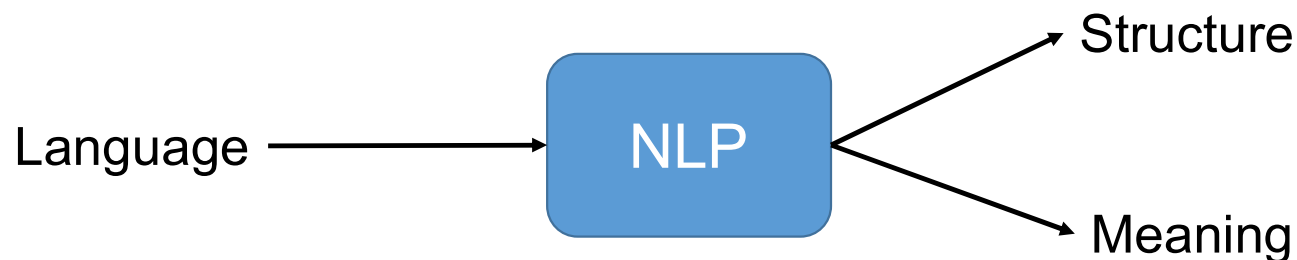
Statistical Foundations of NLP:

By Schutze and Manning:

What is NLP?

Natural-language processing (NLP) is a field of computer science, artificial intelligence concerned with the interactions between computers and human (natural) languages, and particularly concerned with programming computers to fruitfully process large natural language data.

Goal: Develop methods for processing, analysing and understanding the **structure** and **meaning** of language.





What is NLP?

Application: Build systems that help people do stuff (with text):

Question answering, virtual assistants, translation, etc.

There is a lot language out there...



Applications of NLP

1. Search
2. Advertisement matching
3. Translation
4. Sentiment analysis
5. Speech recognition
6. Chatbots
7. Virtual assistants
8. ...

Levels of Analysis in NLP

Phonology: sounds that make up language

Morphology: internal structure of words

Syntax: structure of phrases,
how words modify one another
“pretty little girl’s school”

Semantics: meaning of language in the world
“students sitting in the back row”

Discourse: relations between clauses and sentences
*I registered to the class on NLP **because** it is fascinating*



What's special about Languages?

Invented by humans for communication

Learned from experience (!!)

A symbolic/discrete system:

table:



piano:



that pre-dates logic...

Language is special

Encoded via continuous signals:

- Sounds
- Gestures
- Image (writing)

Brain encodings are continuous





Why it is hard for computers to learn a language?

1. Ambiguity
2. Variability
3. Sparsity
4. Grounding



1. Ambiguity

“Finally, a computer that understands you like your mother” (Ad , 1985)

1. The computer understands you as well as your mother understands you.
2. The computer understands that you like your mother.
3. The computer understands you as well as it understands your mother.

“Finally, a computer that understands your lie that cured mother”



a) Lexical Ambiguity

Definition:

A word belongs to two or more-words (“part of speech”) classes.

Example:

1. the **round** table (is an adjective),
2. to **round** the corner (is a verb),
3. dance in a **round** (is a noun),
4. come **round** and see us (is an adverb),
5. he walked **round** the room (is a preposition).

Finite state grammars can be used for resolving lexical ambiguity



b) Syntactic Ambiguity

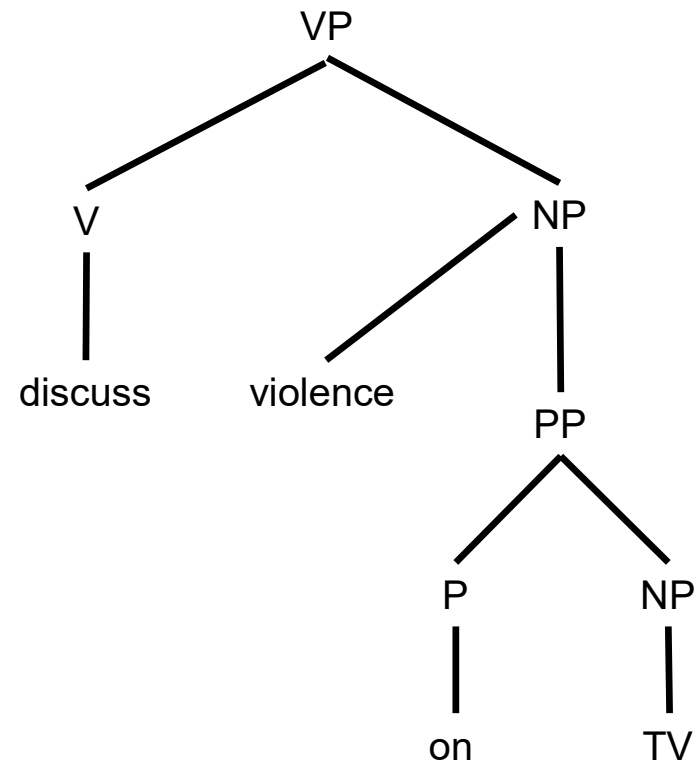
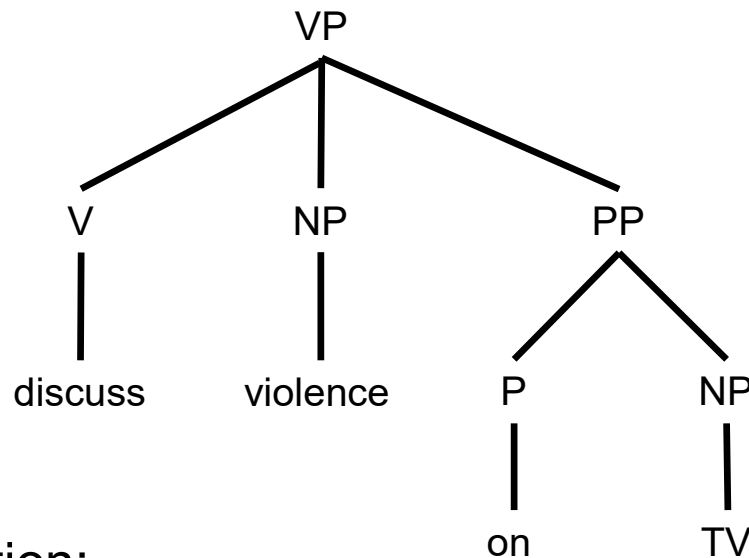
Definition:

Concern with the roles performed by **words** in sentences and possible grammatical constructions

Example,

“They are cooking apples” is **ambiguous** because it may or may not mean that apples are being cooked ...

c) Structural Ambiguity



Definition:

A context-free grammar can assign two or more phrase structures ("parse trees") to one and the same sequence of terminal symbols (words or word classes)

Even short sentences have hundreds of analyses



d) Semantic Ambiguity

Definition:

Concerns the meaning of a word or phrase/sentence

Claims suffer from **semantic ambiguity** when they contain a word (or words) with multiple meanings.

Example:

*“I don't like it when my father **smokes**.”*

The word “smokes” has more than one meaning, and the significance of the sentence changes dramatically depending on which meaning is intended.

(smokes also means without results)

*“There's a river that **crosses** every town.”*

Quantification ambiguity (not syntactic)



1. Ambiguity

Headlines:

- *Enraged Cow Injures Farmer with Axe*
- *Teacher Strikes Idle Kids*
- *Hospitals Are Sued by 7 Foot Doctors*
- *Stolen Painting Found by Tree*
- *Kids Make Nutritious Snacks*

more

2. Variability

Crucial in semantics

- *Dow ends up 255 points*
- *Dow climbs 255*
- *All major stock markets surged*
- *Dow gains 255 points*
- *Stock market hits a high record*
- *The Dow Jones Industrial Average close up at 255*



3. Sparsity

Definition:

Scattered or Distributed

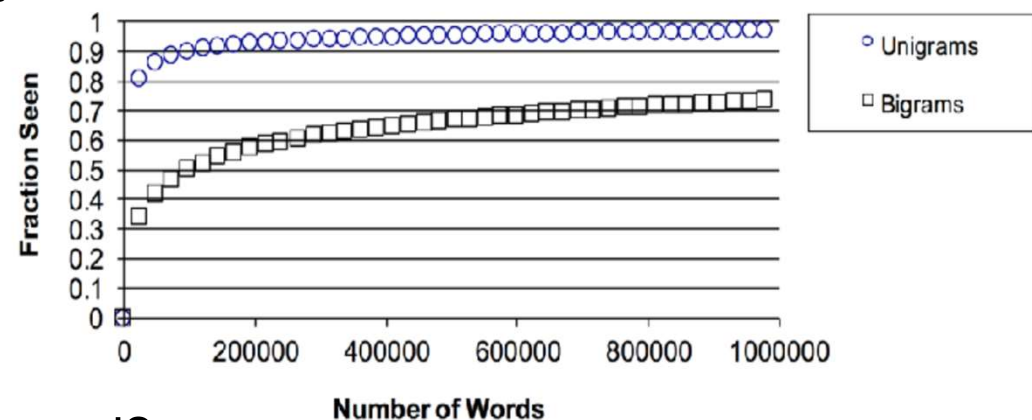
In NLP we consider the Data Sparsity

Example:

“I ate an apple”

Unigrams: “I”, “ate”, “an”, “apple”

Bigrams: “I ate”, “ate an”, “an apple”



How the given example can be processed?

i.e. “Unigrams” or “Bigrams”

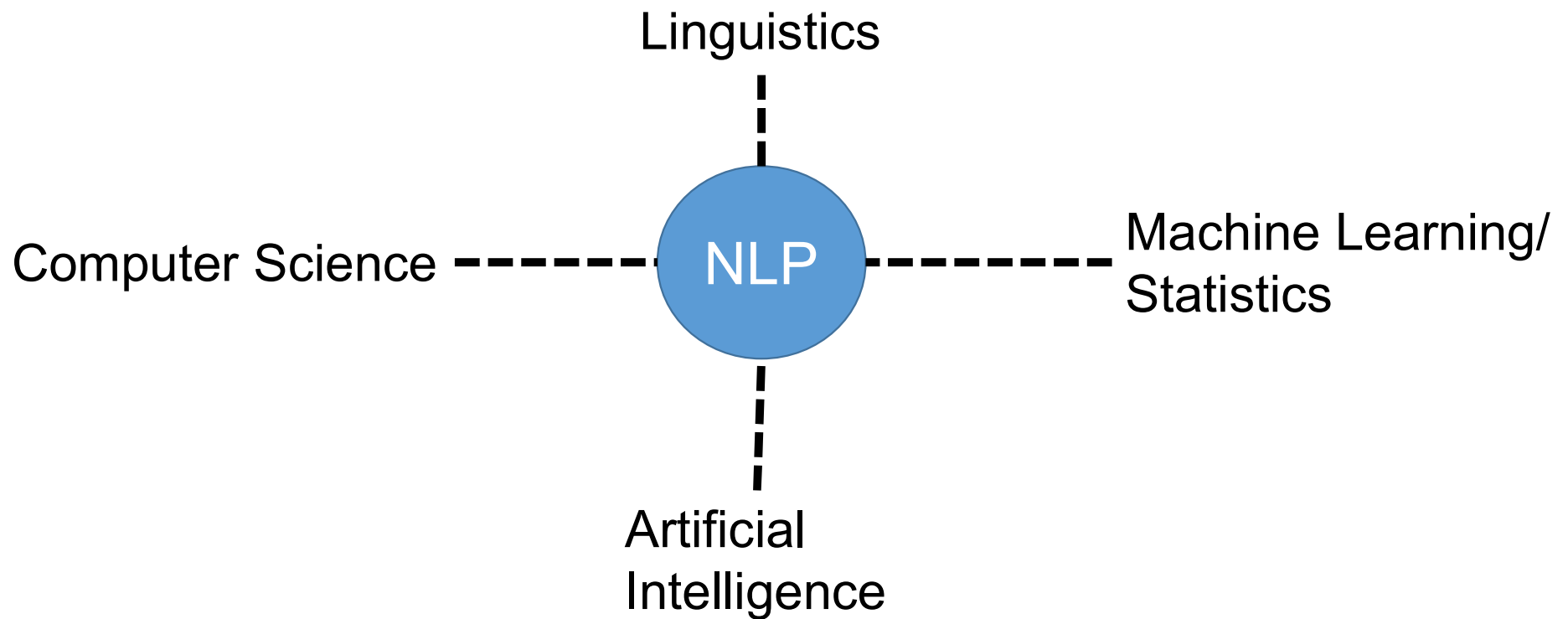
4. Grounding

Humans do not learn language by observation an endless stream of text.

Ground Words are Knowledge based

Knowledge Base	
Relation: has part	
Cat	Tail
Dog	Leg
Relation: type of	
Tiger	Cat
Leg	Limb
Relation: instance of	
Bengal tiger	Tiger

Where NLP lies?





Related Fields

Computational Linguistics

Use computational models to learn about language (e.g., meaning change)

Cognitive Science

How does the human brain process language?



NLP Applications

1. Text categorization
2. Information Extraction
3. Search
4. Question Answering
5. Virtual assistants
6. Machine translation
7. Summarization
8. Reading comprehension

1. Text Categorization



Sports



Politics




Science



2. Information Extraction

New York Times Co. named **Russell T. Lewis**, 45, president and general manager of its flagship **New York Times newspaper**, responsible for all business-side activities. He was executive vice president and deputy general manager. He succeeds **Lance R. Primis**, who in September was named president and chief operating officer of **the parent**.

Person	Company	Post	State
Russell T. Lewis	New York Times newspaper	President and general manager	start
Russell T. Lewis	New York Times newspaper	Executive vice president	end
Lance R. Primis	New York Times newspaper	President and CEO	end

3. Search





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Ungefähr 144.000.000 Ergebnisse (1,17 Sekunden)








Pakistan / Hauptstadt


Islamabad

Andere suchten auch nach

Über 10 weitere ansehen

[Pakistan](#)
[Karatschi](#)
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Google

Which city in the world is best to live?

All Images News Videos More Settings Tools

About 36,900,000 results (0.48 seconds)

The world's most liveable cities for 2017 revealed - The Telegraph
www.telegraph.co.uk/travel/galleries/The-worlds-most-liveable-cities/ ▼
The latest ranking from Mercer has been released - find out which cities are the most desirable. ... Mercer's Quality of Living index takes into account a multitude of factors, including economic and political environment, infrastructure, public transport, health, recreation and housing, to decide ... The best hotels in Stockholm.
Hamburg · Vienna | The world's most ... · Ottawa · Toronto

The 10 Best Places to Live in the World - Photos - Condé Nast Traveler
<https://www.cntraveler.com/gallery/the-most-livable-cities-in-the-world> ▼
Aug 16, 2017 - There's the world's most expensive city (and the world's most expensive city for expats). There's also the world's most beautiful city, and the world's friendliest cities. Now, the results are in for the Economist Intelligence Unit's "Global Liveability Report," which provides scores for lifestyle challenges in 140 ...

The 10 Best Cities to Live in Around the World | Travel + Leisure
www.travelandleisure.com > Trip Ideas ▼
Aug 16, 2017 - Thinking of moving? Here are the cities where you'll find the best quality of life.

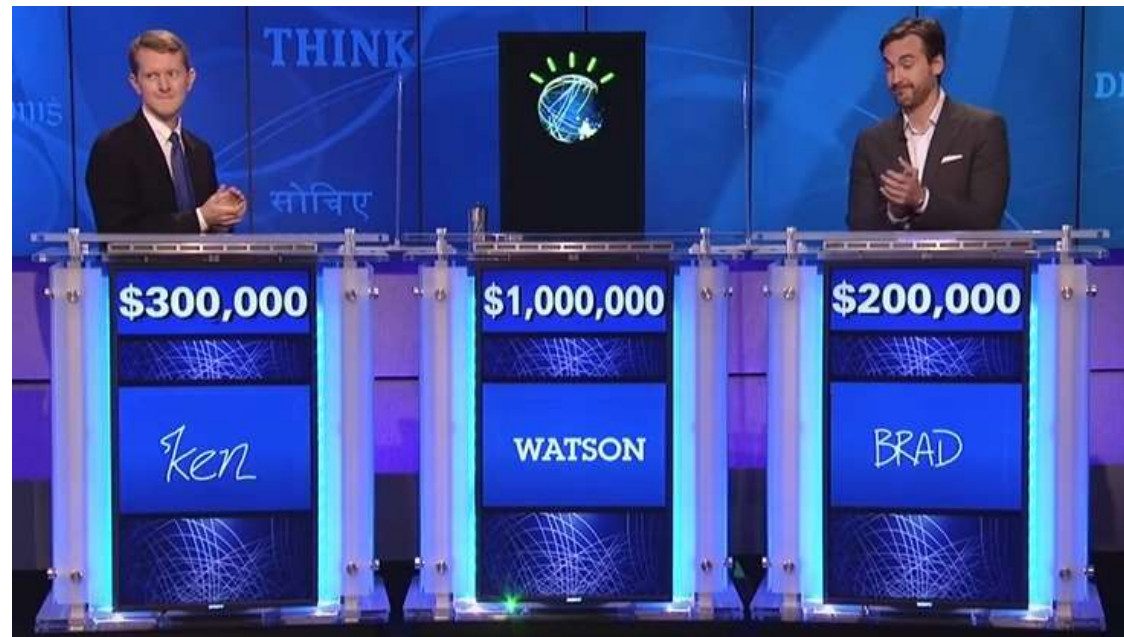
Melbourne revealed as world's best city to live in for seventh year ...
www.independent.co.uk/.../melbourne-worlds-best-city-live-in-7-years-running-austra... ▼
Aug 16, 2017 - Melbourne has once again been named as the world's most 'liveable' city for the seventh year in a row. After ranking 140 destinations each year on healthcare, education, stability, culture, environment and infrastructure, the Economist Intelligence Unit's (EUI) Liveability Index has revealed the best and ...

3. Search

4. Question and Answering

IBM Watson;

Watson is a question answering computer system capable of answering questions posed in natural language, developed in IBM's DeepQA project by a research team led by principal investigator David Ferrucci. Watson was named after IBM's first CEO, industrialist Thomas J. Watson. The computer system was specifically developed to answer questions on the quiz show *Jeopardy!* and, in 2011, the Watson computer system competed on *Jeopardy!* against former winners Brad Rutter and Ken Jennings winning the first-place prize of \$1 million.



<https://www.techrepublic.com/article/ibm-watson-the-inside-story-of-how-the-jeopardy-winning-supercomputer-was-born-and-what-it-wants-to-do-next/>
<https://www.youtube.com/watch?v=P18EdAKuC1U>



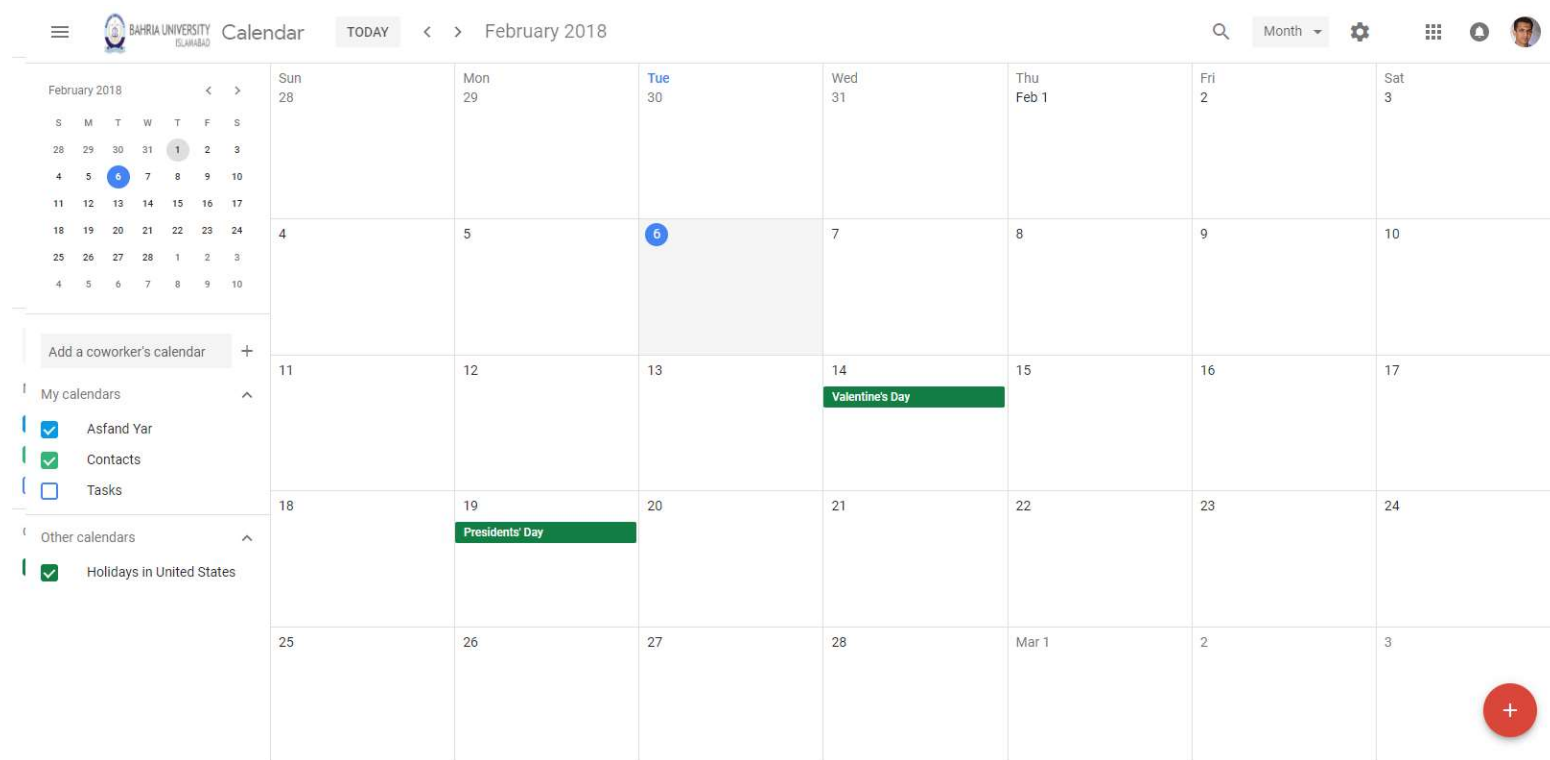
Critique

Douglas Hofstadter: “just a text search algorithm connected to a database, just like Google search. It doesn’t understand what it’s reading.”



5. Virtual Assistants

*Move all my
Wednesday
meetings in
April*



6. Machine Translation

Translate

EnglishSpanishFrenchEnglish - detected

GermanEnglishUrdu

Translate

Earlier on the last hearing, the government had sought time to file reply to the pleas. In its reply submitted on Feb 3, 2018, the federal government has stated that under the law a disqualified parliamentarian can hold a party office, saying that such a person in this case is former prime minister Nawaz Sharif. The reply states that the law neither infringes upon the fundamental rights of any of the petitioners nor is it in derogation of any provisions of the constitution.

اس سے قبل آخری سماعت کے دوران، حکومت نے درخواست کا جواب دینے کا وقت گزرا تھا۔ فروری 3، 2018 کو جمع ہونے والے جواب میں، وفاقی حکومت نے کہا ہے کہ قانون کے تحت ذابیل افراد پارلیمان ایک پارٹی کے دفتر کو رکھ سکتے ہیں، اور یہ کہہ رہے ہیں کہ اس معاملے میں ایسا شخص سابق وزیر اعظم نواز شریف ہے۔ جواب میں کہا گیا ہے کہ قانون کسی بھی درخواست دہندگان کے بنیادی حقوق کے خلاف نہیں ہے اور نہ ہی وہ آئین کے کسی بھی دفعات کے خاتمے میں ہے۔

☆📄↶

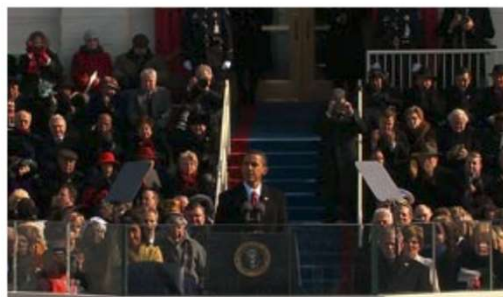
Suggest an edit

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7. Summarization

WASHINGTON (CNN) -- President Obama's inaugural address was cooler, more measured and reassuring than that of other presidents making it, perhaps, the right speech for the times.



Some inaugural addresses are known for their soaring, inspirational language. Like John F. Kennedy's in 1961: "Ask not what your country can do for you. Ask what you can do for your country."

Obama's address was less stirring, perhaps, but it was also more candid and down-to-earth.

"Starting today," the new president said, "we must pick ourselves up, dust ourselves off and begin the work of remaking America."

[Watch Obama's inaugural address »](#)

STORY HIGHLIGHTS

- Obama's address less stirring than others but more candid, analyst says
- Schneider: At a time of crisis, president must be reassuring
- Country has chosen "hope over fear, unity of purpose over ... discord," Obama said
- Obama's speech was a cool speech, not a hot one, Schneider says

[more photos »](#)

"There is nothing wrong with America that cannot be fixed by what is right with America," Clinton declared at his first inaugural.

[Obama](#), too, offered reassurance.

"We gather because we have chosen hope over fear, unity of purpose over conflict and discord," Obama said.

Obama's call to unity after decades of political division echoed Abraham Lincoln's first inaugural address in 1861. Even though he delivered it at the onset of a terrible civil war, Lincoln's speech was not a call to battle. It was a call to look beyond the war, toward reconciliation based on what he called "the better angels of our nature."

Some presidents used their [inaugural address](#) to set out a bold agenda.



8. Reading Comprehension

"The rock was still wet. The animal was glistening, like it was still swimming," recalls Hou Xianguang. Hou discovered the unusual fossil while surveying rocks as a paleontology graduate student in 1984, near the Chinese town of Chengjiang. "My teachers always talked about the Burgess Shale animals. It looked like one of them. My hands began to shake." Hou had indeed found a *Naraoia* like those from Canada. However, Hou's animal was 15 million years older than its Canadian relatives.

It can be inferred that Hou Xianguang's "hands began to shake" because he was

- a) afraid that he might lose the fossil
- b) worried about the implications of his finding
- c) concerned that he might not get credit for his work
- d) uncertain about the authenticity of the fossil
- e) excited about the magnitude of his discovery

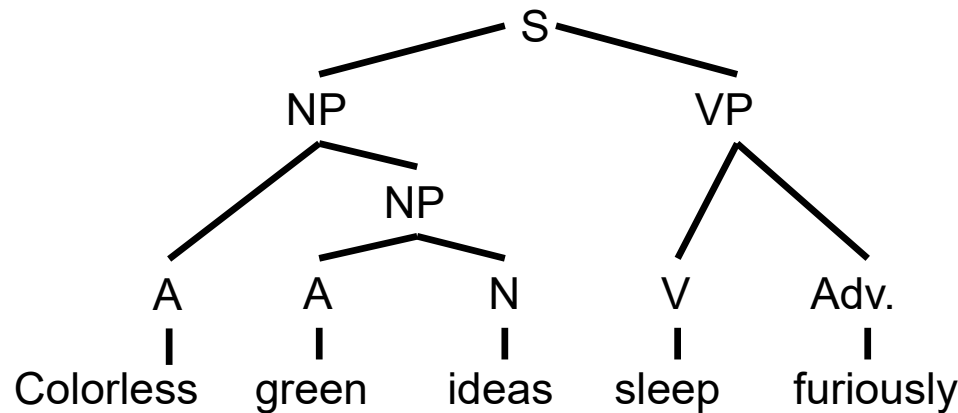
Some History

A. *Colorless green ideas sleep furiously*

B. *Furiously sleep ideas green colorless*

“It is fair to assume that neither sentence (1) nor (2) ... had ever occurred in an English discourse. Hence, in any statistical model for grammaticality, these sentences will be ruled out on identical grounds as equally “remote” from English. Yet (1), though nonsensical, is grammatical, while (2) is not.”

(Chomsky, Syntactic structures, 1957)



History; Rule-based

70s and 80s:

- Grammars (rules) of English syntax
- Small domains
- Substantial engineering effort

$S \rightarrow NP \ VP$
 $NP \rightarrow DET \ N$
 $VP \rightarrow Vt \ N$
 $VP \rightarrow Vi$

$N \rightarrow \text{man}$
 $N \rightarrow \text{woman}$
 $DET \rightarrow \text{the}$
 $DET \rightarrow \text{a}$
 $Vt \rightarrow \text{hugged}$
 $Vi \rightarrow \text{slept}$

$N \rightarrow \text{apple}$
 $N \rightarrow \text{juiciness}$
 $DET \rightarrow \text{the}$
 $DET \rightarrow \text{an}$
 $Vt \rightarrow \text{is}$
 $Vi \rightarrow \text{shines}$



Empirical Revolution

“Whenever I fire a linguist, our system performance improves.”

Jelinek, 1988

When I look at an article in Russian, I say: “This is really written in English, but it has been coded in some strange symbols. I will now proceed to decode.”

Weaver, 1995

Of course, we must not go overboard and mistakenly conclude that the successes of statistical NLP render linguistics irrelevant (rash statements to this effect have been made in the past, e.g., the notorious remark, “Every time I fire a linguist, my performance goes up”). The information and insight that linguists, psychologists, and others have gathered about language is invaluable in creating high performance broad domain language understanding systems; for instance, in the speech recognition setting described above, better understanding of language structure can lead to better language models.”

Lilian Lee, 2001



Empirical Revolution

1990: corpus-based statistical methods

2000s: rich structural formalisms

2010s: representation learning with Neural Nets



Q&A

That's all for today's Lecture