Introduction to Natural Language Processing

a course taught as B4M36NLP at Open Informatics

by members of the Institute of Formal and Applied Linguistics

FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

Today:	**Week 4, lecture**
Today's topic:	**Overview of Language Data Resources**
Today's teacher:	**Zdeněk Žabokrtský**

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Why language data?

In general, when studying any language phenomenon, there are two basic ways to go:

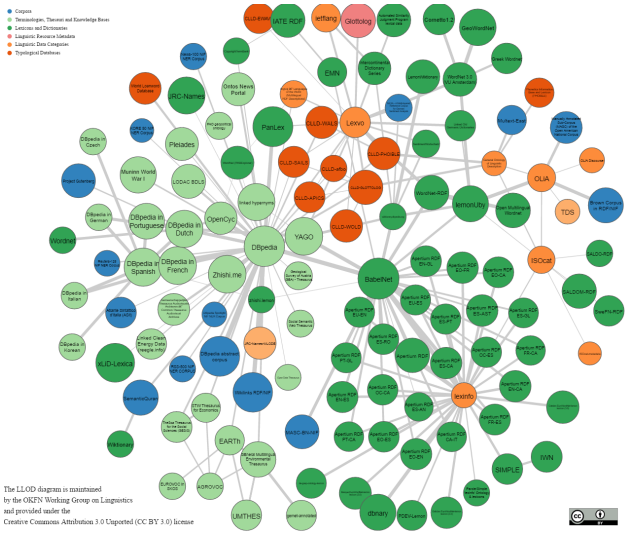
- thinking about it in the context of one's language experience, using **introspection**. . .
- or using **empirical evidence**, statistical models based on real world usage of language . . .
  - side remark: this includes also using brain-imaging methods or at least eye-tracking devices, but such approaches are still rare in the real NLP industry

Armchair linguistics or data crunching?

- 1957: Noam Chomsky's attack: "Any natural corpus will be skewed. Some sentences won't occur because they are obvious, others because they are false, still others because they are impolite. The corpus, if natural, will be so wildly skewed that the description would be no more than a mere list."
- 1992: Charles J. Fillmoore's caricature of "armchair linguists" vs. "corpus linguists"
- 1988: Frederick Jelinek: "Every time I fire a linguist, the performance of the speech recognizer goes up" (perhaps not an exact citation)
- but 2004: Frederick Jelinek: "My colleagues and I always hoped that linguistics will eventually allow us to strike gold."
- 2005: Tony McEnery: "Corpus data are, for many applications, the raw fuel of NLP, and/or the testbed on which an NLP application is evaluated."
- 200?: Eric Brill: "More data is more important than better algorithms."
- 200?: Eugene Charniac: "Future is in statistics."

The world of language data resources today

- Today's Language data resources map - hopelessly diverse.
- A very very tiny fragment for illustration: only ontologically-oriented data collections, just those adhering to the linked open data principles (credit: Wikipedia)



- 2016: 1,250 submissions to LREC 2016 (International Conference on *Language Resources and Evaluation*, biannual)

Why is that so complicated?

Why researchers need so many different pieces of data?

- Is the natural language really so complex? Well, yes.
- In addition,
  - thousands of languages (plus dialects), different writing systems...
  - many underlying theories
  - many end-application purposes

Let's try to systematize the space of data resources

Basic dimensions:

- corpus vs. lexicon
  - lexicon in the broad sense, as a repertory of tokens' types
- modality: spoken vs. written
  - and other, eg. sign languages
- covered languages: monolingual vs. multilingual
  - if multilingual, then possibly parallel
- time axis: synchronic vs. diachronic
  - if annotated, then what on which "level", with which underlying theory, what tag set ...
- time axis: synchronic vs. diachronic
  - if annotated, then what on which "level", with which underlying theory, what tag set ...
- plain vs. annotated
  - if annotated, then what on which "level" (which language phenomena are captured), with which underlying theory, with what set of labels (tag set) ...
- other language variables:
  - original vs. translation
  - native speaker vs. learner

Corpora

CORPUS according to Merriam-Webster

Full Definition of CORPUS

plural **corpora** \-p(ə-)rə\

1 : the body of a human or animal especially when dead

2 **a** : the main part or body of a bodily structure or organ <the *corpus* of the uterus>

b : the main body or corporeal substance of a thing; *specifically* : the principal of a fund or estate as distinct from income or interest

3 **a** : all the writings or works of a particular kind or on a particular subject; *especially* : the complete works of an author

b : a collection or body of knowledge or evidence; *especially* : a collection of recorded utterances used as a basis for the descriptive analysis of a language

A historical remark

- linguists recognized the need for unbiased empirical evidence long before modern NLP
  - excerption tickets collected systematically for Czech from 1911

Corpus size

- typically measured in tokens (words plus puntuation marks)
- sampling is inescapable
  - an I-want-it-all corpus is far beyond our technology (even in a strictly synchronic sense)
- but still, the corpora sizes have been growing at an exponential pace for some time:
  - Brown Corpus in 1964 $\approx$ 1MW
  - (electronic corpus of Czech texts in 1970s: 500kW)
  - British Natural Corpus in 1994 $\approx$ 100 MW
  - English Gigaword in 2004 $\approx$ 1GW
  - Google's 5-gram for 10 European Languages in 2009 based on $\approx$ 1TW

Balanced corpora

- an elusive goal: a balanced corpus whose proportions correspond to the real language usage
- criteria for choosing types of texts their relative proportion in the corpus (and eventually concrete texts)?
  - style, genre
  - reception vs. perception (a few influential authors vs. production of a large community)?
- actually no convincing generally valid answers for an optimal mixture ...
- ... but at least some strategies seem to be more reasonable than others
- an example of a clearly imbalanced corpus: Wall Street Journal Corpus
  - unfortunately used as a material source for the Penn Treebank, which is undoubtedly among the most influential LR
  - "NLP = Wall Street Journal science"

Corpus annotation

- raw texts – difficult to exploit
- solution: gradual "information adding" (more exactly, adding the information in an explicit, machine tractable form)
- annotation = adding selected linguistic information in an explicit form to a corpus

Corpus annotation criticism

- some critics: an annotated corpus is worse than a raw corpus because of forced interpretations
  - one has to struggle with different linguistic traditions of different national schools
  - example: part of speech categories
- relying on annotation might be misleading if the quality is low (errors or inconsistencies)

Variability of PoS tag sets

Penn Treebank POS tagset (for English)

CC coordinating conjunction (*and*)
CD cardinal number (*1, third*)
DT determiner (*the*)
EX existential there (*there is*)
FW foreign word (*d'hoevre*)
IN preposition/subordinating conjunction (*in, of, like*)
JJ adjective (*green*)
JJR adjective, comparative (*greener*)
JJS adjective, superlative (*greenest*)
LS list marker (*1)*)
MD modal (*could, will*)
NN noun, singular or mass (*table*)
NNS noun plural (*tables*)
NNP proper noun, singular (*John*)
NNPS proper noun, plural (*Vikings*)
PDT predeterminer (*¡¿both¡/¿ the boys*)
POS possessive ending (*friend's*)
PRP personal pronoun (*I, he, it*)
PRP$ possessive pronoun (*my, his*)
RB adverb (*however, usually, naturally, here, good*)
RBR adverb, comparative (*better*)
RBS adverb, superlative (*best*)
RP particle (*give up*)
TO to (*to go, to him*)
UH interjection (*uhhuhhuhh*)
VB verb, base form (*take*)
VBD verb, past tense (*took*)
VBG verb, gerund/present participle (*taking*)
VBN verb, past participle (*taken*)
VBP verb, sing. present, non-3d (*take*)
VBZ verb, 3rd person sing. present (*takes*)
WDT wh-determiner (*which*)
WP wh-pronoun (*who, what*)
WP$ possessive wh-pronoun (*whose*)
WRB wh-abverb (*where, when*)

Variability of PoS tag sets, cont.

Negra Corpus POS tagset (for German)

ADJA Attributives Adjektiv
ADJD Adverbiales oder prdikatives Adjektiv
ADV Adverb
APPR Prposition; Zirkumposition links
APPRART Prposition mit Artikel
APPO Postposition
APZR Zirkumposition rechts
ART Bestimmter oder unbestimmter Artikel
CARD Kardinalzahl
FM Fremdsprachliches Material
ITJ Interjektion
KOUI Unterordnende Konjunktion mit zu und Infinitiv
KOUS Unterordnende Konjunktion mit Satz
KON Nebenordnende Konjunktion
KOKOM Vergleichspartikel, ohne Satz
NN Normales Nomen
NE Eigennamen
PDS Substituierendes Demonstrativpronomen
PDAT Attribuierendes Demonstrativpronomen
PIS Substituierendes Indefinitpronomen
PIAT Attribuierendes Indefinitpronomen
PIDAT Attribuierendes Indefinitpronomen mit Determiner
PPER Irreflexives Personalpronomen
PPOSS Substituierendes Possessivpronomen
PPOSAT Attribuierendes Possessivpronomen
PRELS Substituierendes Relativpronomen
PRELAT Attribuierendes Relativpronomen
PRF Reflexives Personalpronomen
PWS Substituierendes Interrogativpronomen
PWAT Attribuierendes Interrogativpronomen
PWAV Adverbiales Interrogativ- oder Relativpronomen
PROAV Pronominaladverb
PTKZU zu vor Infinitiv
PTKNEG Negationspartikel
PTKVZ Abgetrennter Verbzusatz
PTKANT Antwortpartikel
PTKA Partikel bei Adjektiv oder Adverb
TRUNC Kompositions-Erstglied
VVFIN Finites Verb, voll
VVIMP Imperativ, voll
VVINF Infinitiv, voll
VVIZU Infinitiv mit zu, voll
VVPP Partizip Perfekt, voll
VAFIN Finites Verb, aux
VAIMP Imperativ, aux
VAINF Infinitiv, aux
VAPP Partizip Perfekt, aux
VMFIN Finites Verb, modal
VMINF Infinitiv, modal
VMPP Partizip Perfekt, modal
XY Nichtwort, Sonderzeichen
$, Komma
$. Satzbeendende Interpunktion
$(Sonstige Satzzeichen; satzintern
NNE Verbindung aus Eigennamen und normalen Nomen

Variability of PoS tag sets, cont.

Prague Dependency Treebank morphologitagset (for Czech), several thousand combinations using 15-character long positional tags

Form	Lemma	Morphological tag
Některé	*některý*	PZFP1----------
kontury	*kontura*	NNFP1-----A----
problému	*problém*	NNIS2-----A----
se	*se_^(zvr._zájmeno/částice)*	P7-X4----------
však	*však*	J^----------
po	*po-1*	RR--6----------
oživení	*oživení_^(*3it)*	NNNS6-----A----
Havlovým	*Havlův_;S_^(*3el)*	AUIS7M---------
projevem	*projev*	NNIS7-----A----
zdají	*zdát*	VB-P---3P-AA---
být	*být*	Vf--------A----
jasnější	*jasný*	AAFP1----2A----
.	.	Z:----------

Treebanks

Treebanks

- a treebank is a corpus in which sentences' syntax and/or semantics is analyzed using tree-shaped data structures
- a tree in the sense of graph theory (a connected acyclic graph)
- sentence syntactic analysis ... it sounds familiar to most of you, doesn't it?

Credit: http://konecekh.blog.cz

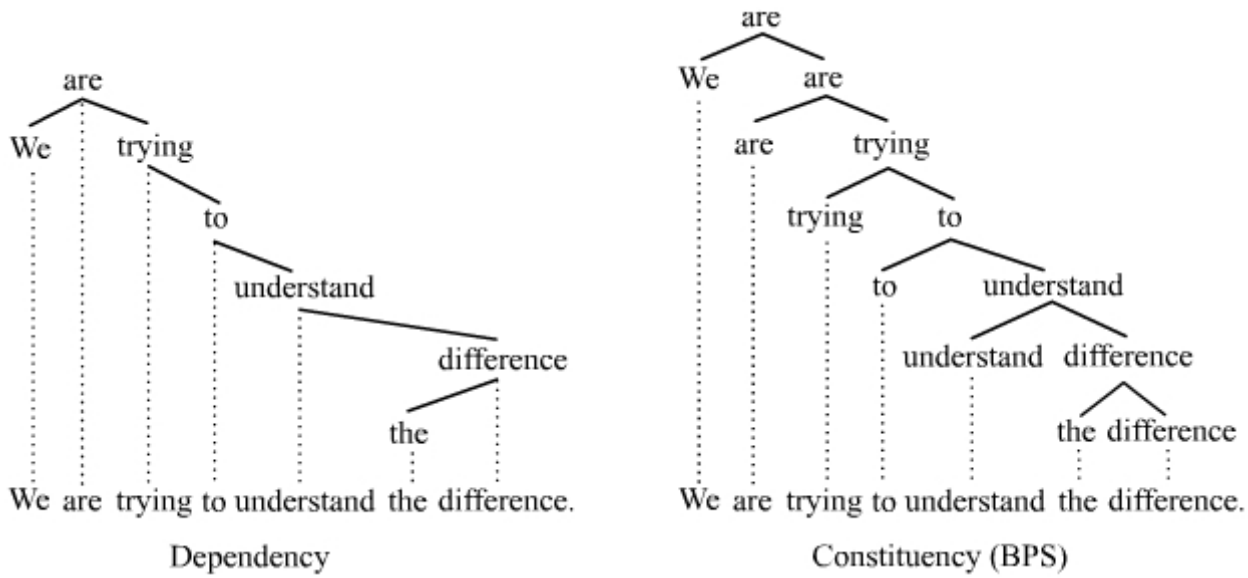
Why trees: Initial thoughts

1. Honestly: trees are irresistibly attractive data structures.
2. We believe sentences can be reasonably represented by discrete units and relations among them.
3. Some relations among sentence components (such as some word groupings) make more sense than others.
4. In other words, we believe there is an latent but identifiable discrete structure hidden in each sentence.
5. The structure must allow for various kinds of nestedness (*. . . a já mu řek, že nejsem Řek, abych mu řek, kolik je v Řecku řeckých řek . . .*).
6. This resembles recursivity. Recursivity reminds us of trees.
7. Let's try to find such trees that make sense linguistically and can be supported by empirical evidence.
8. Let's hope they'll be useful in developing NLP applications such as Machine Translation.

So what kind of trees?

There are two types of trees broadly used:

- constituency (phrase-structure) trees
- dependency trees



Credit: Wikipedia

Constituency trees simply don't fit to languages with freer word order, such as Czech. Let's use dependency trees.

How do we know there is a dependency between two words?

- There are various clues manifested, such as
  - word order (juxtapositon): "*. . . přijdu zítra . . .*"
  - agreement: "*. . . novými*$_{.pl.instr}$ *knihami*$_{.pl.instr}$ *. . .*"
  - government: "*. . . slíbil Petrovi*$_{.dative}$ *. . .*"

- Different languages use different mixtures of morphological strategies to express relations among sentence units.

Basic assumptions about building units

If a sentence is to be represented by a dependency tree, then we need to be able to:

- identify **sentence boundaries**.
- identify **word boundaries** within a sentence.

Basic assumptions about dependencies

If a sentence is to be represented by a dependency tree, then:

- there must be a **unique parent word** for each word in each sentence, except for the root word
- there are **no loops** allowed.

Even the most basic assumptions are violated

- Sometimes **sentence boundaries are unclear** – generally in speech, but e.g. in written Arabic too, and in some situations even in written Czech (e.g. direct speech)
- Sometimes **word boundaries are unclear**, (Chinese, "ins" in German, "abych" in Czech).
- Sometimes its **unclear which words should become parents** (A preposition or a noun? An auxiliary verb or a meaningful verb? ...).
- Sometimes there are too many relations ("Zahlédla ho bosého."), which implies **loops**.

Life's hard. Let's ignore it and insist on trees.

Counter-examples revisited

If we cannot find lingustically justified decisions, then make them at least consistent.

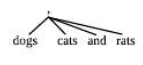
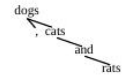
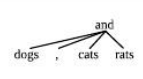
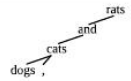
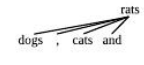
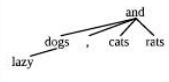
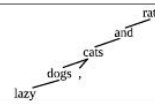
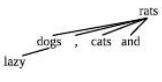
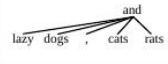
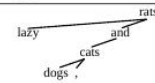
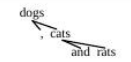
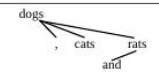
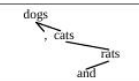
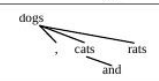
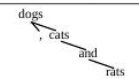
- Sometimes sentence boundaries are unclear (generally in speech, but e.g. in written Arabic too. . .)
  - **OK, so let's introduce annotation rules for sentence segmentation.**
- Sometimes word boundaries are unclear, (Chinese, "ins" in German, "abych" in Czech).
  - **OK, so let's introduce annotation rules for tokenization.**
- Sometimes it's not clear which word should become parent (e.g. a preposition or a noun?).
  - **OK, so let's introduce annotation rules for choosing parent.**
- Sometimes there are too many relations ("Zahlédla ho bosého."), which implies loops.
  - **OK, so let's introduce annotation rules for choosing tree-shaped skeleton.**

Treebanking

- Is our dependency approach viable? Can we check it?
- Let's start by building the trees manually.
- a treebank - a collection of sentences and associated (typically manually annotated) dependency trees
- for English: Penn Treebank [Marcus et al., 1993]
- for Czech: Prague Dependency Treebank [Hajič et al., 2001]
  - layered annotation scheme: morhology, surface syntax, deep syntax
  - dependency trees for about 100,000 sentences
- high degree of design freedom and local linguistic tradition bias
- different treebanks $\Longrightarrow$ different annotation styles

Case study on treebank variability: Coordination

- coordination structures such as "*lazy dogs, cats and rats*" consists of
  - conjuncts
  - conjunctions
  - shared modifiers
  - punctuations
- 16 different annotation styles identified in 26 treebanks (and many more possible)
- different expressivity, limited convertibility, limited comparability of experiments...
- **harmonization of annotation styles badly needed!**

Main family	Prague family (code fP) [14 treebanks]	Moscow family (code fM) [5 treebanks]	Stanford family (code fS) [6 treebanks]
Choice of head			
Head on left (code hL) [10 treebanks]			
Head on right (code hR) [14 treebanks]			
Mixed head (code hM) [1 treebank]	A mixture of hL and hR		
Attachment of shared modifiers			
Shared modifier below the nearest conjunct (code sN) [15 treebanks]			
Shared modifier below head (code sH) [11 treebanks]			
Attachment of coordinating conjunction			
Coordinating conjunction below previous conjunct (code cP) [2 treebanks]	—		
Coordinating conjunction below following conjunct (code cF) [1 treebank]	—		
Coordinating conjunction between two conjuncts (code cB) [8 treebanks]	—		
Coordinating conjunction as the head (code cH) is the only applicable style for the Prague family [14 treebanks]		—	—
Placement of punctuation			
values pP [7 treebanks], pF [1 treebank] and pB [15 treebanks] are analogous to cP, cF and cB (but applicable also to the Prague family)			

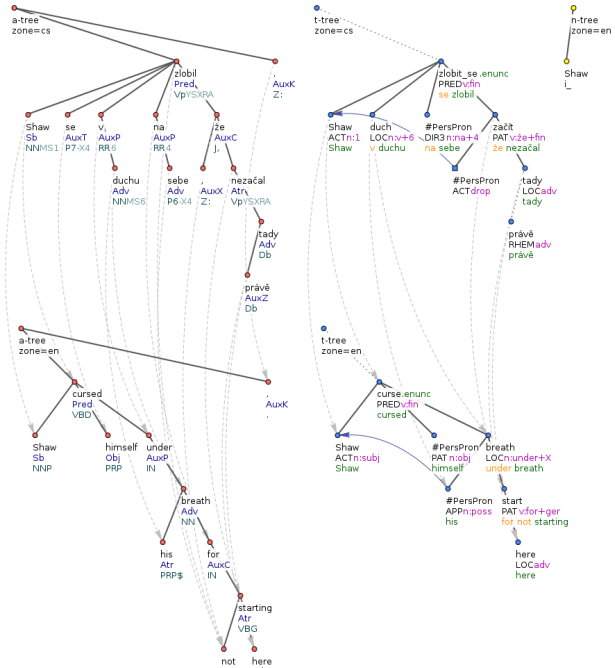
How many treebanks are there out there?

- growing interest in dependency treebanks in the last decade or two
- existing treebanks for about 50 languages now (but roughly 7,000 languages in the world)
- UFAL participated in several treebank unification efforts:
  - 13 languages in CoNLL in 2006
  - 29 languages in HamleDT in 2011
  - 37 languages in Universal Dependencies in 2015:

Other specialized corpora

Parallel corpora

- specific feature: alignment between corresponding units in two (or more) languages
  - document level alignment
  - sentence level alignment
  - word level alignment
  - (morpheme level alignment?)
- example: The Rosetta Stone
- example: CzEng - a Czech-English parallel corpus, roughly 0.5 words for each language, automatically parsed (using PDT schema) and



aligned.

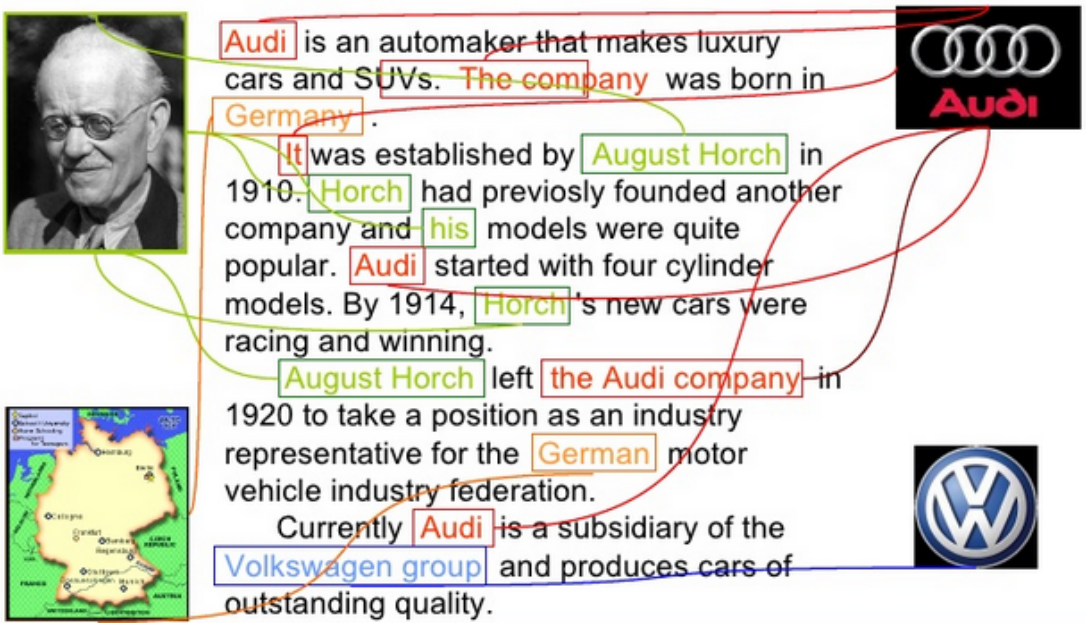
Named entity corpora

- specific feature: instances of proper names, such as names of people, geographical names,
- example: Czech Named Entity Corpus - two-level hierarchy of 46 named entity types, 35k NE instances in 9k sentences

Dnes sehrají fotbalisté Slavie na **Strahově** od 17.30
hodin utkání Interpoháru s Bayerem Leverkusen , v
jehož barvách by se měl představit i bývalý olomoucký
útočník Pavel Hapal .
Cítím , že můj osud je zpečetěn .
Křesťanství pohanům .
ČINNOST **POBOČKY** EVROPSKÉ BANKY PRO OBNOVU A
ROZVOJ (**BERD**) v **Praze** slavnostním přestřižením stuhy
včera zahájil president **BERD** Jacques Attali .

Coreference corpora

- specific feature: capturing relations between expressions that refer to the same entity of the real world



(credit: Shumin Wu and Nicolas Nicolov)

- example: Prague Dependency Treebanks (around 40k coreference links in Czech texts)

Sentiment corpora

- specific feature: capture the attitude (in the sense of emotional polarity) of a speaker with respect to some topic/expression
- simply said: "is this good or is it bad?"
- obviously over-simplified, but highly demanded e.g. by the marketing industry

Authorities are *only too aware* that Kashgar is 4,000 kilometres (2,500 miles) from Beijing but *only* a tenth of the distance from the Pakistani border, and are *desperate* to *ensure instability or militancy* does not leak over the frontiers.
Taiwan-made products *stood a good chance* of becoming *even more competitive thanks to* wider access to overseas markets and lower costs for material imports, he said.
"March *appears* to be a *more reasonable* estimate while earlier admission *cannot be entirely ruled out*," according to Chen, also Taiwan's chief WTO negotiator.
friday evening plans were great, but saturday's plans *didnt go as expected* – i went dancing & it was an *ok* club, but *terribly crowded :-(*
WHY THE *HELL* DO YOU GUYS ALL HAVE MRS. KENNEDY! SHES A FUCKING DOUCHE
AT&T was *okay* but whenever they do something *nice* in the name of customer service it seems like a favor, while T-Mobile makes that a *normal everyday thin*
obama should be *impeached* on *TREASON* charges. Our Nuclear arsenal was TOP Secret. Till HE told our enemies what we had. *#Coward #Traitor*
My graduation speech: "I'd like to *thanks* Google, Wikipedia and my computer! *:D* #iThingteens

(credit: SemEval 2014 documentation)

- example: MPQA Corpus

Highly multi-lingual corpora

- specific feature: as many languages as possible
- examples:
  - W2C - at least 1MW for more than 100 languages
  - The Bible Corpus - translations of the Bible into 900 languages

Examples of Lexicon-like Data Resources

Inflectional lexicons

- specific feature: capturing the relation between a lemma and inflected word forms, ideally in both directions
- example: MorfFlex CZ, around 120M word forms associated with 1M lemmas

```
podle-1_^(*3ý-1) Dg-------3N---6 nejnepodlejc
podle-1_^(*3ý-1) Dg-------3N---- nejnepodleji
podle-1_^(*3ý-1) Dg-------3A---6 nejpodlejc
podle-1_^(*3ý-1) Dg-------3A---- nejpodleji
podle-1_^(*3ý-1) Dg-------1N---- nepodle
podle-1_^(*3ý-1) Dg-------2N---6 nepodlejc
podle-1_^(*3ý-1) Dg-------2N---- nepodleji
podle-1_^(*3ý-1) Dg-------1A---- podle
podle-1_^(*3ý-1) Dg-------2A---6 podlejc
podle-1_^(*3ý-1) Dg-------2A---- podleji
podle-2 RR--2---------- podle
```

Derivational lexicons

- specific feature: capturing the relation between a base word and a derived word (typically by prefixing and/or suffixing)
- example: DeriNet, 1M lemmas, 700k derivation links

Thesaurus

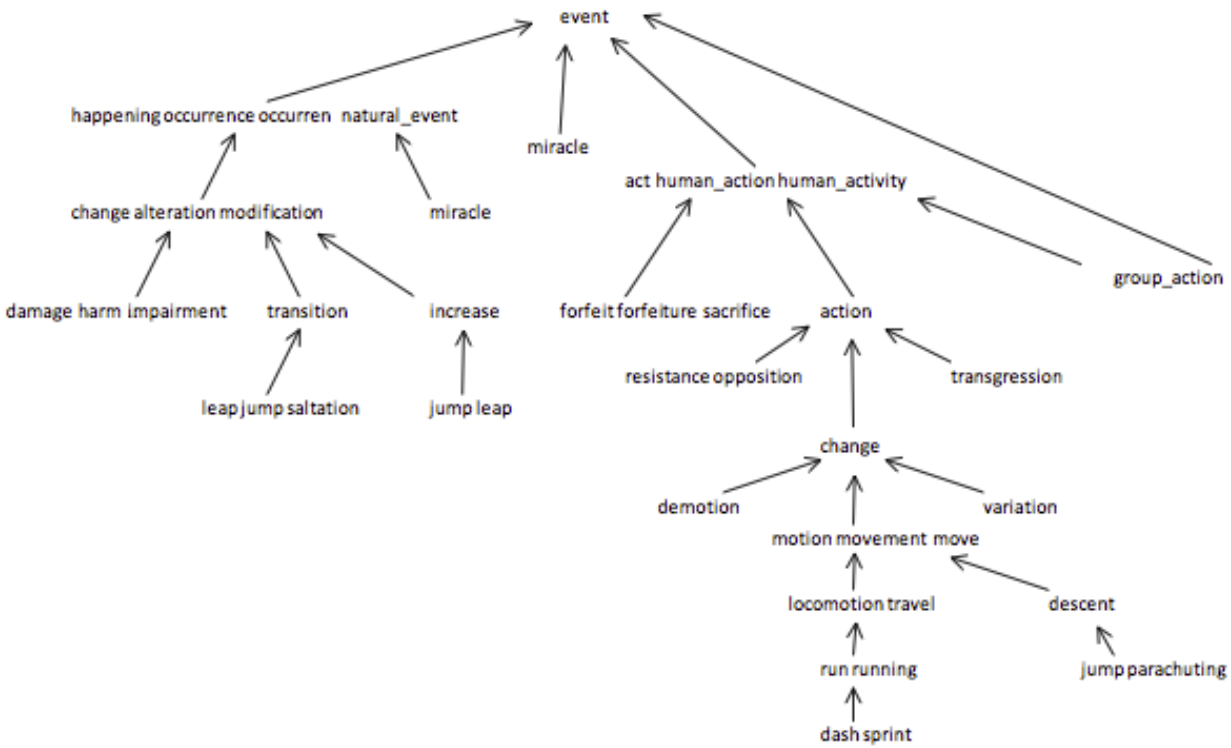
- specific feature: capturing semantic relations between words, such as synonymy and antonymy
- example:

Main Entry:	**great**
Part of Speech:	*adjective*
Definition:	excellent, skillful
Synonyms:	able, absolute, aces, adept, admirable, adroit, awesome, bad*, best, brutal, cold*, complete, consummate, crack*, downright, dynamite, egregious, exceptional, expert, fab, fantastic, fine, first-class*, first-rate, good, heavy*, hellacious, marvelous, masterly, number one, out of sight, out of this world, out-and-out, perfect, positive, proficient, super-duper, surpassing, terrific, total, tough, transcendent, tremendous, unmitigated, unqualified, utter, wonderful
Antonyms:	ignorant, menial, poor, stupid, unskilled, weak

* = informal/non-formal usage

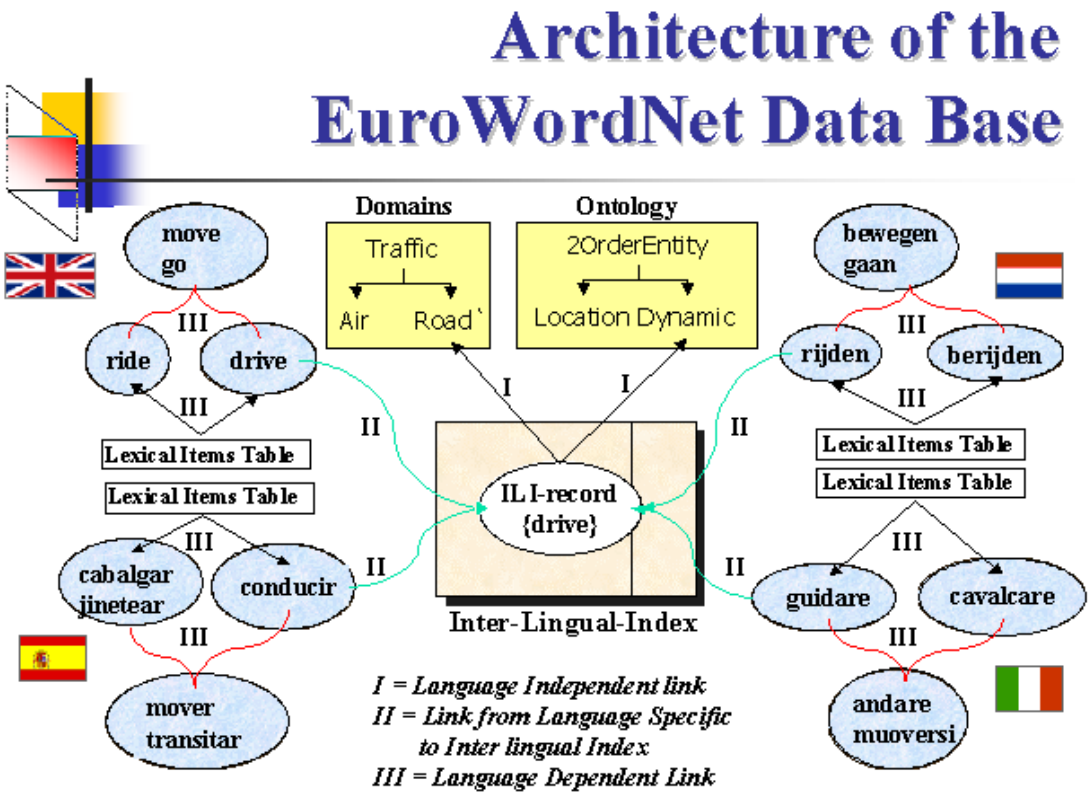
Wordnets

- specific feature: hyponymy (hyperonymy) forest composed of synsets (sets of synonymous words)
- example: Princeton Wordnet



EuroWordNet

- specific feature: wordnets of several languages interconnected through English as the hub language



(credit: intuit.ru)

Valency lexicons

- specific feature: capturing combinatory potential of a word (most frequently of a verb) with other sentence elements
- example: VALLEX - Valency Lexicon of Czech Verbs

odpovídat^{impf}, odpovědět^{pf}

1. odvětit; dávat odpověď

   frame: ACT_{1}^{obl} $ADDR_{3}^{obl}$ PAT_{na+4}^{opt} $EFF_{4,aby,af,zda,že,cont}^{obl}$ $MANN^{typ}$ $MEANS_{7}^{typ}$

   example: impf: odpovídal mu na jeho dotaz pravdu / činem / smíchem / že ... pf: odpověděl mu na jeho dotaz pravdu / činem / smíchem / že ...

2. impf: reagovat pf: reagovat

   frame: ACT_{1}^{obl} PAT_{na+4}^{opt} EFF_{7}^{obl}

   example: impf: pokožka odpovídala na chlad zarudnutím; gruzínští milicionáři neodpovídali střelbou (SYN) pf: vojáci odpověděli střelbou (SYN); na výzvu doby odpověděl změnou vlastního politického chování (SYN)

3. limit odpovídat^{impf}
   mít odpovědnost

   frame: ACT_{1}^{obl} $ADDR_{3}^{opt}$ PAT_{za+4}^{obl} $MEANS_{7}^{typ}$

   example: odpovídá za své děti; odpovídá za ztrátu svým majetkem

4. limit odpovídat^{impf}
   být ve shodě / v souladu; korespondovat

   frame: $ACT_{1,že}^{obl}$ PAT_{3}^{obl} REG_{7}^{typ}

   example: řešení odpovídá svými vlastnostmi požadavkům

... and many other types of language resources

Speech corpora

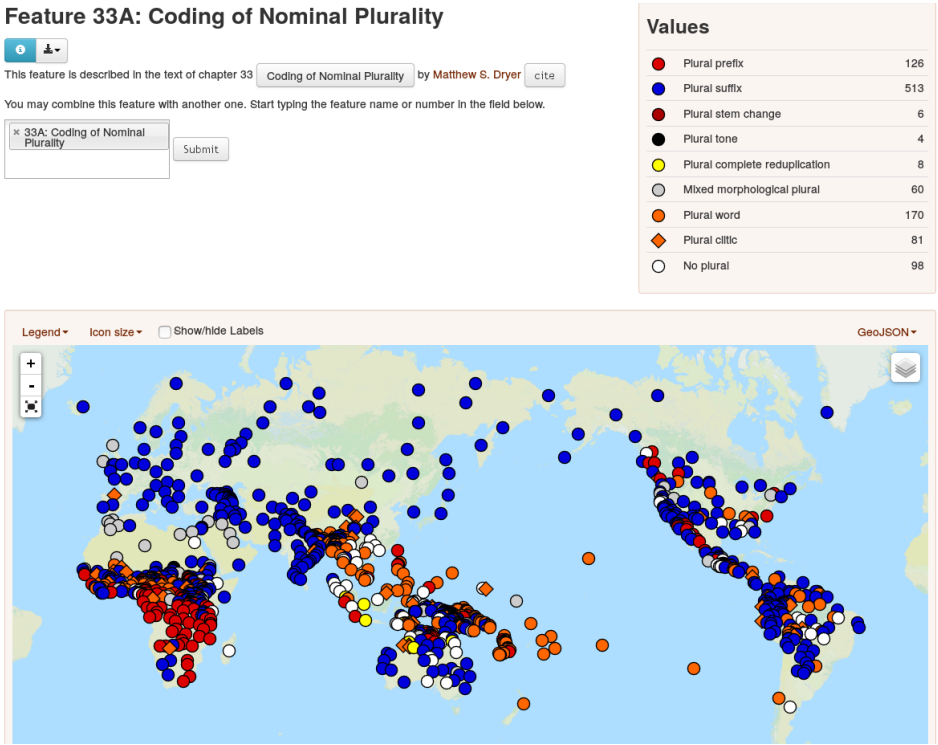
- specific feature: recordings of authentic speech, typically with manual transcriptions
- for training Automatic Speech Recognition systems
- example: The Switchboard-1 Telephone Speech Corpus, 2,400 telephone conversations, manual transcriptions

Datasets primarily uninteded as corpora

- Web as a corpus
- Wikipedia as a corpus
- Enron corpus - 600,000 emails generated by 158 employees of the Enron Corporation

“Metainformation” about languages

- example: The World Atlas of Language Structures (WALS)
  - http://wals.info/
  - specific feature: various language properties (related e.g. to word order, morphology, syntax) captured for hundreds of languages



Final remarks

A final remark: current trends in language resources . . .

trends (in the last few years) according to Nicoletta Calzolari's LREC 2016 foreword

- social media analysis
- discourse, dialog and interactivity
- treebanks
- under-resourced languages
- semantics
- multi-linguality
- evaluation methodologies

. . . and the last word

Be careful when you hear (or say) that some language data resource (or an annotation scheme, or a probabilistic model, or a technological standard. . .) is

- theory neutral, or
  - If fact we cannot "measure" language stuctures *per se*, and thus we always rely on some assumptions or conventions etc.
- language independent.
  - In fact it is impossible for an NLP developer to consider all variations in morphology/syntax/semantics of all language.