CS11-737: Multilingual Natural Language Processing

Words, Parts of Speech, Morphology

Yulia Tsvetkov
What is a word?

- Count the words:
  
  *Bob’s handyman is a do-it-yourself kinda guy, isn’t he?*
What is a word?

Bob’s handy man is a do-it-yourself kinda guy, isn’t he?
What is a word?

Bob’s handy man is a do-it-yourself kinda guy, isn’t he?

clitic
noun-noun compound
multi-word expression?
contraction
What is a word?

*Bob’s* handy man is a do-it-yourself kinda guy, *isn’t he?*

Much’anayakapushaqakupuniŋataqsunamá

Much’a -na -naya -ka -pu -sha -sqa -ku -punį -ña -taq -suna -má

"So they really always have been kissing each other then”

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*וָשְׁבַתָה* and her saturday
*וָשְׁבַתְוָה* and that in tea
*וָשְׁבַתְוָה* and that her daughter
### Structural subfields of linguistics

<table>
<thead>
<tr>
<th>Subject</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Phonetics</td>
<td>The study of the sounds of human language</td>
</tr>
<tr>
<td>Phonology</td>
<td>The study of sound systems in human languages</td>
</tr>
<tr>
<td>Morphology</td>
<td>The study of the formation and internal structure of words</td>
</tr>
<tr>
<td>Syntax</td>
<td>The study of the formation and internal structure of sentences</td>
</tr>
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<td>Semantics</td>
<td>The study of the meaning of sentences</td>
</tr>
<tr>
<td>Pragmatics</td>
<td>The study of the way sentences with their semantic meanings are used for particular communicative goals</td>
</tr>
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</table>
Words

- **Orthographic definition**
  - strings separated by white spaces
  - problems: *Bob’s handy man is a do-it-yourself kinda guy, isn’t he?*
  - unwritten languages, languages that don’t use white spaces, etc.
Words

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- **Prosodic definition**
  - words have one main stress and longer words may have a secondary stress
  - problems: function words, clitics
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  ○ words are units that describe a single idea or a semantic concept
  ○ problem: many semantic concepts span phrases or sentences and don’t have a corresponding word
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● Semantic definition
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● Syntactic definition
  ○ words are the syntactic building blocks of sentences
Parts of speech

● Open classes
  ○ nouns
  ○ verbs
  ○ adjectives
  ○ adverbs

● Closed classes
  ○ prepositions
  ○ determiners
  ○ pronouns
  ○ conjunctions
  ○ auxiliary verbs
### Part of speech tagsets

- **Penn treebank tagset** (Marcus et al., 1993)

<table>
<thead>
<tr>
<th>Tag</th>
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<th>Example</th>
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</thead>
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<tr>
<td>CC</td>
<td>coordinating conjunction</td>
<td>and, but, or</td>
<td>PDT</td>
<td>predeterminer</td>
<td>all, both</td>
<td>VBP</td>
<td>verb non-3sg present</td>
<td>eat</td>
</tr>
<tr>
<td>CD</td>
<td>cardinal number</td>
<td>one, two</td>
<td>POS</td>
<td>possessive ending</td>
<td>'s</td>
<td>VBP</td>
<td>verb 3sg pres</td>
<td>eats</td>
</tr>
<tr>
<td>DT</td>
<td>determiner</td>
<td>a, the</td>
<td>PRP</td>
<td>personal pronoun</td>
<td>I, you, he</td>
<td>WDT</td>
<td>wh-determ.</td>
<td>which, that</td>
</tr>
<tr>
<td>EX</td>
<td>existential ‘there’</td>
<td>there</td>
<td>PRPS</td>
<td>possess. pronoun</td>
<td>your, one’s</td>
<td>WP</td>
<td>wh-pronoun</td>
<td>what, who</td>
</tr>
<tr>
<td>FW</td>
<td>foreign word</td>
<td>mea culpa</td>
<td>RB</td>
<td>adverb</td>
<td>quickly</td>
<td>WPS</td>
<td>wh-possess.</td>
<td>whose</td>
</tr>
<tr>
<td>IN</td>
<td>preposition/ subordin-conj</td>
<td>of, in, by</td>
<td>RBR</td>
<td>comparative</td>
<td>faster</td>
<td>WRB</td>
<td>wh-adverb</td>
<td>how, where</td>
</tr>
<tr>
<td>JJ</td>
<td>adjective</td>
<td>yellow</td>
<td>RBS</td>
<td>superlat. adverb</td>
<td>fastest</td>
<td>$</td>
<td>dollar sign</td>
<td>$</td>
</tr>
<tr>
<td>JJR</td>
<td>comparative adj</td>
<td>bigger</td>
<td>RP</td>
<td>particle</td>
<td>up, off</td>
<td>#</td>
<td>pound sign</td>
<td>#</td>
</tr>
<tr>
<td>JJS</td>
<td>superlative adj</td>
<td>wildest</td>
<td>SYM</td>
<td>symbol</td>
<td>+, %, &amp;</td>
<td>‘ ‘</td>
<td>right quote</td>
<td>‘ or “</td>
</tr>
<tr>
<td>LS</td>
<td>list item marker</td>
<td>1, 2, One</td>
<td>TO</td>
<td>“to”</td>
<td>to</td>
<td>)</td>
<td>right paren</td>
<td>) , ), &gt;</td>
</tr>
<tr>
<td>MD</td>
<td>modal</td>
<td>can, should</td>
<td>UH</td>
<td>interjection</td>
<td>ah, oops</td>
<td>(</td>
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<td>[, (, {, &lt;</td>
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<td>NN</td>
<td>sing or mass noun</td>
<td>llama</td>
<td>VB</td>
<td>verb base form</td>
<td>eat</td>
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<td>comma</td>
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<td>llamas</td>
<td>VBD</td>
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<td>IBM</td>
<td>VBG</td>
<td>verb gerund</td>
<td>eating</td>
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<td>sent-end punc</td>
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<td>Carolinas</td>
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The Universal Dependencies

Universal Dependencies (UD) is a framework for consistent annotation of grammar (parts of speech, morphological features, and syntactic dependencies) across different human languages. UD is an open community effort with over 300 contributors producing more than 150 treebanks in 90 languages. If you’re new to UD, you should start by reading the first part of the Short Introduction and then browsing the annotation guidelines.

- Short introduction to UD
- UD annotation guidelines
- More information on UD:
  - How to contribute to UD
  - Tools for working with UD
  - Discussion on UD
  - UD-related events
- Query UD treebanks online:
  - SETS treebank search maintained by the University of Turku
  - PML Tree Query maintained by the Charles University in Prague
  - Kontext maintained by the Charles University in Prague
  - Greew-match maintained by Inria in Nancy
  - INESS maintained by the University of Bergen
- Download UD treebanks

https://universaldependencies.org
What is a word

*Bob’s* handy man is a do-it-yourself *kinda* guy, *isn’t* he?

Much’ananyakapushasqakupuniñataqsunamá

Much’a -na -naya -ka -pu -sha -sqá -ku -puní -ña -taq -suna -má

"So they really always have been kissing each other then”

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and her saturday  
and that in tea  
and that her daughter
Morpheme

Image from Lori Levin and David R. Mortensen’s draft book “Human Languages for Artificial Intelligence”
Words are made of morphemes

Bob’s handy man is a do-it-yourself kinda guy, isn’t he?

- establish (V)
- disestablish (V)
- disestablishment (N)
- antidisestablishment (N)
- antidisestablishmentary (A)
- antidisestablishmentarian (N)
- antidisestablishmentarianism (N)

Example by Austin Matthews
Morphological processes

- concatenation
- affixation = stem+affix
  - prefix
  - suffix
- non-concatenative affixation
  - infix
- compounding = stem+stem


- establish (V) → stem
- disestablish (V) → prefix + stem
- disestablishment (N) → prefix + stem + suffix = circumcision

- dish (N) + washer (N) = dishwasher (N)
Tagalog

- Tagalog
  - stem - *bundok*
  - singular - *mabundok*
  - plural - *mabubundok*
  - gloss - ‘mountainous’

Example from Lori Levin and David R. Mortensen’s draft book “Human Languages for Artificial Intelligence”
Arabic, Chinese

- Arabic
  - root and pattern morphology

- Chinese
  - compound words

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<td><em>katab-a</em></td>
<td>'he wrote'</td>
</tr>
<tr>
<td><em>kaataba</em></td>
<td>'he corresponded'</td>
</tr>
<tr>
<td><em>kutib-a</em></td>
<td>'it was written'</td>
</tr>
<tr>
<td><em>kitaab</em></td>
<td>'book'</td>
</tr>
<tr>
<td><em>kutub</em></td>
<td>'books'</td>
</tr>
<tr>
<td><em>kaatib</em></td>
<td>'writer; writing'</td>
</tr>
<tr>
<td><em>kuttaab</em></td>
<td>'writers'</td>
</tr>
<tr>
<td><em>uktub</em></td>
<td>'write (to a male)!'</td>
</tr>
</tbody>
</table>

Table 17: Part of the Arabic paradigm for *ktb* 'with reference to writing.'

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<td>客厅</td>
<td>'living room'</td>
</tr>
<tr>
<td>眼</td>
<td>'eye'</td>
</tr>
<tr>
<td>马</td>
<td>'horse'</td>
</tr>
<tr>
<td>雨</td>
<td>'rain'</td>
</tr>
<tr>
<td>沙发</td>
<td>'sofa'</td>
</tr>
<tr>
<td>药</td>
<td>'medicine'</td>
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<tr>
<td>房</td>
<td>'house'</td>
</tr>
<tr>
<td>帽</td>
<td>'hat'</td>
</tr>
<tr>
<td>‘living room sofa’</td>
<td>‘eye medicine’</td>
</tr>
<tr>
<td>‘manger’</td>
<td>‘rain hat’</td>
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Morphological functions

● Derivational morphemes
  ○ bound morphemes used to create new words
  ○ is these affixes are attached to a new base, the resulting combination yields a word with a new meaning
  ○ often derived word belongs to a different syntactic class

● Inflectional morphemes
  ○ bound morphemes used to mark grammatical distinctions
  ○ change the form but not POS tag or the key meaning of the word

• establish (V)
• disestablish (V)
• disestablishment (N)

• eat (V) + -s = eats (V)
Morphological typology

- Isolating or Analytic
  - Vietnamese, Chinese, English
- Synthetic
  - Fusional or Flexional
    - German, Greek, Russian
    - Templatic: Hebrew and Arabic
  - Agglutinative or Agglutinating
    - Finnish, Turkish, Malayalam, Swahili
  - Polysynthetic
    - Inuit, Yupik
UniMorph

The Universal Morphology (UniMorph) project is a collaborative effort to improve how NLP handles complex morphology in the world's languages. The goal of UniMorph is to annotate morphological data in a universal schema that allows an inflected word from any language to be defined by its lexical meaning, typically carried by the lemma, and by a rendering of its inflectional form in terms of a bundle of morphological features from our schema. The specification of the schema is described here and in Sylak-Glassman (2016).

Plus, we're now available in a Python package! `pip install unimorph`

UniMorph Events

- SIGMORPHON 2019 Shared Task
- CoNLL–SIGMORPHON 2018 Shared Task
- CoNLL–SIGMORPHON 2017 Shared Task
- SIGMORPHON 2016 Shared Task

https://unimorph.github.io

Annotated Languages

The following 110 languages have been annotated according to the UniMorph schema. Missing parts of speech will be filled in soon.

Workshops

- **2020**: Seattle, co-located with ACL 2020
- **2019**: Florence, co-located with ACL 2019
- **2018**: Brussels, co-located with EMNLP 2018
- **2016**: Berlin, co-located with ACL 2016
- **2014 (with SIGFSM)**: Baltimore, co-located with ACL 2014
- **2012**: Montréal, co-located with NAACL-HLT 2012
- **2010**: Uppsala, co-located with ACL 2010
- **2008**: Columbus, co-located with ACL 2008
The SIGMORPHON shared tasks

- Cross-lingual transfer for morphological inflection
- Morphological analysis in context
- Morphological paradigm completion

The SIGMORPHON 2019 Shared Task: Morphological Analysis in Context and Cross-Lingual Transfer for Inflection

Arya D. McCarthy*, Ekaterina Vylomova*, Shijie Wu*, Chaitanya Malaviya*, Lawrence Wolf-Sonkin*, Garrett Nicolai*, Christo Kirov², Miikka Silfverberg², Sebastian Mielke*, Jeffrey Heinz², Ryan Cotterell³, and Mans Hulden³

*Johns Hopkins University  University of Melbourne  Allen Institute for AI
*Google  University of Helsinki  Stony Brook University  University of Colorado
Related NLP problems

- tokenization
- lemmatization

- processing words in multilingual NLP tasks, e.g. language modeling or machine translation
  - tokens
  - characters
  - subwords
  - +morphological knowledge

- syntactic tagging (next class) and morphological analysis (later in the course)
Readings and class discussion

- Read Chapter 2 in Bender E., 2013. *Linguistic Fundamentals for Natural Language Processing: 100 Essentials from Morphology and Syntax*.

- Pick a language in one of the following branches of language families: Bantu, Dravidian, Finno-Ugric, Japonic, Papuan, Semitic, Slavic, Turkic languages. Tell us about some interesting aspects of morphology of that language, following examples from the assigned reading; cite your sources.

  If you would need to implement a tokenizer for that language, what language specific knowledge it would be important to incorporate into the tokenizer?