Overview: Computational Lexical Semantics and the Week Ahead

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University of Melbourne, July 2011
Outline

1. Computational Lexical Semantics
   - Word Meaning Representation
   - Distributional Similarity
   - Word Sense Disambiguation
   - Semantic Relations
   - Multiword Expressions
   - Predicate Argument Structure: the syntax-semantics interface

2. My Background and Research Interests
   - Academic Interests
   - Commercial Interests / Demos
     - Sketch Engine, and related tools
     - Dante
     - Other Related Projects
Motivation

- we interpret and use language for communication
- words have meaning
- if we want to machines to manipulate language as we do they need to be able to distinguish meanings and use words appropriately
Drawbacks

- semantic phenomena covert
- what is the appropriate representation?
- more variation compared to syntax and morphology
- less straightforward to evaluate, unless we focus on easy distinctions
The Emergence of Computational Lexical Semantics

- importance of the lexicon, 80’s onwards [Gazdar, 1996]
- default inheritance (expressing generalisations e.g. DATR http://www.informatics.susx.ac.uk/research/groups/nlp/datr/)
- word sense disambiguation [Weaver, 1949]
- importance of lexical semantics (growing fast)
  - word meanings
  - semantic relationships
Outline

1. **Computational Lexical Semantics**
   - Word Meaning Representation
   - Distributional Similarity
   - Word Sense Disambiguation
   - Semantic Relations
   - Multiword Expressions
   - Predicate Argument Structure: the syntax-semantics interface

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Representing Word Meaning

- with other words
  - from manually produced resources e.g. dictionaries, thesauruses
  - automatic extraction (from corpora)
- potentially other media [Feng and Lapata, 2010]
Manually produced inventories: e.g. WordNet

- man made on-line thesaurus
- organised by POS
- synonym sets - senses rather than word form
- relations between these sets e.g. hyponymy meronymy.
coach (noun) has 5 senses in WordNet:-

1. coach, manager, handler – ((sports) someone in charge of training an athlete or a team)
2. coach, private instructor, tutor – (a person who gives private instruction (as in singing, acting, etc.))
3. passenger car, coach, carriage – (a railcar where passengers ride)
4. coach, four-in-hand, coach-and-four – (a carriage pulled by four horses with one driver)
5. bus, autobus, coach, charabanc, double-decker, jitney, motorbus, motorcoach, omnibus, passenger vehicle – (a vehicle carrying many passengers; used for public transport; "he always rode the bus to work")
Lumper or Splitter?

1. (20) coach, manager, handler – ((sports) someone in charge of training an athlete or a team)

2. coach, private instructor, tutor – (a person who gives private instruction (as in singing, acting, etc.))

3. passenger car, coach, carriage – (a railcar where passengers ride)

4. coach, four-in-hand, coach-and-four – (a carriage pulled by four horses with one driver)

5. bus, autobus, coach, charabanc, double-decker, jitney, motorbus, motorcoach, omnibus, passenger vehicle – (a vehicle carrying many passengers; used for public transport; "he always rode the bus to work")
(40) sum, sum of money, amount, amount of money – (a quantity of money; ”he borrowed a large sum”; ”the amount he had in cash was insufficient”)

(39) amount – (the relative magnitude of something with reference to a criterion; ”an adequate amount of food for four people”)

(20) measure, quantity, amount – (how much there is or how many there are of something that you can quantify)

(6) sum, amount, total – (a quantity obtained by the addition of a group of numbers)
OntoNotes [Hovy et al., 2006]

- multi-year large scale semantic annotation project
- consortium (BBN Technologies, the University of Colorado, the University of Pennsylvania, the University of Southern Californias Information Sciences Institute)
- various levels of annotation (syntax, propositions, word sense, names, coference)
- 90% agreement from annotators (Inter-tagger agreement: average pairwise agreement on same sense for an item)
- English, Chinese, Arabic
Ontonotes (2.0): amount noun

<sense n="1" type="" name="A quantity of something" group="1">
   <commentary>AMOUNT[+quantity]
       Note: the quantity may be referred to precisely or approximately.
       Note: usually occurs with mass nouns, but usage with count nouns is increasing.</commentary>
   <examples>
       We have an adequate amount of food for four people.
       Writing my thesis involved a certain amount of procrastination.
   </examples>
</sense>

<sense n="3" type="" name="A sum of money" group="1">
   <commentary>AMOUNT[+quantity][+sum][+money]
       Note: always refers to a quantity of money.
       Note: a narrow, specialized use of Sense 1</commentary>
   <examples>
       He borrowed a large amount when he started that business.
       The amount he had in his wallet was insufficient.
       ...
   </examples>
</sense>
Roget: *amount* noun

- **Definition:** quantity
  - Synonyms: aplenty, bags, bulk, bundle, chunk, expanse, extent, flock, gob, heap, hunk, jillion, load, lot, magnitude, mass, measure, mess*, mint, mucho, number, oodles*, pack, passel, peck, pile, scads, score, slat, slew, supply, ton, volume, whopper
  - Notes: use 'amount' with things that cannot be counted but 'number' with things that can be counted. Number is regularly used with count nouns, while amount is mainly used with mass nouns: number of mistakes, amount of money

- **Definition:** total
  - Synonyms: addition, aggregate, all, bad news, body, budget, cost, damage*, entirety, expense, extent, list, lot, net, outlay, output, price tag, product, quantum, score, set-back, sum, tab, tidy sum, whole

* = informal/non-formal usage
Homonymy vs polysemy

- **Homonyms**: same spelling, pronunciation but different meanings. Two different ‘words’
  - *bank*: a financial institution
  - *bank*: slope at the side of a river
- Different words on basis of etymology: historical origin (but not so straightforward)
- **Polysemes**: different meanings, same origins *mouth* (river or animal)
- **Systematic Polysemes**: regular difference in meaning e.g. *meat* - *animal* (*chicken, duck, goose*)
- **Homographs**: words that are written the same but pronounced differently e.g. *lead*
- **Homophones**: words that are pronounced the same, but written differently e.g. *two, to, too read, reed*
Homonymy vs Polysemy

but...

- We don’t always know the etymology
- some meanings are more related than others
- how do we decide the degree of relatedness?
Generative Lexicon [Pustejovsky, 1995]

- related senses generated from rules capturing regularities
- lexical typing structure, argument structure, event structure and qualia structure
- senses expressed by qualia roles (semantic features)
  - formal (type or relation)
  - constitutive (relation between object and its parts)
  - telic (purpose or function)
  - agentive (origins)
Generative Lexicon [Pustejovsky, 1995]

\[
\text{beer} \\
\text{ARGSTR} = \begin{cases} 
\text{ARG1} = \quad \text{X:liquid} \\
\text{QUALIA} = \begin{cases} 
\text{FORMAL} = \quad x \\
\text{TELIC} = \quad \text{drink}(e,y,x) 
\end{cases}
\end{cases}
\]
Generative Lexicon [Pustejovsky, 1995]

book

ARGSTR =

\[
\begin{align*}
\text{ARG1} &= x: \text{information} \\
\text{ARG2} &= y: \text{phys_obj}
\end{align*}
\]

QUALIA =

\[
\begin{align*}
\text{information} \cdot \text{phys_obj} \_ \text{lcp} \\
\text{FORMAL} &= \text{hold}(y,x) \\
\text{TELIC} &= \text{read}(e,w,x \cdot y) \\
\text{AGENT} &= \text{write}(e',v,x \cdot y)
\end{align*}
\]
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Distributional approaches to Word Meaning

plant:

1. see if you can make the plant grow to its full and healthy height
2. A hydro power plant can be operated using either a diverted water stream system
3. Job profile of a water/wastewater treatment plant worker
4. We know from a very early age that plants obtain water through their roots
Distributional approaches to Word Meaning

*plant:*

1. *see if you can make the* plant *grow to its full and healthy height*
2. *A hydro power* plant *can be operated using either a diverted water stream system*
3. *Job profile of a water/ wastewater treatment* plant *worker*
4. *We know from a very early age that plants obtain water through their roots*

water  grow  root  job  hydro  power . . .

3  1  1  1  1  1  1
## Proximity Relations

<table>
<thead>
<tr>
<th>context</th>
<th>frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>plant</td>
</tr>
<tr>
<td>worker</td>
<td>55</td>
</tr>
<tr>
<td>healthy</td>
<td>32</td>
</tr>
<tr>
<td>water</td>
<td>34</td>
</tr>
<tr>
<td>root</td>
<td>8</td>
</tr>
<tr>
<td>operate</td>
<td>4</td>
</tr>
<tr>
<td>power</td>
<td>3</td>
</tr>
</tbody>
</table>
### Dependency Relations

<table>
<thead>
<tr>
<th>context</th>
<th>frequency</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>plant</strong></td>
<td><strong>tree</strong></td>
<td><strong>factory</strong></td>
<td></td>
</tr>
<tr>
<td><strong>grow</strong></td>
<td>verb object</td>
<td>52</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td><strong>weed</strong></td>
<td>verb object</td>
<td>31</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td><strong>water</strong></td>
<td>verb object</td>
<td>23</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td><strong>dead</strong></td>
<td>adj modifier</td>
<td>10</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td><strong>operate</strong></td>
<td>verb subject</td>
<td>16</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td><strong>demolish</strong></td>
<td>verb object</td>
<td>11</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>
Distributional similarity: nearest neighbours

Thesaurus (nearest neighbour) output
Word: <closest word> <score> <2nd closest > <score>...
Distributional similarity: nearest neighbours

Thesaurus (nearest neighbour) output
Word: <closest word> <score> <2nd closest > <score>...

**plant:** tree 0.178 flower 0.163 factory 0.152 bush 0.131

**coach:** train 0.171 bus 0.166 player 0.149 captain 0.131 car 0.131

**match:** game 0.171 tournament 0.166 matchstick 0.149 cigarette 0.131 competition 0.131
Distributional similarity: nearest neighbours

Thesaurus (nearest neighbour) output
Word: <closest word> <score> <2nd closest > <score>...

plant: tree 0.178 flower 0.163 factory 0.152 bush 0.131

dcoach: train 0.171 bus 0.166 player 0.149 captain 0.131 car 0.131

match: game 0.171 tournament 0.166 matchstick 0.149 cigarette 0.131 competition 0.131

Grouping similar words  [Pantel and Lin, 2002]
Frequency data input to a vector space model:

<table>
<thead>
<tr>
<th>context</th>
<th>coach</th>
<th>bus</th>
<th>trainer</th>
</tr>
</thead>
<tbody>
<tr>
<td>take</td>
<td>50</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>teach</td>
<td>30</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>ticket</td>
<td>8</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>match</td>
<td>15</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>
Vector Based Approaches

Diagram: A 2D vector space with words like "take", "train", "carriage", "bus", "coach", "trainer", and "teacher" plotted. The words are connected by lines indicating similarity, with "take" and "teach" at opposite ends of the axes. The relative positions suggest a distributional similarity approach to word meaning representation.
Vector Based Approaches

- take
- bus
- carriage
- coach
- trainer
- teacher
- train
- s4
- s3
- s2
- s8
- s1
- s7
- s6
- s5
Vector Based Approaches

- Take
- Coach
- Train
- Carriage
- Bus
- Teacher
- Trainer
- Teach
- 30
- 50
Prototypes and Exemplars

- Prototype single vector per category (centroid)
- cluster instances [Schütze, 1998] and then take centroid
- Multiprototype: [Reisinger and Mooney, 2010]
- can remove irrelevant vectors given the context [Thater et al., 2010]
- Exemplars: keep all vectors and compare to input (kNN, q%) [Erk and Padó, 2010]
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Word Sense Disambiguation

- process of assigning words to word senses
- class of semantic tagging, but note tagging can include broader semantic classes that apply to groups of words
- which meanings?
- which words? (all or just a fixed set)
Word Sense Disambiguation

how easy?

[Bar-Hillel, 1960] No existing or imaginable program will enable an electronic computer to determine that the word pen is used in its **enclosure** sense in the passage below, because of the need to model, in general, all world knowledge like, for example, the relative sizes of objects:

“Little John was looking for his toy box. Finally he found it. The box was in the **pen**. John was happy.”
WSD and Semantic tagging: why bother?

- NLP applications e.g.
  - question answering
  - machine translation
  - information retrieval
  - summarisation

- enabling other tasks e.g.
  - anaphora resolution
  - lexical acquisition (preferences)
  - parsing / semantic role labelling

- Lexicography, linking dictionary with corpus, synonym extraction
Word sense disambiguation (WSD)

Given a word in context, find the best-fitting “sense”

_Residents say militants in a station wagon pulled up, doused the building in gasoline, and struck a match._
Word sense disambiguation (WSD)

Given a word in context, find the best-fitting “sense”

Residents say militants in a station wagon pulled up, doused the building in gasoline, and struck a match.
Word sense disambiguation (WSD)

Given a word in context, find the best-fitting “sense”

Residents say militants in a station wagon pulled up, doused the building in gasoline, and struck a match.
WSD Evaluation

- against manually tagged resources e.g. SemCor [Miller et al., 1993]
- SemCor largest manually tagged resource
- English, WordNet 1.6 (later versions simply remapped taggings)
  - 230,000 words of Brown Corpus [Francis and Kučera, 1979]:
  - also Red Badge of Courage
- cntlist (both sources, used to order WordNet senses) vs release SemCor files (Brown only)
- no inter-tagger agreement figures, but remarkable resource for its size and availability!
The Grand Jury said Friday an investigation of Atlanta's primary on recent primary election produced'
WSD Evaluation Measures

Coverage = \frac{\text{#answers provided}}{\text{total #items requiring answer}}

Precision = \frac{\text{#correct answers provided}}{\text{#answers provided}}

Recall = \frac{\text{#correct answers provided}}{\text{total #items requiring answer}}

F_\alpha = \frac{(1 + \alpha)PR}{\alpha P + R}

F_1 = \frac{2PR}{P + R}

harmonic mean of precision and recall, or balanced F score
Aside on Evaluation Measures

\[ F_1 = \frac{2PR}{P + R} \]

- In WSD Precision denominator is subset of Recall.
- Lexical acquisition meanwhile uses terms for trade off (finding things, and are they correct) and not interested in true negatives (in abundance).

\[
\text{precision} = \frac{\text{True positives}}{\text{true positives} + \text{false positives}}
\]

\[
\text{recall} = \frac{\text{true positives}}{\text{true positives} + \text{false negatives}}
\]
For some semantic tasks also see

Correlation Spearman’s $\rho$

$$\rho(X, Y) = \frac{\text{covariance}(X, Y)}{\sigma_X \sigma_Y}$$

- Pearson’s coefficient
- correlation between two random variable ($X$ and $Y$)
- Spearman’s (non parametric) uses ranks rather than absolute values
- $\rho$ tends to yield smaller coefficients compared to parametric counterparts [Mitchell and Lapata, 2008]
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Semantic Relations

- In addition to lexical information we often want information on the relationships between two lexical items.
- Semantic relations e.g. synonymy.
- Syntactic relations e.g. subcategorization *eat*, *direct object*.
- Semantics and syntax e.g. selectional preferences.
Semantic Relations

- gem jewel
Semantic Relations

- gem jewel synonyms
Semantic Relations

- gem jewel **synonyms**
- dog animal
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
Semantic Relations

- gem jewel *synonyms*
- dog animal *hyponym*
- animal cat
Semantic Relations

- gem jewel *synonyms*
- dog animal *hyponym*
- animal cat *hypernym* (or *hyperonym* [Sampson, 2000])
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
- animal cat **hypernym** (or **hyperonym** [Sampson, 2000])
- car bus
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
- animal cat **hypernym** (or **hyperonym** [Sampson, 2000])
- car bus **co-hyponyms**
Semantic Relations

- gem jewel synthesis
- dog animal hyponym
- animal cat hypernym (or hyperonym [Sampson, 2000])
- car bus co-hyponyms
- hand body
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
- animal cat **hypernym** (or **hyperonym** [Sampson, 2000])
- car bus **co-hyponyms**
- hand body **meronym**
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
- animal cat **hyponym** (or **hypernym** [Sampson, 2000])
- car bus **co-hyponyms**
- hand body **meronym**
- tree bark
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
- animal cat **hyponym** (or **hyperonym** [Sampson, 2000])
- car bus **co-hyponyms**
- hand body **meronym**
- tree bark **holonym**
Semantic Relations

- gem jewel \textit{synonyms}
- dog animal \textit{hyponym}
- animal cat \textit{hypernym} (or \textit{hyperonym} [Sampson, 2000])
- car bus \textit{co-hyponyms}
- hand body \textit{meronym}
- tree bark \textit{holonym}
- stroll, walk
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
- animal cat **hypernym** (or **hyperonym** [Sampson, 2000])
- car bus **co-hyponyms**
- hand body **meronym**
- tree bark **holonym**
- stroll, walk **troponym**
Semantic Relations

- gem jewel *synonyms*
- dog animal *hyponym*
- animal cat *hypernym* (or *hyperonym* [Sampson, 2000])
- car bus *co-hyponyms*
- hand body *meronym*
- tree bark *holonym*
- stroll, walk *troponym*
- cough, make a noise
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
- animal cat **hypernym** (or **hyperonym** [Sampson, 2000])
- car bus **co-hyponyms**
- hand body **meronym**
- tree bark **holonym**
- stroll, walk **troponym**
- cough, make a noise **entailment**
Semantic Relations

- gem jewel synonyms
- dog animal hyponym
- animal cat hypernym (or hyperonym [Sampson, 2000])
- car bus co-hyponyms
- hand body meronym
- tree bark holonym
- stroll, walk troponym
- cough, make a noise entailment
- hot cold
Semantic Relations

- gem jewel **synonyms**
- dog animal **hyponym**
- animal cat **hypernym** (or **hyperonym** [Sampson, 2000])
- car bus **co-hyponyms**
- hand body **meronym**
- tree bark **holonym**
- stroll, walk **troponym**
- cough, make a noise **entailment**
- hot cold **antonym**
WordNet Provides Semantic Relationships

- **entity**
  - **object**
    - **lighter, light, igniter**
      - #1 match, lucifer
        - thin wood tipped with combustible
      - #3 match
        - burning piece of wood
  - **social group**
    - **family**
      - #8 match mates couple
        - pair living together
  - **cognition knowledge**
    - **counterpart**
      - #9 match
        - something that resembles something
WordNet Provides Semantic Relationships

- light <-> heavy
- is-a (hyponym)
- opposites (antonym)
- part of (meronym)
- car
- artifact
- headlight
- wheel

WordNet provides semantic relationships such as:
- Antonym: is-a (opposite)
- Hyponym: part of
- Meronym: wheel, car, headlight
- Semantic relations: light <-> heavy
Acquiring Semantic Relations

hypernyms [Hearst, 1992] output of a parser and then bootstrap patterns

e.g. such NP as \{NP ,} {(or | and)} NP

... works by such authors as Herrick, Goldsmith, and Shakespeare

⇒ hypo(author, Herrick), hypo(author, Goldsmith), hypo(author, Shakespeare), NP \{, NP\} * \{,,\} or other NP

Bruises, wounds, broken bones or other injuries ...

⇒ hypo(bruise, injury), hypo(wound, injury), hypo(broken bone, injury)

extended [Snow et al., 2004, Snow et al., 2006]
Synonyms and Antonyms

- distributional similarity [Padó and Lapata, 2007, McCarthy et al., 2010]
- interference from different relations [Weeds et al., 2004, Geffet and Dagan, 2004]
- ruling out antonyms [Lin et al., 2003]
  patterns from X to Y, either X or Y, ⇒
- antonym discovery (uses a thesaurus) [Mohammad et al., 2008]
WordNet Similarity

- Leacock and Chodorow [Leacock and Chodorow, 1998] path based, scaled by depth of hierarchy
- Lesk [Lesk, 1986]: gloss overlap, uses semantic relations
  \[
  \text{lesk}(s_1, s_2) = \left| \{ w_1 \in \text{definition}(s_1) \} \right| \cap \left| \{ w_2 \in \text{definition}(s_2) \} \right| \tag{1}
  \]
- Information Content e.g. jcn [Jiang and Conrath, 1997]: uses frequency counts from corpus
  \[
  IC(s) = -\log(p(s)) \tag{2}
  \]
  Probability of a concept \((s)\), high information content for very specific terms
  Jiang and Conrath specify a distance measure:
  \[
  D_{jcn}(s_1, s_2) = IC(s_1) + IC(s_2) - 2 \times IC(s_3) \tag{3}
  \]
It was an important moment for Jake, all his friends and family were watching him. There was only a minute of the game left and neither team had scored yet. The crowd watched in silence as Jake took the penalty shot.
It was an important moment for Jake, all his friends and family were watching him. There was only a minute of the game left and neither team had scored yet. The crowd watched in silence as Jake took the penalty shot.

textual cohesion (linguistics) [Halliday and Hasan, 1976]
structure of texts [Morris and Hirst, 1991]
Associating Lexical Inventories with Corpus Data

- Selectional Preferences [Resnik, 1993]
  - argument head data e.g. direct objects of *eat*
  - propagate frequencies in noun hierarchy

- feature vectors at senses [Pantel, 2005]
  - propagate features shared by hyponyms
  - second phase (disambiguate) remove features at leaf that are in other senses parents
Domain and Topic Information

- topic signatures [Agirre et al., 2001] attributed to senses, retrieved from documents, pertinent to this sense but not others of the same word

<table>
<thead>
<tr>
<th>topic signature</th>
<th>topic</th>
<th>topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>star/celebrity</td>
<td>gossip</td>
<td>marriage divorce</td>
</tr>
<tr>
<td></td>
<td>screen</td>
<td>actor football</td>
</tr>
<tr>
<td>star/celestial</td>
<td>planet</td>
<td>galaxy</td>
</tr>
<tr>
<td></td>
<td>space</td>
<td>telescope</td>
</tr>
<tr>
<td></td>
<td>science</td>
<td>journal</td>
</tr>
</tbody>
</table>

- domain
  - models [Magnini and Cavaglià, 2000, Magnini et al., 2002] attributed to senses

- sentiment (pragmatics, but most people focusing on semantic prosodies of words) [Wiebe and Mihalcea, 2006]
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Multiword Expression NLP Publications

- A Pain in the Neck for NLP  [Sag et al., 2002]
- workshops:
  - Collocations (Vienna) 2002
  - Collocations and Idioms (Berlin) 2003, 2006,
  - Multiwords (LREC) 2008
  - Multiwords Coling 2010
  - Multiwords ACL 2011
- Multiword Special Issues:
  - Having a crack at a hard nut [Villavicencio et al., 2005]
  - Hard going or plain sailing? [Rayson et al., 2005]
Terminology: Multiwords, Idioms and Collocations
A *multiword expression* is a combination of two or more words whose semantic, syntactic etc... properties cannot fully be predicted from those of its components, and which therefore has to be listed in a lexicon.

[Boleda and Evert, ESLLI 2009]
Motivation for finding MWEs

1. NLP
   - semantic interpretation
     e.g. *throw me a bone*
   - associated syntactic behaviour
     e.g. *blow up the houses of parliament*
   - lexical acquisition e.g. *eat my hat*
   - associated behaviour important for generation

2. lexicography

3. corpus linguistics
Approaches for Detecting MWEs

- statistical: e.g. pointwise mutual information
  \[ PMI = \log \frac{p(chew, fat)}{p(chew)p(fat)} \]
- translations in parallel text:
  \[ chew the fat \leftrightarrow conversar \]
- dictionaries:
  listings, semantic codes and relationships
- lexical variation: couch potato
  sofa potato, couch onion
- syntactic variation:
  take heart
- distributional similarity: hot and dog vs hot dog
1. **Computational Lexical Semantics**
   - Word Meaning Representation
   - Distributional Similarity
   - Word Sense Disambiguation
   - Semantic Relations
   - Multiword Expressions
   - Predicate Argument Structure: the syntax-semantics interface

2. **My Background and Research Interests**
   - Academic Interests
   - Commercial Interests / Demos
     - Sketch Engine, and related tools
     - Dante
     - Other Related Projects
Subcategorisation

She loaded the bag with chicken
NP V NP PP
Subcategorisation

She  loaded  the bag  with chicken
NP   V       NP       PP_with
Subcategorisation

\[\text{She \ loaded \ the \ bag \ with \ chicken}\]
\[\text{NP \ V \ NP \ PP\_with}\]

\[\text{He \ loaded \ chicken \ into \ the \ bag}\]
\[\text{NP \ V \ NP \ PP\_into}\]
Selectional Preferences

She **loaded** the **bag** with **chicken**

NP  **V**  NP  **PP**
Selectional Preferences

*She* loaded *the bag* with *chicken*

NP  V  NP  PP

*load*  with *?*
Selectional Preferences

She \textit{loaded} \textit{the bag} \textit{with chicken}

\begin{align*}
\text{NP} & \quad \text{V} & \quad \text{NP} \\
\text{load} & \quad \text{with} & \quad ? \\
\text{load} & \quad \text{NP} & \quad \text{with} & \quad ?
\end{align*}
Selectional Preferences

She \textit{loaded} the bag \textit{with chicken}.

- \texttt{load} \texttt{NP} \texttt{with} ?
- \texttt{load} \texttt{NP} \texttt{with} ?

explosive ammunition scrap fish supplies brick fat food water \ldots
Semantic Role Labelling

She loaded the bag with chicken

```
She  loaded  the bag  with chicken
NP    V      NP         PP
```
Semantic Role Labelling

*She* loaded *the bag* with *chicken*

<table>
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FrameNet style labels [Ruppenhofer et al., 2010]
agent  predicate  object / goal  theme

Propbank style labels [Palmer et al., 2005]
Arg0   predicate   Arg2   Arg1

SRL identify the arguments of a given verb and assign them semantic labels describing the roles they fulfil
Diathesis Alternations

She loaded the bag with chicken
She loaded chicken into the bag
Lexical Information: Verb Class

Pour Verbs: *dribble, drop, pour, slop, slosh, spew, spill, spurt*

Causative Alternation:
*I pour water into the pot*  \(\leftrightarrow\)  *Water poured into the pot*

*Locative Alternation:
*I pour water into the pot*  \(\leftrightarrow\)  *I poured the pot with water*

*Conative Alternation:
*I pour water into the pot*  \(\leftrightarrow\)  *I poured at water into the pot*
Outline

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My background: academia

- syntax-semantics interface
  - subcategorization frames
  - selectional preferences
  - diathesis alternations
- word sense disambiguation
  - selectional preferences
  - prior sense distributions
  - evaluation
- distributional similarity
- multiwords and compositionality
- lexical substitution
- lexical semantics for reading comprehension
My background: recent commercial

- Using Computational Linguistics for Corpus Linguistics
- Corpora for computational linguistics
- Corpus linguistics e.g. CLAEVIPS
- Corpus linguistics for lexicography e.g. Dante
- Learner English
Sketch Engine Demos: Preliminaries

- corpus (plural: corpora):
- concordancer (output: concordance):
- collocation:
- word sketch:
- distributional thesaurus:
- Web Boot Cat:
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- **Web Boot Cat**: 


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- **distributional thesaurus:** an automatically produced ‘thesaurus’ which finds words that tend to occur in similar contexts as the target word.
- **Web Boot Cat:** a web-based tool for building corpora instantly from publicly accessible documents on the web.
Purposes

- teaching language (schools, second language learners)
- linguistics research and teaching
- lexicography
- computational linguistics
- translation
CLAEVIPS: A Corpus Linguistics Analysis of Ecosystems Vocabulary in the Public Sphere

- commissioned by the UK National Ecosystem Assessment (NEA)
- 100 words and phrases concerning the ecosystem
- 4 corpora:
  - UKWaC [Ferraresi et al., 2008]
  - 3 specialised corpora
CLAEVIPS: Corpora

- ukWaC [Ferraresi et al., 2008] 1.5 billion word corpus from internet domains ending ‘.uk’
- three specialised corpora harvest from the web. Web pages contain at least:
  - three types from a set of seed words, and
  - at least three occurrences of a subset of whitelist words
- the three corpora (each approx 1.5 million words)
  1. academic (ac.uk)
  2. government (.gov.uk)
  3. public (news, NGO, blogs)
CLAEVIPS: Methodology

- examine salient collocates using ‘word sketch’ (words), and contrasted in the 3 specialised corpora
- examine 100 random citations from UKWaC:
  - subjective/objective
  - positive / negative / neutral
  - other ...
- (phrases) find collocates in above citations and contrast to 50 random from specialised corpora
- some words selected for additional examination using thesaurus and sketch diff
CLAEVIPS: (some) Findings [Wild et al., 2011]

- words not widely understood e.g. biotype, natural capital
- differences in specialised corpora e.g. public interest in rainforest and global warming
- promotional use of nature in advertising ‘eco’
- nature as a commodity (esp government corpus)
- in ukWaC and public corpus: evidence of scepticism regarding empty use of words sustainable and claims on climate change
- relationship between humans and nature
- fear of open spaces
- avoid reference to agency with words such as pollute, see also [Schleppegrell, 1997]
Dante: Database of Analysed Texts of English [Atkins et al., 2010]

- commissioned by Foras na Gaeilge for production of New English Irish Dictionary
- lexical resource as monolingual analysis of English
- corpus based. Lexicographers produced using Word Sketches from a corpus of 1.7 billion words (UKWaC, American newspaper, Irish English data)
- concordance sorted according to the ‘GDEX’ program
- containing entries for:
  - 42,000 headwords (6,300+ verbs)
  - 27,000 idioms and phrases
  - 20,500 compounds
  - just under 3,000 phrasal verbs
Dante: Contents

- meanings with definitions
- over 622,000 examples from the corpus,
- argument structure (valency) e.g. NP-Vinf *let him go* (42 frames for verbs, further specified by preposition)
- attitude e.g. *meddle* (pejorative)
- regional e.g. *nick* (British) as in *you’re nicked*
- style e.g. *oxidise* (technical) *perambulate* (humorous)
- register e.g. *ameliorate* (formal) *go ape* (informal)
- subject e.g. *multiply* (maths)
- time e.g. *punch* (cattle: dated) or *quoth* (obsolete)
- inherent grammar e.g. reciprocal
  
  *John marries Mary* ↔ *Mary and John marry*

- support verbs e.g. *make an appeal*

see webdante.com
blend: (PoS: v)
meaning: combine
SCF: NP

corpus pattern: with plural noun as object
example: I have very little idea of how to blend colour.
corpus pattern: blend sth and sth
example: High Points: The attempt to blend melodrama comedy and horror is a worthy if failed effort.
SCF: NP_PP_X with
example: Kazakhstan was interested in blending palm oil with its own cotton seed and sunflower seed oils for industrial application, officials said.

SCF: NP_PP_X into
texample: I blend different colours into the background of my paintings to evoke sections of light.
The winner is **definitely**
(Click on columns to see concordance)

<table>
<thead>
<tr>
<th>definitely</th>
<th>definately</th>
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LoogleFight takes two terms as input and finds their frequencies in the ACL Reference Corpus. We hope it is a useful tool for non-native speakers of English (and possibly also native speakers) writing NLP research papers. It accesses the ACL Anthology compiled in the Sketch Engine, to which free access is provided here. You can input words, phrases or CQL expressions.
ForBetterEnglish.com
The GDEX Demo Dictionary

This is an experimental automatic collocations dictionary, based on the Sketch Engine technology. Metzler, Kilgarriff et al 2008: GDEX: Automatically finding good dictionary examples in a corpus. Proc EURALEX.

Enter a word (in English) here to see its collocations, each with an example sentences from the corpus.

| involve (v) | object | everyone : Few words can describe how delighted and proud everyone involved in the event. |
| risk : Scuba Diving is a sport that involves some risk to life.
| people : For many people involved in politics the defining characteristic of the driver is state intervention in reducing inequality.
| staff : Involve primary care staff in the delivery of the programme or ensure that you send the same messages.
| anyone : Useful for anyone involved, or planning to be involved, in humanitarian assistance.
| party : For example, ACAS mediation may involve the third party neutral issuing a report.
| pp_at stage : All Welsh media channels (TV, radio and press) would need to be involved.
| ing_comp widen : Aim higher ‘s remit involves widening participation in higher education.
| inject : Awful experiments, involving injecting BSE material into the brains of living creatures.
| This field sales role will involve selling both online and directory advertising.


“TEDDCLoG”

Taiwan English Data-Driven Cloze Generator

Lemma: involve
POS: verb
Corpus: BNC, ukWaC
Statistic used: Salience
Search priority: Collocate
No. of Items: 2
No. of KOCs: 3
No. of Distractors: 4
Answers: Blank, Underline

Submit

* For further details link
KOC 1': 'actively'

1) The modern father generally wants to be more actively _____ at home.

2) Young children learn most effectively when they are actively _____ in first hand experiences.

4 suggested distractors for KOC 'actively' :

(a) suggest (b) enable (c) allow (d) regard

KOC 2': 'heavily'

1) Are you heavily _____ in the visual side as well?

2) Those same mood swings and the need to become heavily _____ in crime also severely damage family and other relationships.

4 suggested distractors for KOC 'heavily' :

(a) mean (b) require (c) suggest (d) need

KOC 3': 'directly'

1) There are only a few disputes every year that directly _____ band parades.
The week ahead

- **Tuesday**: Word Sense disambiguation
- **Wednesday**: Lexical substitution, monolingual and crosslingual, motivations results and analyses
- **Thursday**: Alternative graded judgments of word meaning in context
- **Friday**: Predicate Argument Structure (very brief overview biased to my work) + discussion and project ideas for the future
http://ixa.si.ehu.es/Ixa/Argitalpenak/Artikuluak/1018540147/publiko


Visual information in semantic representation.

Introducing and evaluating ukwac, a very large web-derived corpus of english.
In *Proceedings of the Sixth International Conference on Language Resources and Evaluation (LREC 2008)*, Marrakech, Morocco.
Department of Linguistics, Brown University, Rhode Island. Revised and amplified ed.

Paradigm merger in natural language processing.

Feature vector quality and distributional similarity.

Cohesion In English.
Longman.

Automatic acquisition of hyponyms from large text corpora.

Ontonotes: The 90% solution.
In Proceedings of the HLT-NAACL 2006 workshop on Learning word meaning from non-linguistic data, New York City, USA. Association for Computational Linguistics.

Semantic similarity based on corpus statistics and lexical taxonomy.
In *International Conference on Research in Computational Linguistics*, Taiwan.


**Mitchell, J. and Lapata, M. (2008).**
Vector-based models of semantic composition.
In *Proceedings of ACL-08: HLT*, pages 236–244, Columbus, Ohio. Association for Computational Linguistics.

**Mohammad, S., Dorr, B., and Hirst, G. (2008).**
Computing word-pair antonymy.

**Morris, J. and Hirst, G. (1991).**
Lexical cohesion, the thesaurus, and the structure of text.

**Padó, S. and Lapata, M. (2007).**


Linguistics and education.

Automatic word sense discrimination.

Snow, R., Jurafsky, D., and Ng, A. Y. (2004).
Learning syntactic patterns for automatic hypernym discovery.

Snow, R., Jurafsky, D., and Ng, A. Y. (2006).
Semantic taxonomy induction from heterogenous evidence.


