Computational Modelling of Metaphor

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I think that metaphor really is a key to explaining thought and language. [...] Our powers of analogy allow us to apply ancient neural structures to newfound subject matter, to discover hidden laws and systems in nature, and not least, to amplify the expressive power of language itself. (Pinker, 2007)

- Metaphor structures our conceptual system
- It helps us derive and comprehend new information
- It is frequent in language
What is metaphor?

“A political *machine*”
What is metaphor?

“A political machine”

“The wheels of Stalin’s regime were well oiled and already turning”

“Time to mend our foreign policy”

“20 Steps towards a Modern, Working Democracy”
How does it work?

Conceptual Metaphor Theory
(Lakoff and Johnson, 1980)

Metaphorical associations between concepts

**POLITICAL SYSTEM** is a **MECHANISM**

Cross-domain knowledge projection and inference

Reasoning about the target domain in terms of the properties of the source
A few more examples

ARGUMENT is a WAR
He shot down all of my arguments.
He attacked every point in my argument.
He lost that verbal battle.
You disagree? Okay, shoot!

CRIME is a DISEASE / VIRUS
Cure juvenile delinquency in the slums!
The best way to diagnose corruption is ...
Intergenerational transmission of abuse.
Find a cure for crime.
Metaphor influences our decision-making

Thibodeau and Boroditsky (2011)

- investigated how metaphor influences decision-making
- subjects read a text containing metaphors of either
  1. CRIME IS A VIRUS
  2. CRIME IS A BEAST
- then they were asked a set of questions on how to tackle crime in the city
  1. preventive measures
  2. punishment, restraint
Real-world text processing applications

- Information Retrieval
- Machine Translation
- Sentiment Analysis
- Question Answering
- Information Extraction
- Text Mining

Metaphor occurs on average in every third sentence! (according to corpus studies)
Levels of metaphor analysis

**Linguistic:** The *coupling of the carriages* may not be reliably secure, but the pan-European *express is in motion.*

**Conceptual:** EUROPEAN INTEGRATION as a TRAIN JOURNEY

**Extended metaphor:** "There is a fear that the European train will thunder forward, laden with its customary cargo of gravy, towards a destination neither wished for nor understood by electorates. But the train can be stopped." (Margaret Thatcher, *Sunday Times*, 20 Sept 1992)

**Metaphorical inferences:** e.g. expensive tracks have to be laid for the train to move forward
Metaphor and polysemy

Metaphor plays a role in language evolution:

Metaphors begin their lives as novel poetic creations with marked rhetorical effects, whose comprehension requires a special imaginative leap. As time goes by, they become a part of general usage, their comprehension becomes more automatic, and their rhetorical effect is dulled. (J. Nunberg)

Metaphorical expressions differ in their level of conventionality:

Gibbs (1984) suggests that literal and figurative meanings are situated at the ends of a single continuum, along which metaphoricity and idiomaticity are spread.

Conventional and not so conventional metaphors

New regulations are *strangling* business.
How can I *enter* emacs?
These conditions were *imposed* by the government.
Metaphor processing tasks

1. Learn metaphorical associations from corpora

   “POLITICAL SYSTEM is a MECHANISM”

2. Identify metaphorical language in text

   “mend the policy”

3. Interpret the metaphorical language

   “mend the policy” means “improve the policy; address the downsides of the policy”
History of metaphor modelling

- Knowledge-based approaches
  - Martin (1990) (MIDAS)
  - Fass (1991) (met*)
  - Narayanan (1999) (KARMA)
  - Barnden and Lee (2002) (ATT-meta)

- Approaches using lexical resources (and some statistics)
  - Mason (2004) (Cormet)
  - Krishnakumaran and Zhu (2007)
  - Veale and Hao (2008) (Slipnet)
  - Shutova (2010) (paraphrasing)
  - Wilks et al. (2013)
  - Gandy et al. (2013)

- Statistical approaches
  - Gedigian et al. (2006)
  - Shutova, Sun and Korhonen (2010)
  - Turney et al. (2011)
  - Hovy et al. (2013)
  - Heintz et al. (2013) and others
Influential theories

- Solutions based on selectional preference violation view (Wilks, 1978)
  - Fass (1991) (met*)
  - Krishnakumaran and Zhu (2007)
  - Wilks et al. (2013)

- Solutions stemming from the conceptual metaphor theory (Lakoff and Johnson, 1980)
  - Mason (2004) (Cormet)
  - Shutova, Sun and Korhonen (2010)
  - Heintz et al. (2013)
  - Shutova and Sun (2013)
  - Li et al. (2013)

- Solutions based on abstract-concrete distinction
  - Turney et al (2011)
  - Neuman et al (2013)
  - Gandy et al (2013)
Investigated system features

- Selectional preferences
  - Fass (1991); Mason (2004); Krishnakumaran and Zhu (2007); Wilks et al. (2013)

- Concreteness

- Supervised classification
  - Gedigian et al. (2006); Mohler et al. (2013); Tsvetkov et al. (2013); Hovy et al. (2013)

- Clustering
  - Shutova et al. (2010); Shutova and Sun (2013)

- Topical structure of text
  - Strzalkowski et al. (2013); Heintz et al. (2013)
Selectional preference [violation]
Selectional preference violation

Example

"My car *drinks* gasoline"
(car, drink, gasoline) \(!=\) (animal, drink, liquid)

Fass (1991): met* system

- utilizes hand-coded knowledge
- detects non-literalness via selectional preference violation
- tests the phrases for being metonymic using hand-coded patterns (e.g. CONTAINER-FOR-CONTENT)
The approach of Krishnakumaran and Zhu (2007)

- Use hyponymy relation in WordNet
- and bigram counts
- to predict metaphors at the sentence level

**IS-A metaphor**
All the world is a *stage*.

**Verb metaphor**
He *planted* good ideas in their minds.

**Adjectival metaphor**
He has a *fertile* imagination.
Non-violation applications of SPs

Mason (2004) (CorMet)

- Detects metaphorical mappings
- using domain specific selectional preferences

**LAB domain**

When *pouring* a caustic or corrosive liquid into a beaker, use a stirring rod to avoid spills.

**FINANCE domain**

Several mining giants are reportedly wary on *pouring* in more investments in the Philippines.

**Identified mapping**

FINANCE – LAB: MONEY – LIQUID

Accuracy = 0.77
Non-violation applications of SPs

Shutova et al. (2010)

- filter verbs based on selectional preference strength
- verbs that do not exhibit strong preferences are less likely to be used metaphorically
- e.g. choose, remember

Shutova (2010)

- retrieve literal paraphrases of metaphorical expressions
- generate a set of candidates
- measure literalness as semantic fit of the context to the SPs of the candidate
Abstract-concrete distinction
Abstractness-based systems

Turney et al (2011)

- classify verbs and adjectives as literal or metaphorical
- based on their level of concreteness (or abstractness) in relation to the noun they appear with
- learn concreteness ratings for words automatically (starting from a set of examples)
- search for expressions where a concrete adjective or verb is used with an abstract noun

Example

"dark humour" vs. "dark hair"

F-score = 0.68
Followed by Neuman et al. (2013) and Gandy et al. (2013)
Abstractness-based systems (continued)

Neuman et al. (2013)

- proposed an extension of the method of Turney et al. (2011)
- incorporated the concept of selectional preferences into the concreteness-based model
- with the aim of covering metaphors formed of concrete concepts only (e.g. "broken heart")
- by detecting selectional preference violations
- Precision = 0.72; Recall = 0.80
Supervised learning approaches
Supervised learning from metaphor-annotated data

Gedigian et al. (2006)

- trained a maximum entropy classifier to discriminate between literal and metaphorical use
- extracted lexical items whose frames are related to MOTION and CURE frames in FrameNet
- searched PropBank Wall Street Journal Corpus for sentences containing such lexical items
- annotated the sentences for metaphoricity
- classifier accuracy = 0.95 (majority baseline accuracy = 0.92)

Examples

MET : Texas Air has run into difficulties.
LIT : I nearly broke my neck running upstairs to see ...
Tsvetkov et al. (2013)

- annotate metaphor at the sentence level, in English and Russian
- using coarse semantic features (concreteness, animateness, named entity labels, coarse-grained WordNet features, e.g. `noun.artifact`, `verb.motion`)
- trained a logistic regression classifier on English
- ported the trained model to Russian using a dictionary
- English F-score = 0.78; Russian F-score = 0.76
Supervised learning from metaphor-annotated data

Mohler et al. (2013)

- based on the concept of semantic signatures
- semantic signatures are sets of linked WordNet senses, acquired from WordNet itself, Wikipedia links, corpus co-occurrence statistics
- experimented within a limited domain (target: governance)
- manually constructed an index of known conceptual metaphors
- created semantic signatures for the target and source domains
- classified sentences according to how well their semantic signature matches those of known conceptual metaphors
- a set of classifiers: MaxEnt, decision tree, SVM, random forest
- best result: decision tree classifier, F-score = 0.70
Clustering-based methods
Example feature vectors (verb–object relations)

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NEED TO FIND A GOOD WAY TO PARTITION THE SPACE!
**Clustering-based methods**

- Use distributional properties of concepts to learn metaphorical associations from large amounts of linguistic data
- Use the identified metaphorical associations to detect metaphorical expressions
- **Semi-supervised system of Shutova et al (2010)**
  - Spectral clustering of verbs and nouns
  - Use seed metaphors to connect the clusters into a network
- **Unsupervised system of Shutova and Sun (2013)**
  - Hierarchical graph factorization clustering of nouns to build a graph of concepts
  - Identify metaphorical associations in that graph
The approach of Shutova et al. (2010)

Spectral clustering of verbs and nouns

ABSTRACT

marriage affair
democracy
coopération
relationship ...

VERBS

work mend repair
function oil
operate run break

CONCRETE

mechanism
computer bike
machine engine ...

Computational Modelling of Metaphor
Clusters

**ABSTRACT**

- marriage
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- democracy
- cooperation
- relationship

**CONCRETE**

- mechanism
- computer
- bike
- machine
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**Seed phrase expansion**

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<th>Expansion</th>
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<tr>
<td>stir excitement</td>
<td>swallow anger</td>
</tr>
<tr>
<td>reflect concern</td>
<td>disguise interest</td>
</tr>
<tr>
<td>throw remark</td>
<td>hurl comment</td>
</tr>
<tr>
<td>cast doubt</td>
<td>spark enthusiasm etc.</td>
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**Output sentences from the British National Corpus**

- K2W 1771 The committee heard today that gangs regularly hurled abusive comments at local people.
- CKM 391 Time and time again he would stare at the ground, hand on hip, [...] and then swallow his anger and play tennis.
- AD9 3205 He tried to disguise the anxiety he felt when he found the comms system down, [...]  
- ADK 634 Catch their interest and spark their enthusiasm so that they begin to see the product’s potential.

Precision 0.79
The approach of Shutova and Sun (2013)

- Hierarchical graph factorization clustering of nouns
- identifying metaphorical connections in the graph
- using clustering features to detect metaphorical expressions
System output: CMs identified in the graph

**SOURCE: fire**
TARGET: sense hatred emotion passion enthusiasm sentiment hope interest feeling resentment optimism hostility excitement anger
TARGET: coup violence fight resistance clash rebellion battle drive fighting riot revolt war confrontation volcano row revolution struggle

**SOURCE: disease**
TARGET: fraud outbreak offence connection leak count crime violation abuse conspiracy corruption terrorism suicide
TARGET: opponent critic rival

**FEELING IS FIRE LMs**
anger blazed (Subj), optimism raged (Subj), passion flared (Subj), interest lit (Subj), fuel resentment (Dobj), anger crackled (Subj), light with hope (Iobj)

**CRIME IS A DISEASE LMs**
cure crime (Dobj), abuse transmitted (Subj), eradicate terrorism (Dobj), suffer from corruption (Iobj), diagnose abuse (Dobj),

CM: Precision = 0.69; Recall = 0.61; Met Exp.: Precision = 0.65.
Different use of clustering

Gandy et al. (2013)

- first discover metaphorical expressions using the method of Turney et al. (2011)
- then assigns the corresponding metaphorical mappings
- using lexical resources and context clustering

Figure 1: Three levels of metaphor processing.

- Conceptual Metaphors
  - ORGANIZATION is a CONNECTION
  - government ~ door
    - club ~ door
  - institution ~ passageway
  - “open government”
  - “leave government”
  - “into government”

- Nominal Analogies

- Linguistic Metaphors
Gandy et al. (2013) (continued)

- Precision = 0.76; Recall = 0.82 for the identification of verb metaphors
- Precision = 0.65 for the annotation of metaphorical mappings.
Topical structure of text

![Diagram with the words "The Narrative" and "Just Say Yes" and a person holding a net catching fish.](image-url)
Approaches modelling topical structure

Strzalkowski et al. (2013)
- discover topic chains in the text
- by linking semantically-related vocabulary
- identify words outside the main topic chains as metaphors
- limited domain; Accuracy 0.71

Heintz et al. (2013)
- use LDA topic model
- learn topics from Wikipedia
- identify sentences that contain vocabulary from two different topics (source and target) as metaphorical
- limited domain; F-score 0.59
Achievements and challenges

- a lot of progress in modelling individual aspects of metaphor
- an ideal system needs to incorporate a model of various aspects
- and integrate the most successful system features

but ...

- there is still no unified task definition
- there is still no large dataset, suitable for system evaluation
- evaluation standards need to be defined
  - should we treat metaphor as a binary or graded phenomenon?
  - we need a measure that can appropriately incorporate the fuzziness or graded assignment
Why we should work on metaphor

1. Metaphor is a well structured phenomenon suitable for computational modeling
2. It reveals a lot about the way we think!
3. It is highly frequent in language and thus important for NLP
4. It has a number of real-world applications
5. Its mechanisms are used in a range of creative tasks and play an important part in innovation
6. Far from being a solved problem!
Questions?
Questions?

Even more questions?

katia@icsi.berkeley.edu
Pictures come from: I

- open.salon.com
- www.deslive.com
- pctechnotes.com
- Wikipedia
- Flickr
- shirahvollmermd.wordpress.com
Computational modelling of metaphor


Language Processing, EMNLP ’09, pages 315–323.


**Taxonomies and Metaphor**


Categorization, Prototype Theory and Metaphor


Conventional Metaphors


**Similes**


**Conceptual Blending Theory**


**Analogy and Structure-Mapping Theory**


**Lexical Analogy**


**Metaphor and Similarity**


**Ironic**


**Incongruity and Humour**


**N-Gram / Web / Corpus-derived models of linguistic norms**


**Web-Services and Metaphor**

