BIU-NLP
is proud to present:

Introduction to
Natural Language Processing

Reut Tsarfaty
Faculty of Math and Computer Science
Bar-Ilan University & AI2 Israel

@rtsarfaty @OnlpLab
What is Natural Language Processing
Dave Bowman: Hello, HAL. Do you read me, HAL?
HAL: Affirmative, Dave. I read you.
Dave Bowman: Open the pod bay doors, HAL.
HAL: I'm sorry, Dave. I'm afraid I can't do that.
Dave Bowman: What's the problem?
HAL: I think you know what the problem is just as well as I do.
Dave Bowman: What are you talking about, HAL?
HAL: This mission is too important for me to allow you to jeopardize it.
Dave Bowman: I don't know what you're talking about, HAL.
HAL: I know that you and Frank were planning to disconnect me, and I'm afraid that's something I cannot allow to happen.
Dave Bowman: [feigning ignorance] Where the hell did you get that idea, HAL?
HAL: Dave, although you took very thorough precautions in the pod against my hearing you, I could see your lips move.
Dave Bowman: Alright, HAL. I'll go in through the emergency airlock.
HAL: Without your space helmet, Dave? You're going to find that rather difficult.
Dave Bowman: HAL, I won't argue with you anymore! Open the doors!
HAL: Dave, this conversation can serve no purpose anymore. Goodbye.
NLP | H.A.L Capabilities

לקרוא תנועות שפה (phonology) לתרגומים שלילים למלים (syntax)
לדעת להבר מלים לחשיפת המילים (lexical semantics)
לדעת את השמעת המילים (compositional semantics)
לדעת ליצר מילים למשמעות (world knowledge)
לדעת של הgiatan של למגנון היסק (inference)
לדעת של קוד אתי/מוסרי (ethical code)
לדעת של תורת מוחשה (theory of mind)
לדעת של מגרה лишיה (communicative speech act)
NLP | Goals
Natural Language Processing

https://www.youtube.com/watch?v=WFR3lOM_xhE
NLP | Watson?

(phonology) לוחות אלילים למילים
(syntax) לדעת לוח מילים למשפעים תקינים
(lexical semantics) לדעת את множעות המילים
(compositional semantics) לדעת לэрפ מילים למשמעות
(world knowledge) understood in the world
(inference) היסק מנוגן
(ethical code)moses
(Theory of mind) תורת המחשבה
(Communicative speech act) פעולות משיח
NLP | Watson

- Phonology
- Syntax
- Lexical semantics
- Compositional semantics
- World knowledge
- Inference
- Ethical code
- Theory of mind
- Communicative speech act
What is Natural Language?

Levels of Linguistic Knowledge

- **Phonology**: Sounds combination
- **Morphology**: Word Structure
- **Syntax**: Sentence Structure
- **Semantics**: Utterance Meaning
- **Pragmatics**: Intention/Act
NLP | What Is It?

Natural Language Processing
Levels of Language Processing

NLP | What Is It?

x → NLP → y
NLP | What Is It?

Levels of Language Processing

- Phonology
NLP | What Is It?
Levels of Language Processing

- Phonology

TAVILITAKADUR → free text
NLP | What Is It?
Levels of Language Processing

Phonology

TAVILITAKADUR

תביעה ל
את הכרור
NLP | What Is It?
Levels of Language Processing

- Phonology
- Morphology
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology

independently
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology

independently
It is because they cannot be introduced to each other

He was excellent at making kayaks

‘Life insurance company employee’
NLP | What Is It?
Levels of Language Processing

- Phonology
- Morphology
- Syntax
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology
- Syntax

The dog bit the man
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology
- Syntax

The dog bit the man

```
S
  NP
    DT N V NP
      the dog bit the
  VP
    DT N
      the man
```
Levels of Language Processing

- **Phonology**
- **Morphology**
- **Syntax**

```
The dog bit the man
```

Diagram: 
```
S
  └── NP
  │    └── DT N
  │       └── The dog
  └── VP
      └── NP
          └── DT N
              └── the man
```

**NLP | What Is It?**
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology
- Syntax
- Semantics

The dog bit the man
NLP | What Is It?
Levels of Language Processing

- Phonology
- Morphology
- Syntax
- Semantics

The dog bit the man
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology
- Syntax
- Semantics

\[ \exists x,y: \text{Dog}(x) & \text{Man}(y) & \text{BITE}(x,y) \]

The dog bit the man
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology
- Syntax
- Semantics

The dog bit the man
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology
- Syntax
- Semantics
- Pragmatics
NLP | What Is It?

Levels of Language Processing

- Phonology
- Morphology
- Syntax
- Semantics
- Pragmatics

Brrr.. It’s cold in here
NLP | Questions So Far?

- Phonology
- Morphology
- Syntax
- Semantics
- Pragmatics
NLP | Why is it hard?
Across all Levels of Description

Why Can’t We Simply Ask Our Linguists?
NLP | Why is it hard?

Ambiguity

Across all Levels of Description
Phonology

“AF”
NLP | Why is it hard?

Phonology

“AF”
NLP | Why is it hard?

Phonology

“AF”
NLP | Why is it hard?

- Morphology
  “Flies”
**NLP | Why is it hard?**

- Morphology

  "Flies"

  Noun+PL  Verb+SG
NLP | Why is it hard?

Morphology

“Books”
NLP | Why is it hard?

Morphology

“Books”

Noun+PL

Verb+SG
Lexical

“Bank”
NLP | Why is it hard?

Lexical

“Bank”

Noun

Noun
Syntactic

“We ate a pizza with anchovies”
NLP | Why is it hard?

- Syntactic
  
  “We ate a pizza with anchovies”
NLP | Why is it hard?

Semantic

“All men love a woman”
Pragmatic

“Brrr.. it’s cold in here”
NLP | Why is it hard?

Extreme Ambiguity!!!!

Am mishava ruch al sos uvozu, az hoe fros aw la?

Lehadot lemiysho befa malam, zo mnomes aw la?

Aic heb' denomination yodeso m'daleh shasomrim el "tnina li"?

Am orkevolog haluha hodes bido, hame hazelita aw la?

Baisutanbol la songrim далхот. hame torkim.

Shkaliti horeba lefi shahalatiti leushot diawon.
NLP | Why is it hard?

Try it yourself:

Join with this CODE at join.nearpod.com

CODE: WY439
NLP | How is it done?

Modeling

Natural Language Processing

X ➔ y
NLP | How is it done?

Rule-Based Modeling

\[ X \rightarrow \text{Natural Language Processing} \rightarrow y_1, y_2, y_3, y_4, y_5 \]
NLP | How is it done?

Statistical Modeling

Natural Language Processing

X → Natural Language Processing → Y

data
NLP | How is it done?

Statistical Modeling

\[ x \xrightarrow{\text{Prediction}} \text{data} \xrightarrow{\text{Learning}} y \]
NLP | How is it done?

Machine Learning | Deep Learning

X → Prediction → Y

Learning

<x, y>
Natural Language Processing

- Define $x$
- Define $y$
- Curate Data $\{(x,y)\}$
- Devise Learning
- Devise Prediction
- Evaluate $y^* = ? y$
NLP | To Sum UP

Natural Language Processing

- Linguistic Levels of Analysis
- Extreme Ambiguity
- Statistical Learning
- Context Matters!
Thank You! | Questions?
“Time Flies”
“Time Flies”

Noun Verb

Verb Noun
NLP | Why is it hard?

“Time Flies”

Noun Verb

Verb Noun
What Does Hebrew Have to do with it

הקפה
What Does Hebrew Have to do with it

עוז לא שיתתי את הקפה

בראשית השלימה הקפה מלאה
NLP | How is it done?

An Interdisciplinary Skill Set

- Computational Linguistics & psycholinguistics
- Logic & Philosophy of Language
- Computer Science
- Math and Statistics
- Machine Learning & deep Learning

How is it done?
The ONLP Lab

Infrastructure for Hebrew NLP
Deep Models for Deep Semantics
Natural Language Programming

Computational Linguistics
Natural Language Processing
Artificial Intelligence

The ONLP Lab
Natural Language Programming
Infrastructure for Hebrew NLP
Deep Models for Deep Semantics
Natural Language Programming

Natural Language Processing
Artificial Intelligence
Computational Linguistics
NLP | Applications

Applications of Language Processing

- Machine Translation
- Sentiment Analysis
- Question Answering
- Information Extraction
- Dialogue Systems
שאלות?

Good Luck!