

# Automatische Verarbeitung natürlicher Sprache

## Eine Schlüsseltechnologie der Künstlichen Intelligenz

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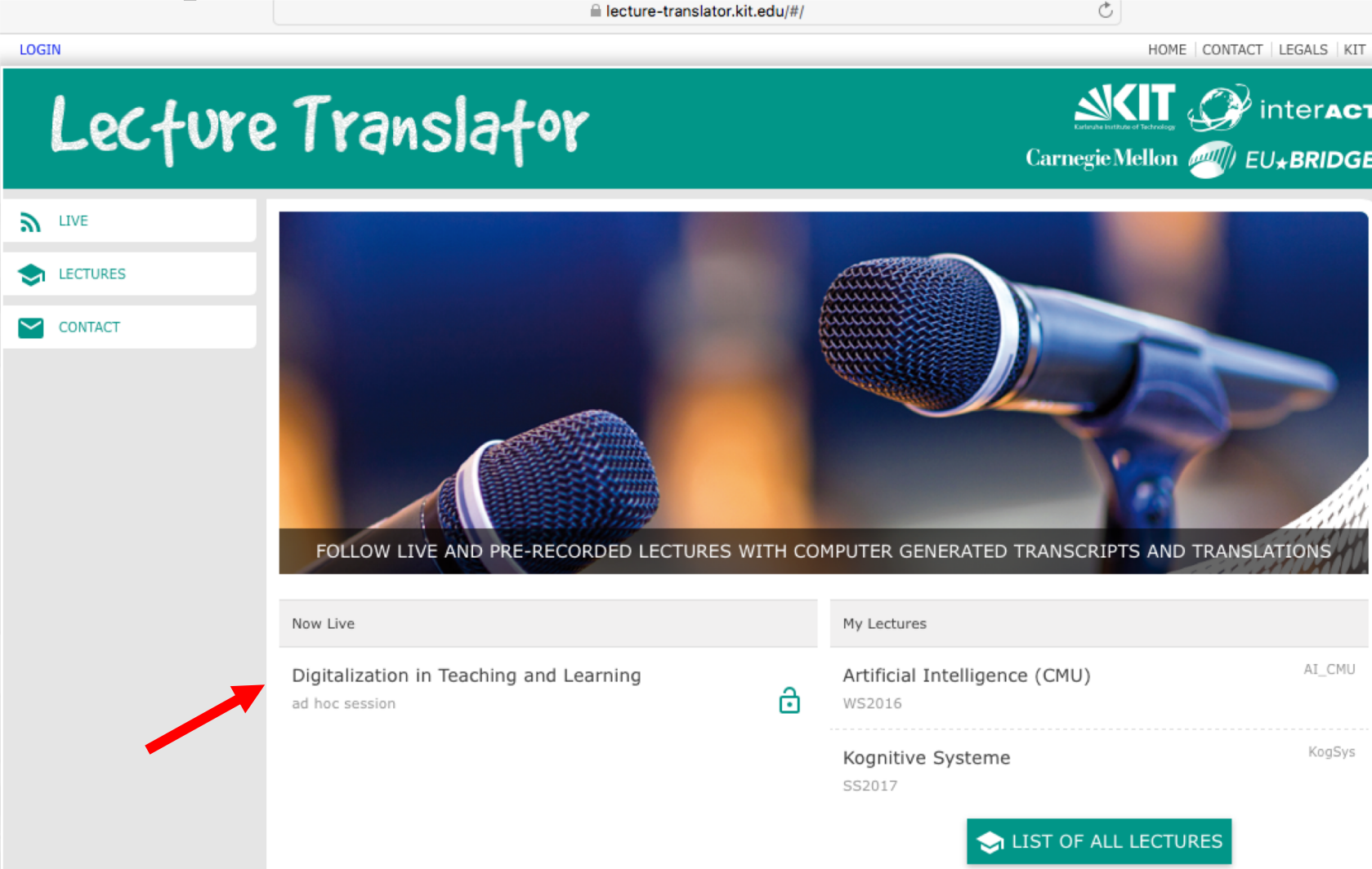


# Importance of Language

- 5.000 to 7.000 languages exist in the world today
- “Language is the pinnacle achievement of man-kind”  
(Vivianne Redding, European Commission)
- Language is inherently linked with culture
- The way we speak / the way our language is structured influences the way we think (e.g., see research on cognition by Lera Boroditsky at UCLA)
- Language Diversity as important for human well-being and prosperity, as biodiversity in nature
- Language is deeply intertwined with human thinking, i.e. intelligence

# Using the System

# https://lecture-translator.kit.edu



The screenshot shows the website interface for Lecture Translator. At the top, there is a navigation bar with 'LOGIN' on the left and 'HOME | CONTACT | LEGALS | KIT' on the right. Below this is a green banner with the text 'Lecture Translator' in white, and logos for 'KIT', 'interACT', 'Carnegie Mellon', and 'EU\*BRIDGE' on the right. A left sidebar contains three menu items: 'LIVE' with a Wi-Fi icon, 'LECTURES' with a graduation cap icon, and 'CONTACT' with an envelope icon. The main content area features a large image of two microphones with the text 'FOLLOW LIVE AND PRE-RECORDED LECTURES WITH COMPUTER GENERATED TRANSCRIPTS AND TRANSLATIONS'. Below this are two columns: 'Now Live' and 'My Lectures'. The 'Now Live' column shows a lecture titled 'Digitalization in Teaching and Learning' with a sub-note 'ad hoc session'. A red arrow points to this entry. The 'My Lectures' column lists 'Artificial Intelligence (CMU) WS2016' and 'Kognitive Systeme SS2017'. At the bottom right, there is a green button labeled 'LIST OF ALL LECTURES'.

# Natural Language Processing

## ■ Wikipedia:

■ **Natural language processing (NLP)** is a field of computer science, artificial intelligence, and linguistics concerned with the interactions between computers and human (natural) languages. As such, NLP is related to the area of human–computer interaction.

## ■ Joint work of computer science and linguistics

## ■ Natural communication with computers

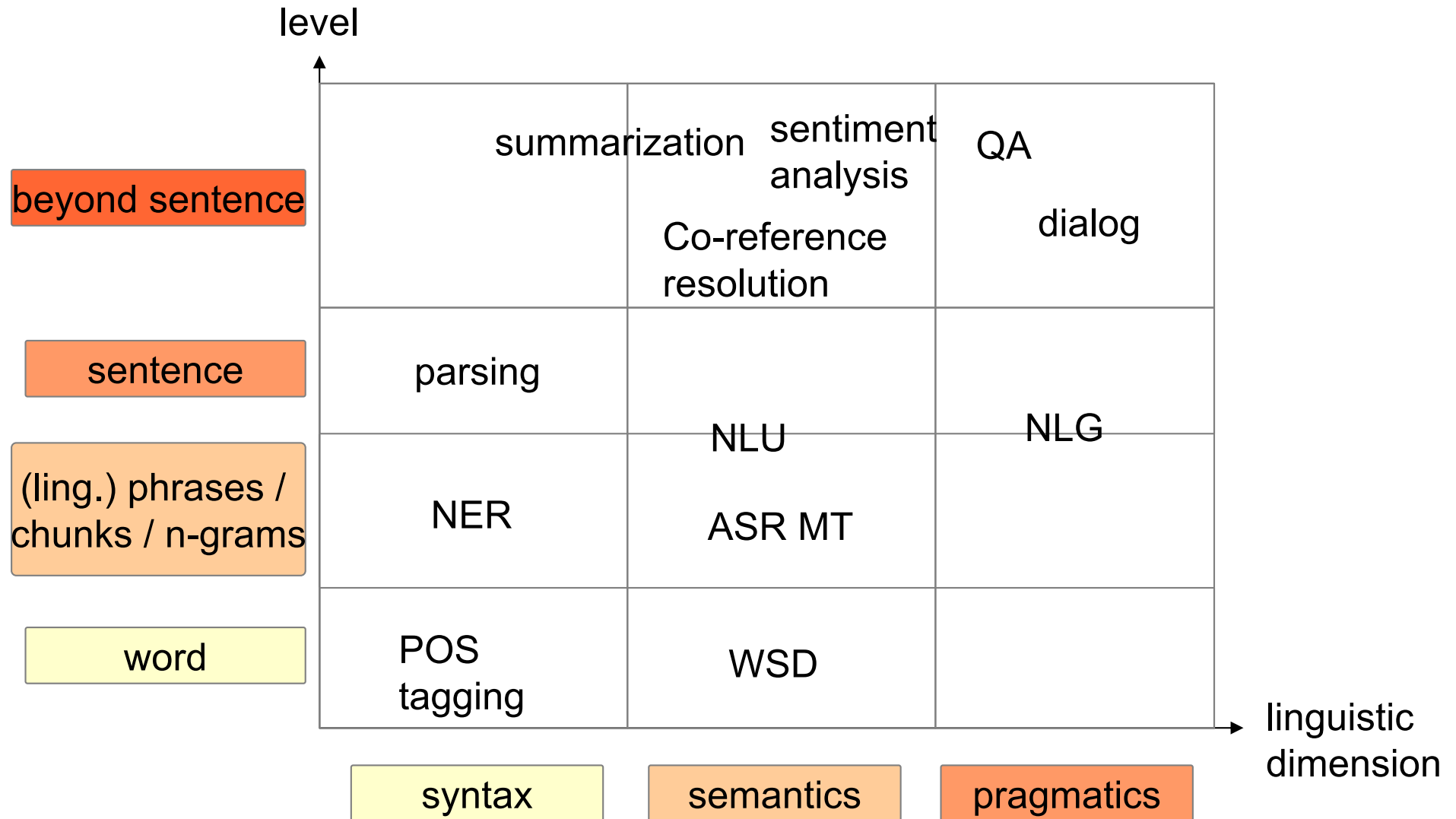
■ Computers “understand”/process natural language

■ Acquire knowledge from texts

■ Generate text

■ Overlap with Human-computer interaction/Dialog modeling

# Natural Language Processing



# Corpus-based Approaches to NLP - Overview

Output

Statistical Model

Word: 546; Case: Upper-case; POS: NN; ...

Feature Extraction

Input Text:

# Deep learning Approaches to NLP

## Problems of simple statistical models

### Feature engineering

What features are important to determine the class

Word ending

Surrounding words

Capitalization

## Deep learning:

Use neural networks to automatically infer features

Better generalization

Successfully applied to many NLP tasks

# Deep Learning Approaches to NLP - Overview

Output

Statistical Model

10010010010101

Feature Extraction

Input Text:



# Why is NLP hard?

Ambiguities

Ambiguities

Ambiguities

→ due to semantics and/or syntactic level...

# Ambiguities - Examples

“I saw the man on the hill with a telescope.”

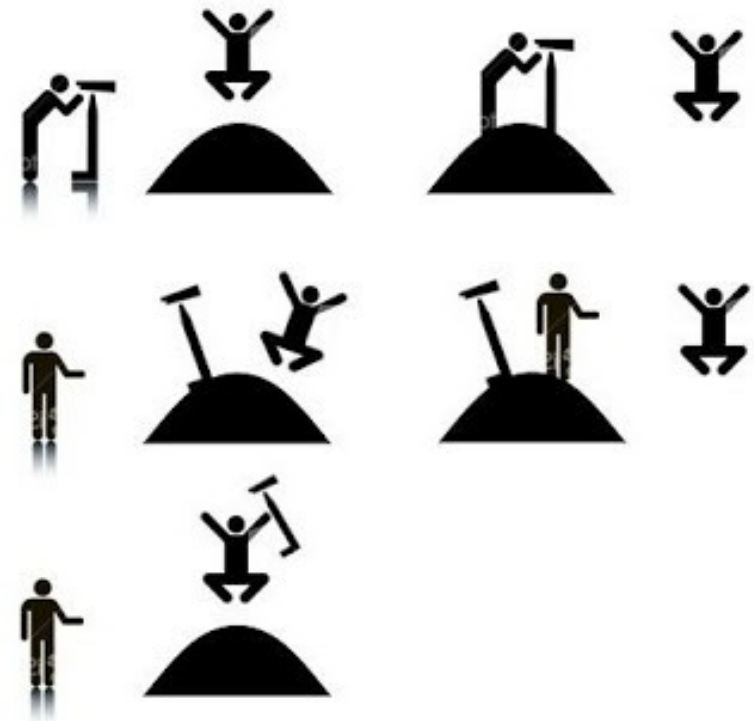
I saw the man. The man was on the hill. I was using a telescope.

I saw the man. I was on the hill. I was using a telescope.

I saw the man. The man was on the hill. The hill had a telescope.

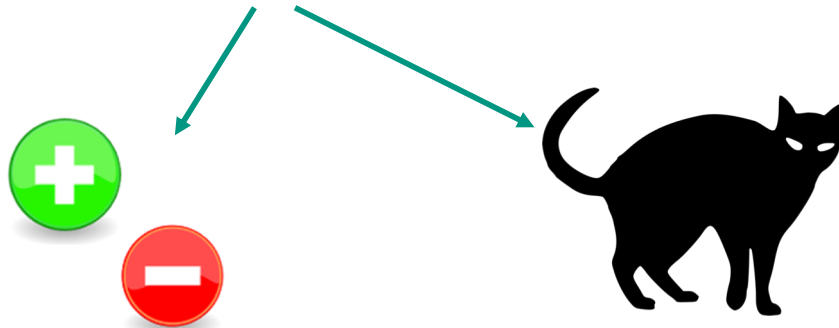
I saw the man. I was on the hill. The hill had a telescope.

I saw the man. The man was on the hill. I saw him using a telescope.

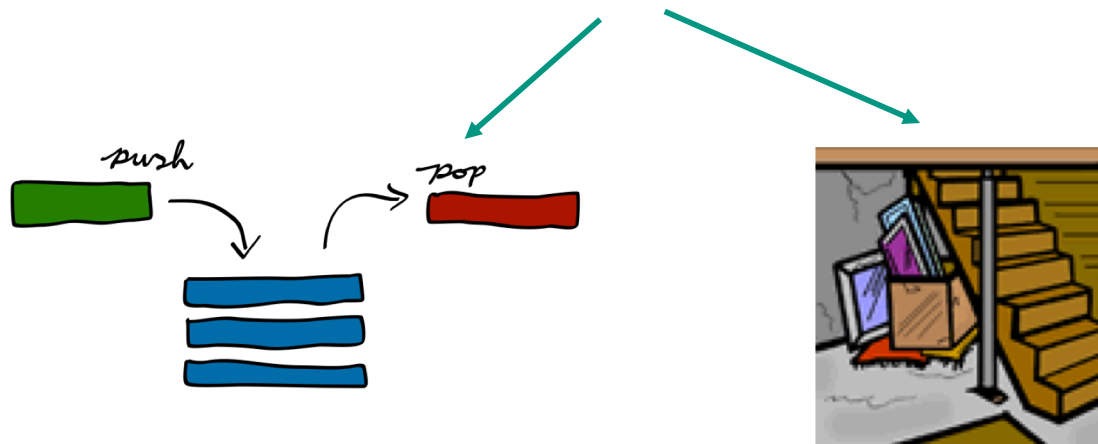


# Ambiguities - Examples

- Computer Science Lecture
  - Das Vorzeichen der Zahl



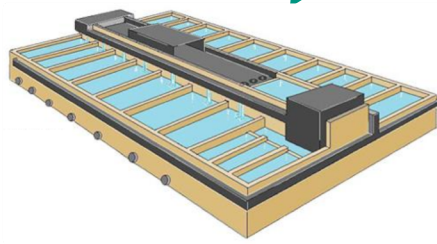
- Als Datenstruktur wird ein Keller-Automat benutzt



# Ambiguities - Examples

TED

Fisch zucht anlage [fish farm *sound system* instead of *facility*]



## Ambiguities - Jokes

One morning I shot an elephant in my pajamas. How he got into my pajamas, I'll never know.

Policeman to little boy: "We are looking for a thief with a bicycle."  
Little boy: "Wouldn't you be better using your eyes."

Why is the teacher wearing sunglasses. Because the class is so bright.




# Examples

- Lecture Translator
- Natural Language Understanding
- Summarization
- Backchannel Prediction

# Simultane Vorlesungsübersetzung

## Lecture Translator



- Sessions
- List of Lectures
- Contact
- Old System

### Demo V / H

**German (de)** rt von Spracherkennungssystemen habe ich.

Zusätzlich gibt es aber noch ein paar andere. Kategorien mit den ich dahinter. Ein Spracherkennungssystem klassifizieren kann, Eine mit der wichtigsten, Eigenschaften für ein Spracherkennungssystem ist auf den Sprecher abhängig. Oder Sprecher unabhängig ist. Das bedeutet nichts anderes als, kann dieses Spracherkennungssystem nur, einen bestimmten Sprecher erkennen oder ist es ein Spracherkennungssysteme gerade.

Und das ist für alle, Sprecher geeignet insbesondere für viele Sprecher, die es vorher noch nie in seinem Leben gesehen hat. Haben wir hat schon mal mit so einem. Hier System gearbeitet wird wird schon ist beat them Dragon Dictate irgendwas in der Richtung. Man andere angefasst, wenn man das dann macht. Und sich so den Sieg Teil System aus vom wird.

Das ist das Aller Erste was man machen wird. Zumindest war das noch bis bei der vorletzten Version der Fall und ich glaub der neusten Version, von wo aus. Natürlich nur wenn die Täter sowas wie das langsam bisschen aufgehoben. Aber im Prinzip

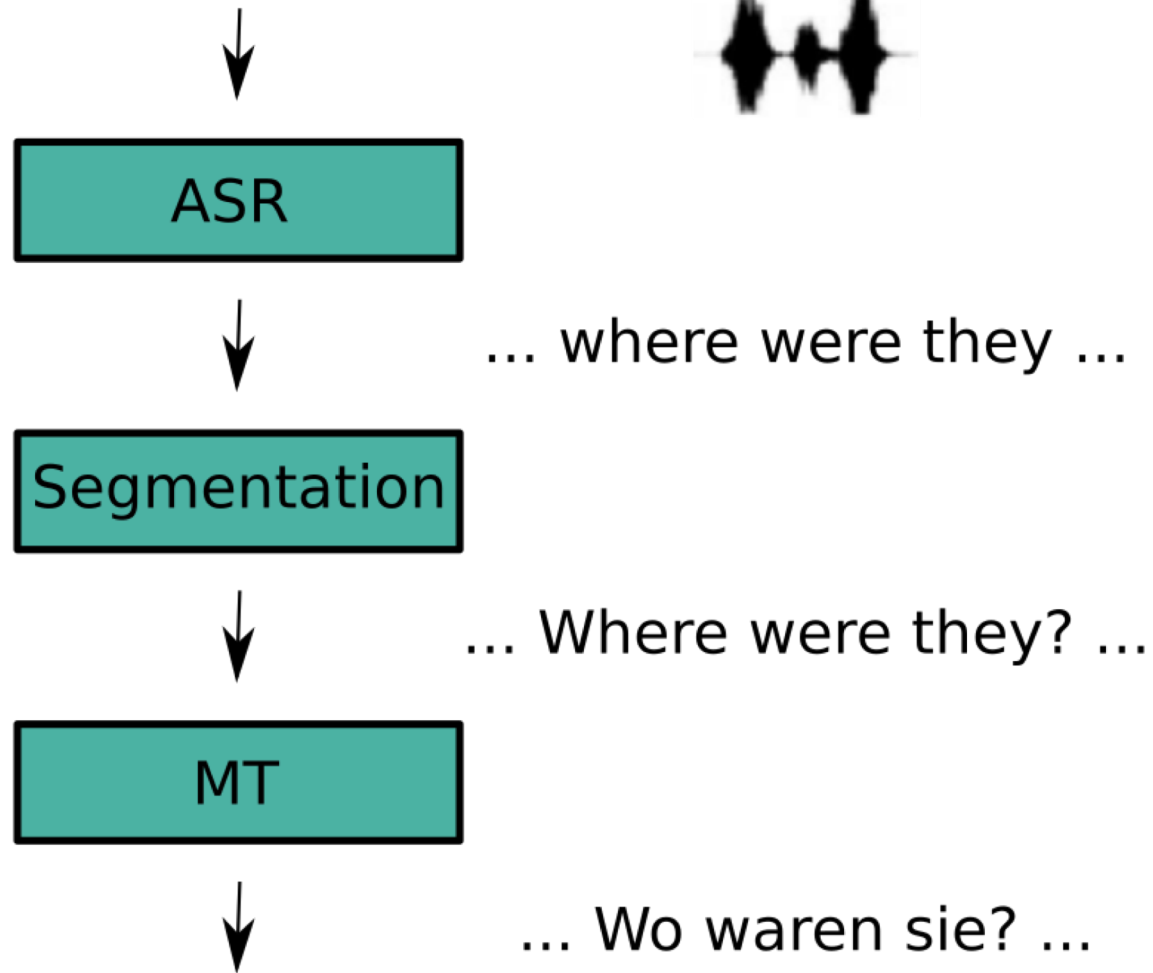
**English (en)**

In addition, there is, however. A couple of other. Categories, with which I behind it. A speech recognition system can classify a with the most important features for a speech recognition system is dependent on the speaker. Or is speaker independent. That means nothing other than can recognize this speech recognition system only a certain speakers, or is it a speech recognition, just systems.

And that is appropriate for all the speakers, especially for many speakers, the it never before still in. His life has seen. We have already has time with such a. This will be worked system will already is beat them Dragon Dictate something in the direction of. You grasped in the other, if you then makes. And so the victory part of the system from the will.

This is the first what you will make. At least that was still up in the penultimate version of the case, and I think, in the latest version of where from. Of course, only if the perpetrators of such things as the slowly bit lifted. But in principle this in front

# Components



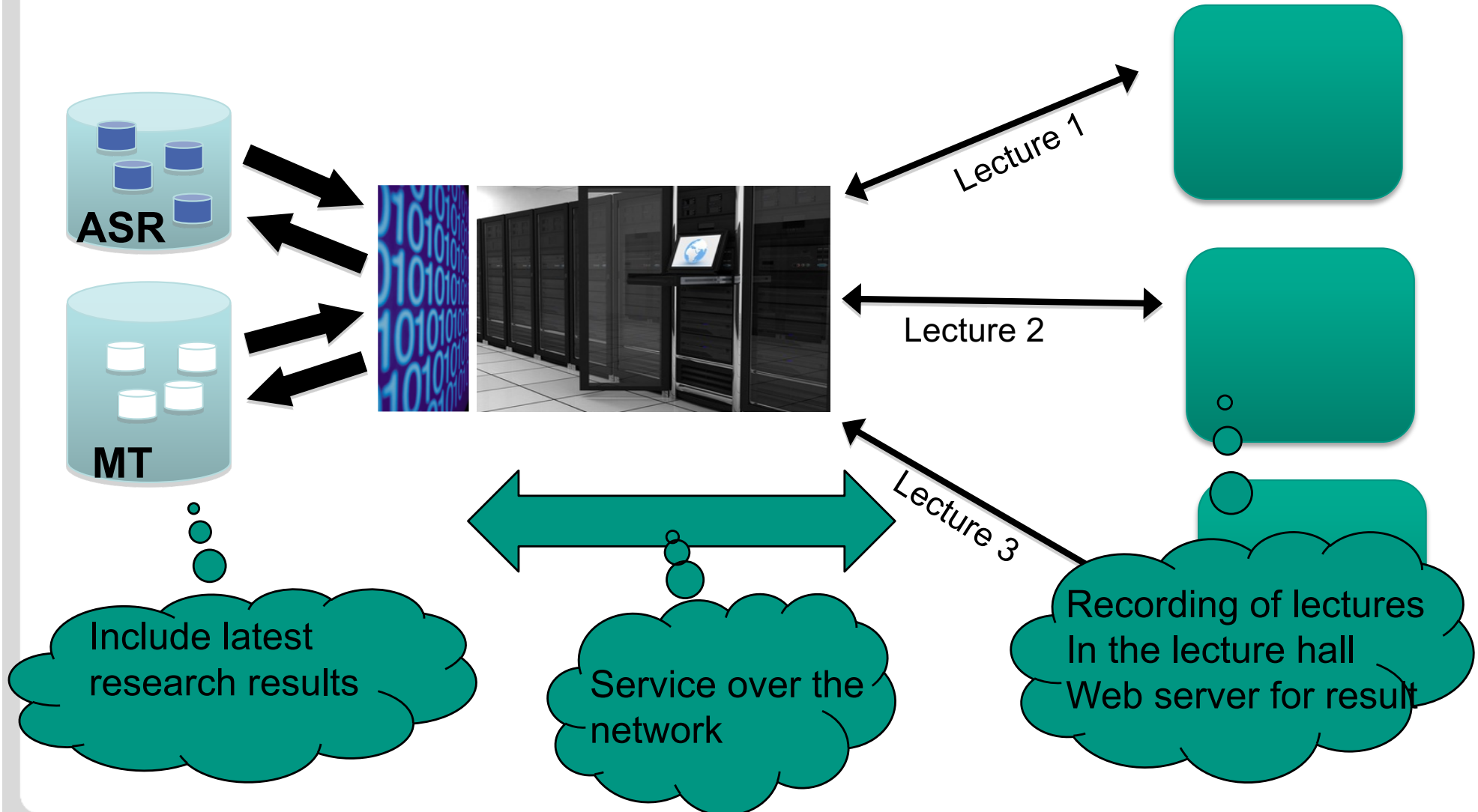


# System Overview

## Components

## Services

## Lecture



# Natural language understanding – Slot Filling

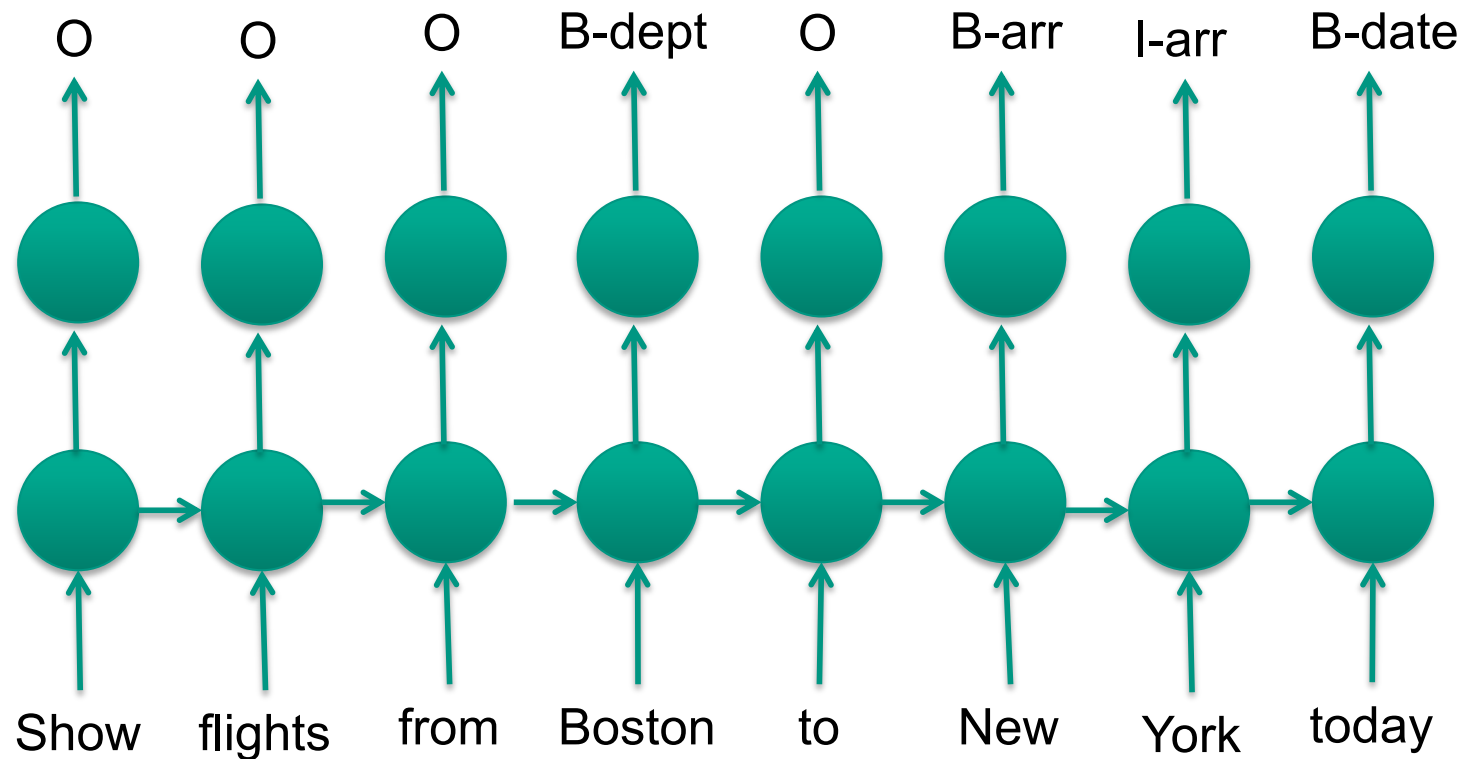
- Sequence labeling task
  - Assign semantic class label to every word

<b>Sentence</b>	<i>show</i>	<i>flights</i>	<i>from</i>	<i>Boston</i>	<i>To</i>	<i>New</i>	<i>York</i>	<i>today</i>
<b>Slots/Concepts</b>	O	O	O	B-dept	O	B-arr	I-arr	B-date
<b>Named Entity</b>	O	O	O	B-city	O	B-city	I-city	O
<b>Intent</b>	<i>Find Flight</i>							
<b>Domain</b>	<i>Airline Travel</i>							

# RNN-based Slot filling

Input: Words in one-hot encoding

Output: Label probabilities



# Summarization

- Summarization:
  - Reduce natural language text document
  - Goal:
    - Compress text by extracting the most important/relevant parts
  
- Information overload
  - High quantity of data
  - Processing summary only

# Applications

- Articles, news:
  - Outlines or abstracts
- **Email / Email threads**
- Health information
- Meeting summarization
- ...

# Techniques

## Extraction

Select subset of existing text segments:

E.g.:

- Sentence extraction

- Key-phrase extraction

Simpler, most focus in research in the past

## Abstraction

“Understand” text

Use natural language generation to create summary

More human like

Latest trend in research

# Techniques

Fourscore and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty and dedicated to the proposition that all men are created equal. Now we are engaged in a great civil war, testing whether that nation or any nation so conceived and so dedicated can long endure. We are met on a great battlefield of that war. We have come to dedicate a portion of that field as a final resting-place for those who here gave their lives that that nation might live. It is altogether fitting and proper that we should do this. But in a larger sense, we cannot dedicate, we cannot consecrate, we cannot hallow this ground. The brave men, living and dead who struggled here have consecrated it far above our poor power to add or detract. The world will little note nor long remember what we say here, but it can never forget what they did here. It is for us the living rather to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great task remaining before us — that from these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion — that we here highly resolve that these dead shall not have died in vain, that this nation under God shall have a new birth of freedom, and that government of the people, by the people, for the people shall not perish from the earth.

Figure 1.1: The **Gettysburg** Address

# Techniques

Four score and seven years ago our fathers brought forth upon this continent a new nation, conceived in liberty, and dedicated to the proposition that all men are created equal. Now we are engaged in a great civil war, testing whether that nation, or any nation so conceived and so dedicated, can long endure. The brave men, living and dead, who struggled here, have consecrated it far above our poor power to add or detract.

Figure 1.3: Another 25% extract of the **Gettysburg** Address

This speech by Abraham Lincoln commemorates soldiers who laid down their lives in the Battle of **Gettysburg**. It reminds the troops that it is the future of freedom in America that they are fighting for.

Figure 1.4: A 15% abstract of the **Gettysburg** Address



# Extractive summarization

- Three main components
  
- Content selection:
  - Which parts are important to be in the summary?
  
- Information ordering:
  - How to order summaries?
  
- Sentence realization:
  - Clean up/Simplify sentences

# Sentence Extraction

Use statistic heuristics to select sentences

Do not change content and meaning

Idea:

- Use measure to determine importance of sentence

  - TF-IDF

  - Supervised trained combination of several features

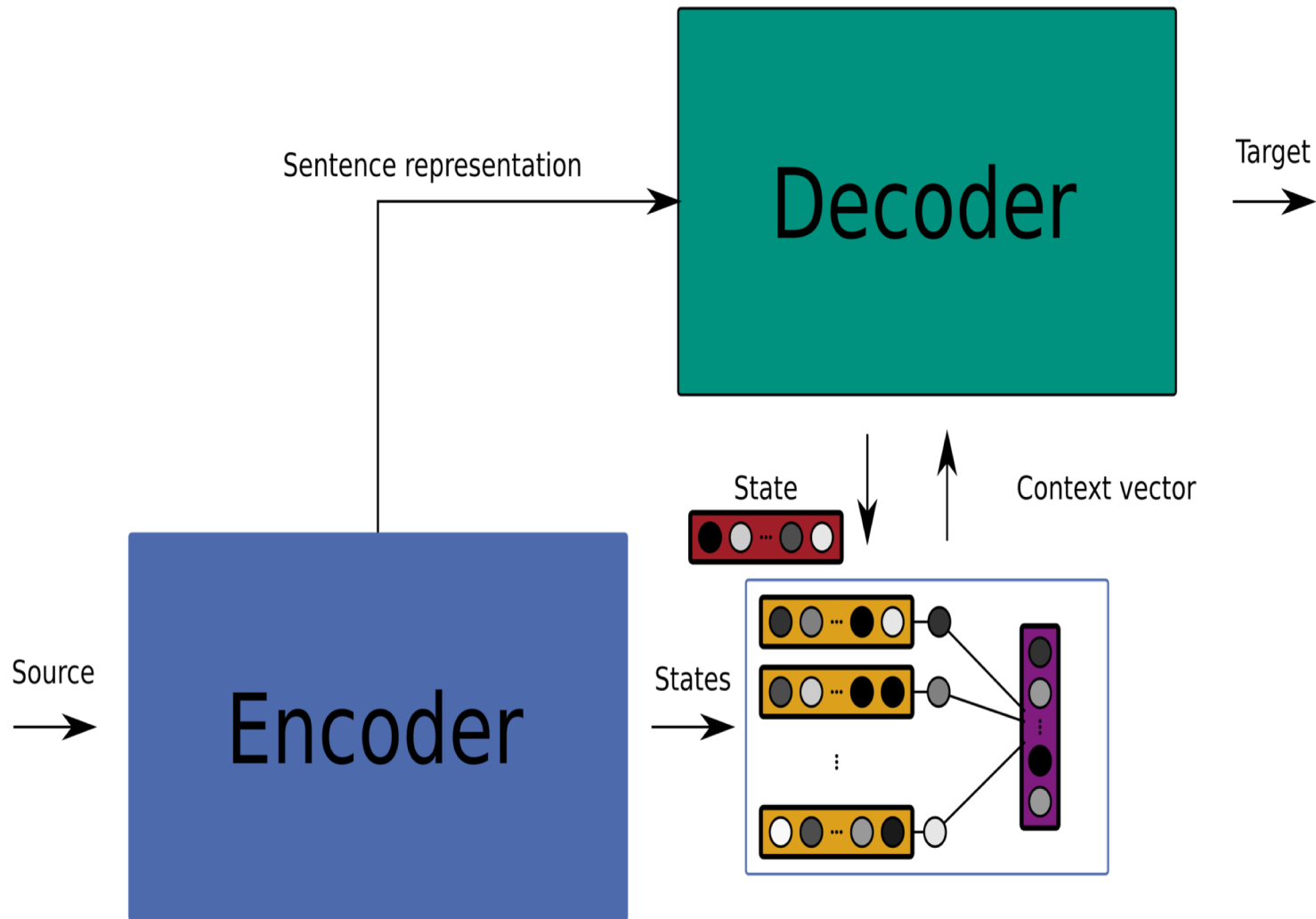
- Rank sentence according to metric

- Output sentences with heights score:

  - Fixed number

  - All sentence above threshold

# Attention-based Encoder -Decoder



# Attention-based Encoder -Decoder

Good quality summary output
<p><b>S:</b> a man charged with the murder last year of a british backpacker confessed to the slaying on the night he was charged with her killing , according to police evidence presented at a court hearing tuesday . ian douglas previte , ## , is charged with murdering caroline stuttle , ## , of yorkshire , england</p> <p><b>T:</b> man charged with british backpacker 's death confessed to crime police officer claims</p> <p><b>O:</b> man charged with murdering british backpacker confessed to murder</p>
<p><b>S:</b> following are the leading scorers in the english premier league after saturday 's matches : ## - alan shearer -lrb- newcastle united -rrb- , james beattie .</p> <p><b>T:</b> leading scorers in english premier league</p> <p><b>O:</b> english premier league leading scorers</p>
<p><b>S:</b> volume of transactions at the nigerian stock exchange has continued its decline since last week , a nse official said thursday . the latest statistics showed that a total of ##.### million shares valued at ###.### million naira -lrb- about ##.### million us dollars -rrb- were traded on wednesday in #,### deals .</p> <p><b>T:</b> transactions dip at nigerian stock exchange</p> <p><b>O:</b> transactions at nigerian stock exchange down</p>

# Attention-based Encoder -Decoder

Poor quality summary output
<p><b>S:</b> broccoli and broccoli sprouts contain a chemical that kills the bacteria responsible for most stomach cancer , say researchers , confirming the dietary advice that moms have been handing out for years . in laboratory tests the chemical , &lt;unk&gt; , killed helicobacter pylori , a bacteria that causes stomach ulcers and often fatal stomach cancers .</p> <p><b>T:</b> for release at ##### &lt;unk&gt; mom was right broccoli is good for you say cancer researchers</p> <p><b>O:</b> broccoli sprouts contain deadly bacteria</p>
<p><b>S:</b> norway delivered a diplomatic protest to russia on monday after three norwegian fisheries research expeditions were barred from russian waters . the norwegian research ships were to continue an annual program of charting fish resources shared by the two countries in the barents sea region .</p> <p><b>T:</b> norway protests russia barring fisheries research ships</p> <p><b>O:</b> norway grants diplomatic protest to russia</p>
<p><b>S:</b> j.p. morgan chase 's ability to recover from a slew of recent losses rests largely in the hands of two men , who are both looking to restore tarnished reputations and may be considered for the top job someday . geoffrey &lt;unk&gt; , now the co-head of j.p. morgan 's investment bank , left goldman , sachs &amp; co. more than a decade ago after executives say he lost out in a bid to lead that firm .</p> <p><b>T:</b> # executives to lead j.p. morgan chase on road to recovery</p> <p><b>O:</b> j.p. morgan chase may be considered for top job</p>

# Backchannel Prediction

Acoustic cues for the speaker

Backchannel responses used by listener in social dialog

Provide feedback to speaker (positive, negative, neutral)

Establish relationship

Artificial assistants are becoming increasingly popular

Still distinctive non-human

Make human-computer interaction more social

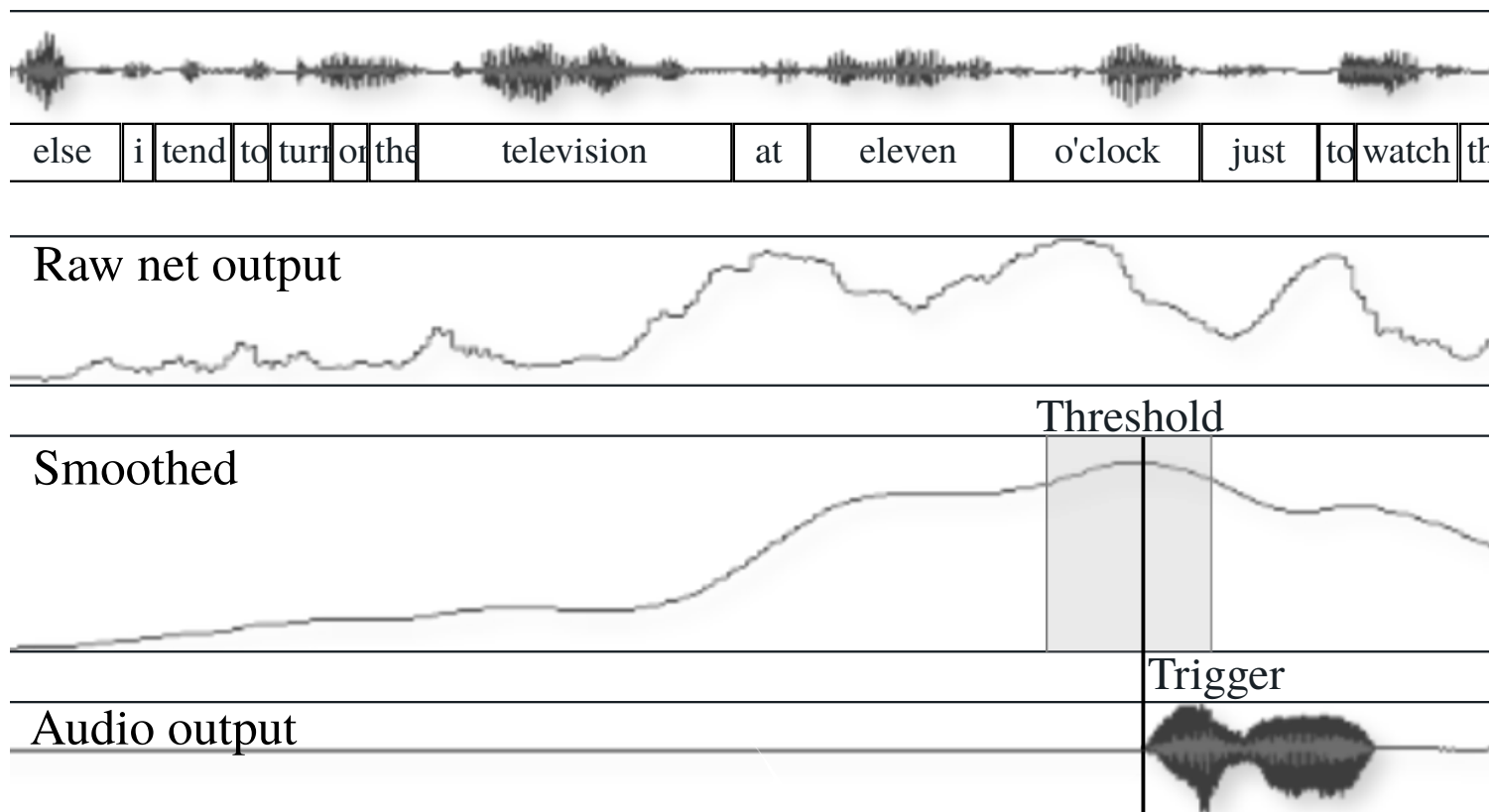
Neural network based approach using LSTMs

User study for evaluation

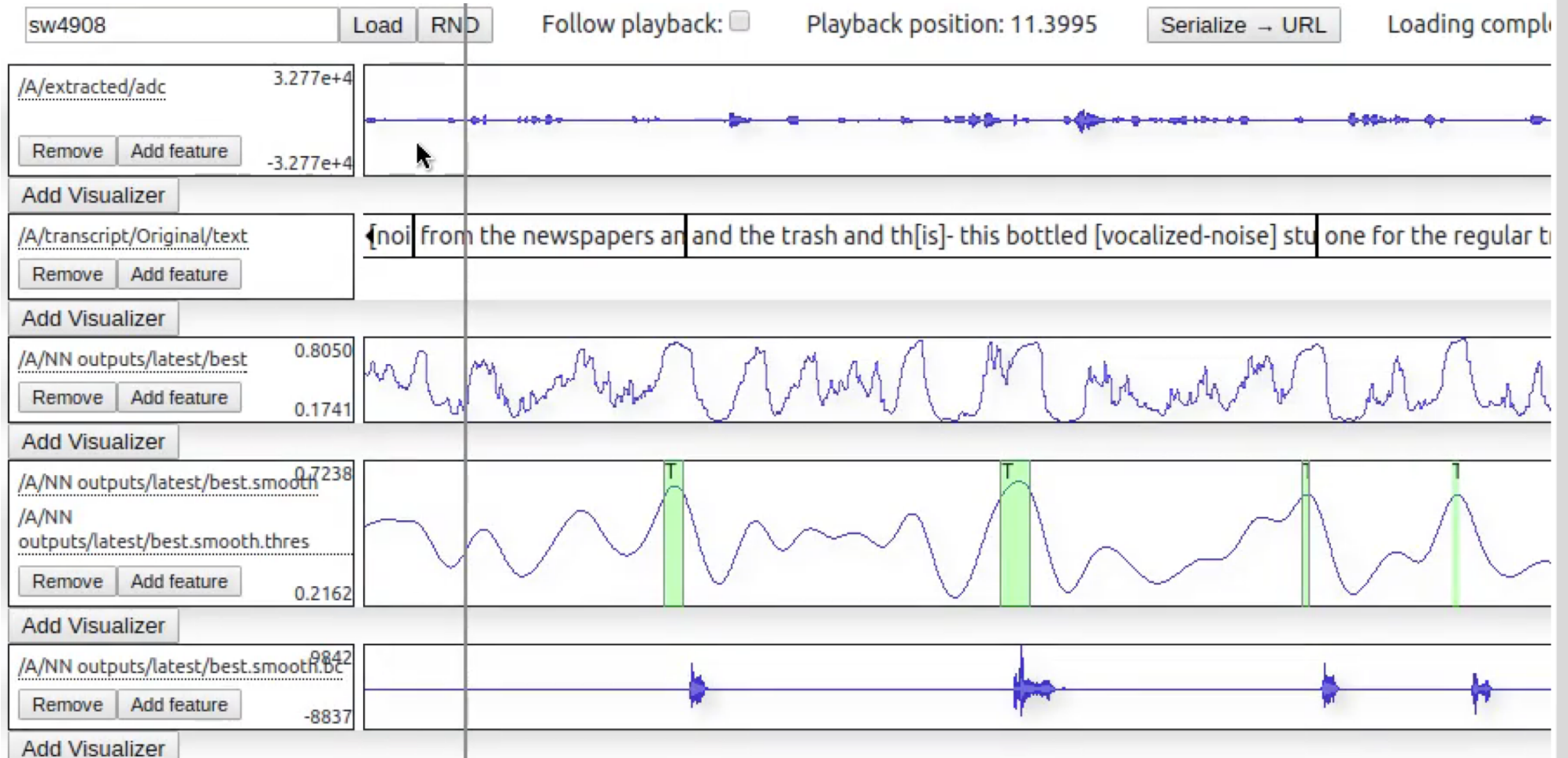
# Post processing

Smooth output by applying low-pass filter

Use threshold to detect BC



# Example Video





# Conclusion

Natural language processing a key technology in artificial intelligence

Large number of diverse applications, e.g.

- Speech translation

- Natural language understanding

- Backchannel prediction

Many solutions nowadays use artificial neural networks

Understanding natural language processing will give insights into the making of human intelligence

# People

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Markus Müller Chrisitan Saam  
Christian Mohr Teresa Herrmann  
Matthias Sperber Mohammed Mediani  
Kay Rottmann Thai-Son Nguyen  
Sebastian Stüker Christian Fügen  
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