

ConnotationWordNet:

Learning Connotation over the Word+Sense Network

Jun S. Kang, Song Feng, Leman Akoglu, Yejin Choi



Stony Brook University

Part sculpture, part table, all artisanal. Craftspeople in Jaipur, India, hand carved the delicate rosettes on this low-lying solid mango wood table, which takes its original inspiration from a ceremonial stool used by Bamileke royalty in the African country of Cameroon.



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[Overview](#)

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Part *sculpture*, part table, all *artisanal*. Craftspeople in Jaipur, India, hand carved the delicate *rosettes* on this low-lying solid *mango wood* table, which takes its original inspiration from a *ceremonial* stool used by Bamileke *royalty* in the African country of Cameroon.



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1

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Overview

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Connotation

- Con + notation
 - “com-”: together or with
 - “notare”: to mark

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 - Commonly understood cultural or emotional association that some word carries, in addition to its explicit or literal meaning(denotation)

Connotation

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 - “com-”: together or with
 - “notare”: to mark
 - Commonly understood cultural or emotional association that some word carries, in addition to its explicit or literal meaning(denotation)
 - We consider them to be somewhere between *positive* and *negative*

WordNet

- WordNet (Miller, 1995)

WordNet Search - 3.1
- [WordNet home page](#) - [Glossary](#) - [Help](#)

Word to search for:

Display Options:

Key: "S:" = Show Synset (semantic) relations, "W:" = Show Word (lexical) relations
Display options for sense: (gloss) "an example sentence"

Noun

- **S: (n) intension, connotation** (what you must know in order to determine the reference of an expression)
- **S: (n) connotation** (an idea that is implied or suggested)

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List of senses

Noun

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Display **sense: a set of synonyms** tence"

Noun

- S: (n) **intension, connotation** (what you must know in order to determine the reference of an expression)
- S: (n) **connotation** (an idea that is implied or suggested)

Words & Senses

- “**science**”
 - Senses:
 - (n) science, scientific discipline
 - a particular branch of scientific knowledge
 - (n) skill, science
 - ability to produce solutions in some problem domain
 - Connotation: *positive*

Words & Senses

- “**abound**”
 - Senses:
 - (v) **abound**
 - be abundant or plentiful; exist in large quantities
 - (v) **abound, burst, bristle**
 - be in a state of movement or action
 - "*The room abounded with screaming children*"; "*The garden bristled with toddlers*"
 - Connotation
 - Different connotative polarities at sense-level

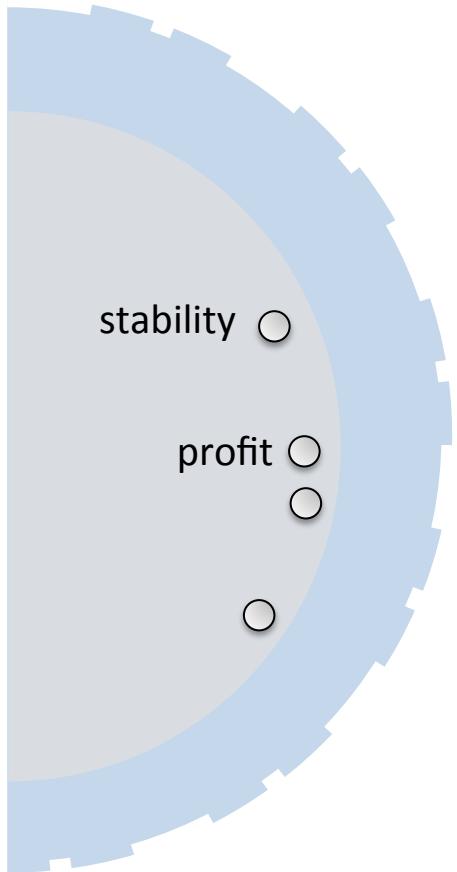
Finer Granularity: Sense-level

- Different connotative polarities at sense-level
- Sentiment Analysis
 - Subjectivity & Objectivity at sense-level (Pestian, 2012; Mihalcea, 2012; Balahur, 2014)
 - Found to be useful to further improve the sentiment analysis
- Word Sense Disambiguation
 - Sense-level resources
 - Sometimes too noisy to integrate
 - Word-level label aggregation over senses
 - Loss of granularity

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- Learn both word-/sense-level connotations
 - Exploiting *bipartite* structure of WordNet

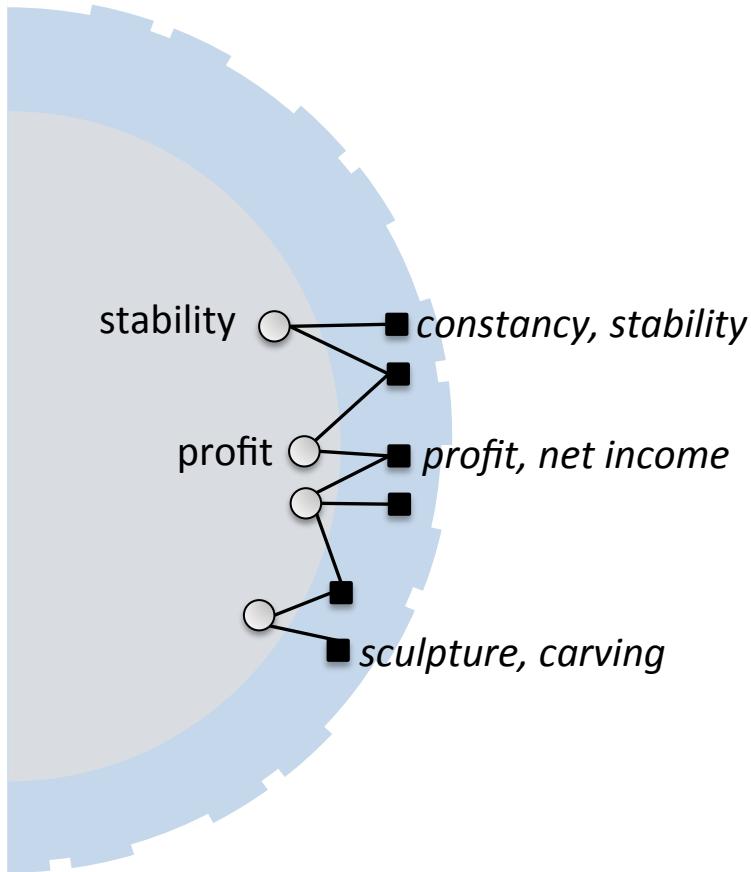
Related Work



Sentiment Lexicons

- Word-level
 - Wiebe et al., 2005; Qiu et al., 2009; Wilson et al., 2005; Kamps et al., 2004; Takamura et al., 2005; Andreevskaia and Bergler, 2006; Su and Markert 2009; Lu et al., 2011; Kaji and Kit-suregawa, 2007
 - ...

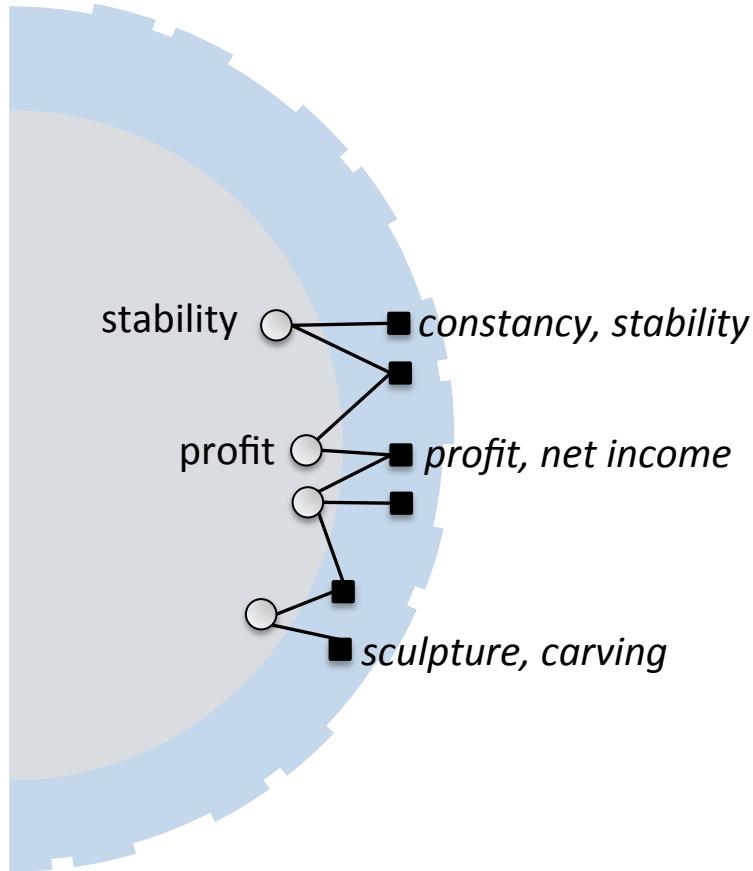
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- Sense-level
 - SentiWordNet (Baccianella et al., 2010)

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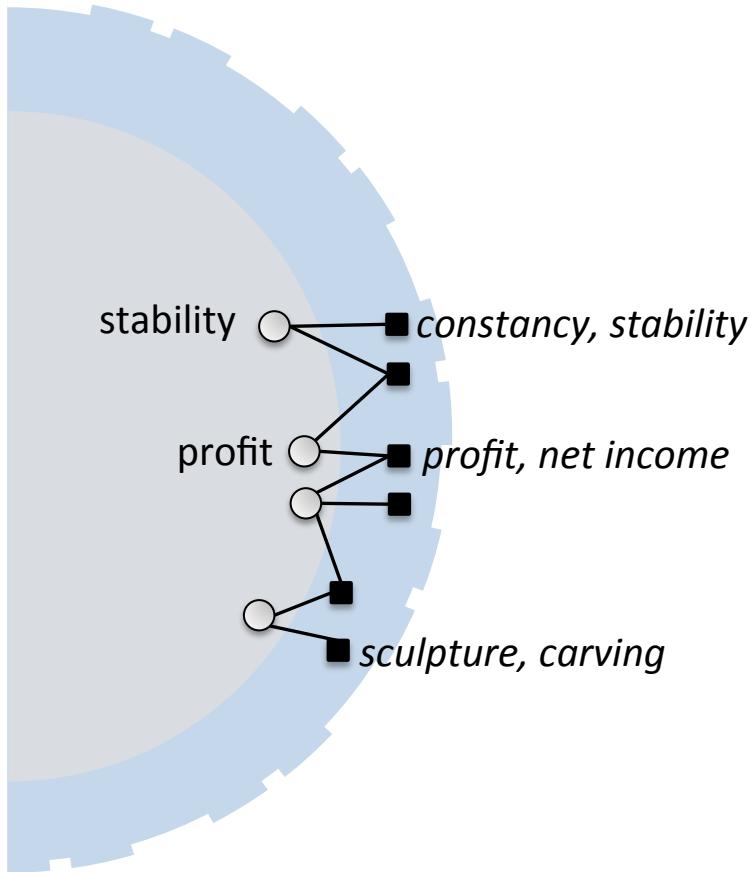
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- Word-level
 - Connotation Lexicon(Feng, 2011/2013)

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Connotation Lexicons

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 - This Work!

ConnotationWordNet

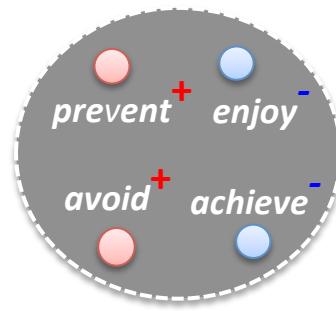
- Connotation?
- Words & Senses
- Finer Granularity: Sense-level
- Related Work
- Graph Construction
- Inference Algorithm
- Evaluations

Graph Construction

Nodes

Edges

seed(pred)

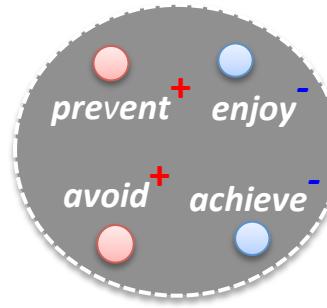


Graph Construction

Nodes

Edges

seed(pred)



- Connotative Predicates

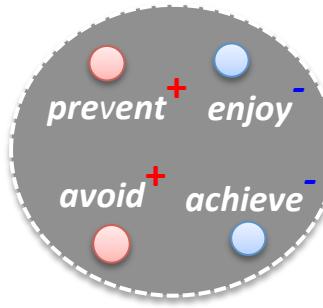
"A predicate that has selectional preference on the connotative polarity of some of its semantic arguments."
(Feng, 2011)

Graph Construction

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- Connotative Predicates

"A predicate that has selectional preference on the connotative polarity of some of its semantic arguments." (Feng, 2011)

- Selectional Preference

→ enjoy^{pred} swimming^{arg}

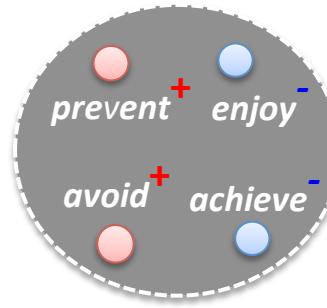
→ prevent^{pred} leakage^{arg}

Graph Construction

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- Connotative Predicates

"A predicate that has selectional preference on the connotative polarity of some of its semantic arguments."

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- Selectional Preference

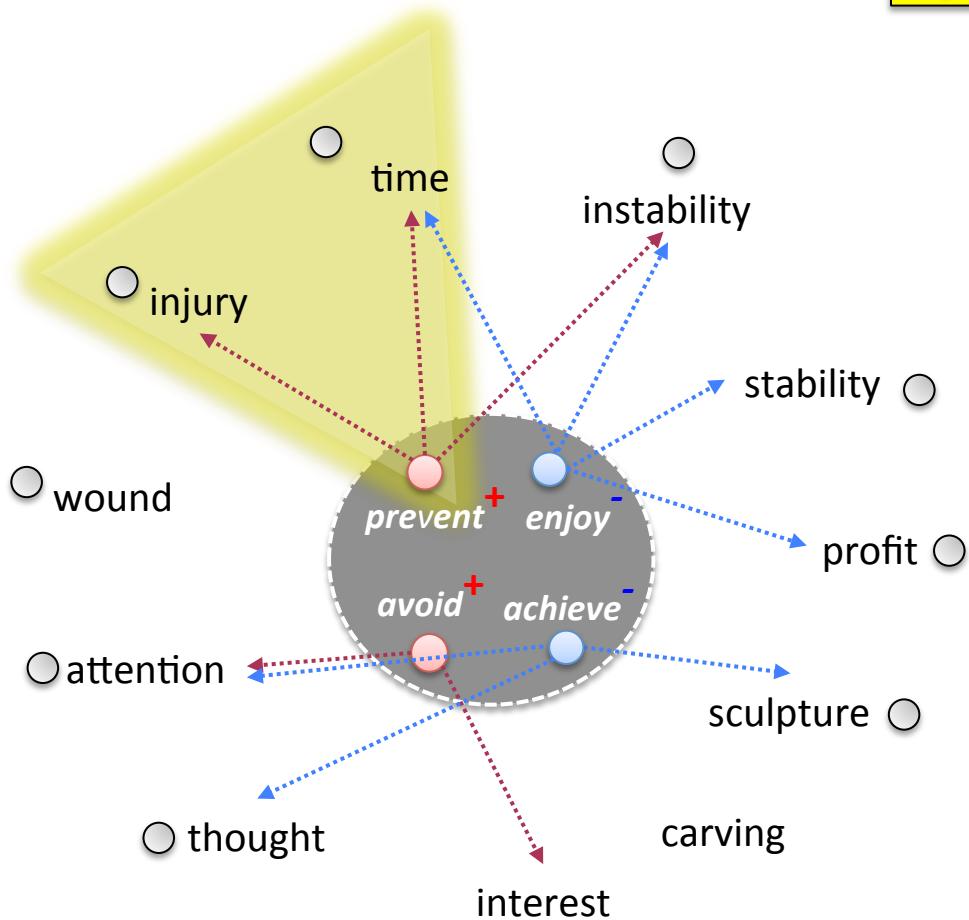
→ $\text{enjoy}^{\text{pred}}$ $\text{swimming}^{\text{arg}}$



→ $\text{prevent}^{\text{pred}}$ $\text{leakage}^{\text{arg}}$



Graph Construction



Nodes

- seed(pred)
- word

Edges

- seed - word

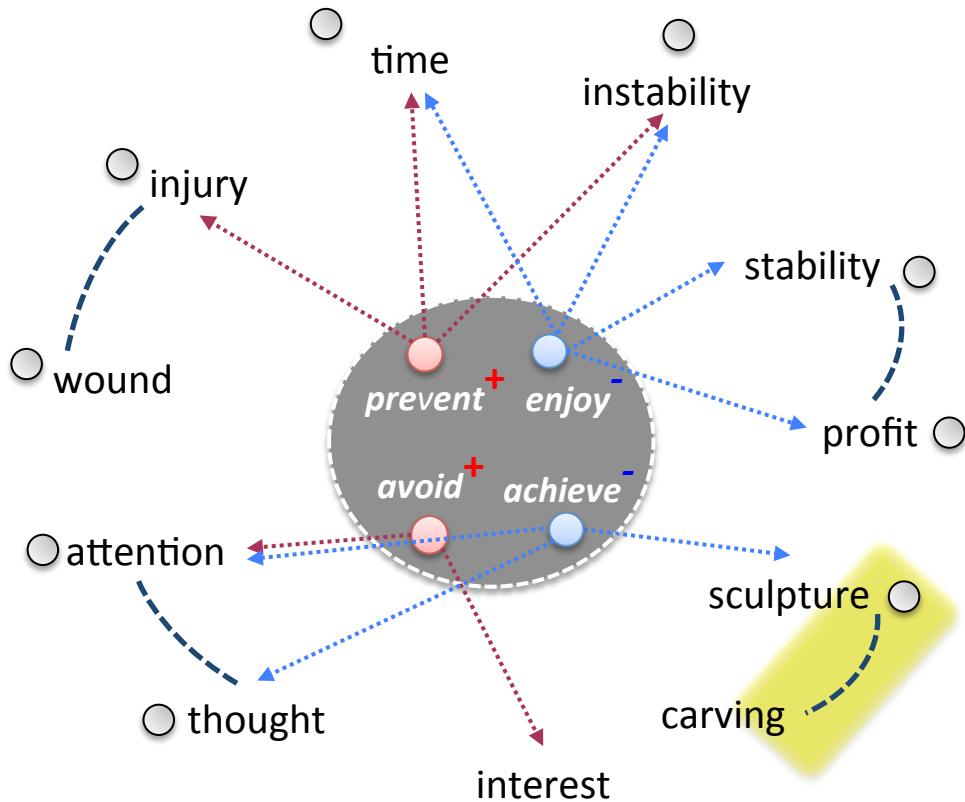
Graph Construction

Nodes

- seed(pred)
- word

Edges

- seed - word
- word - word
 - parallelism



Graph Construction

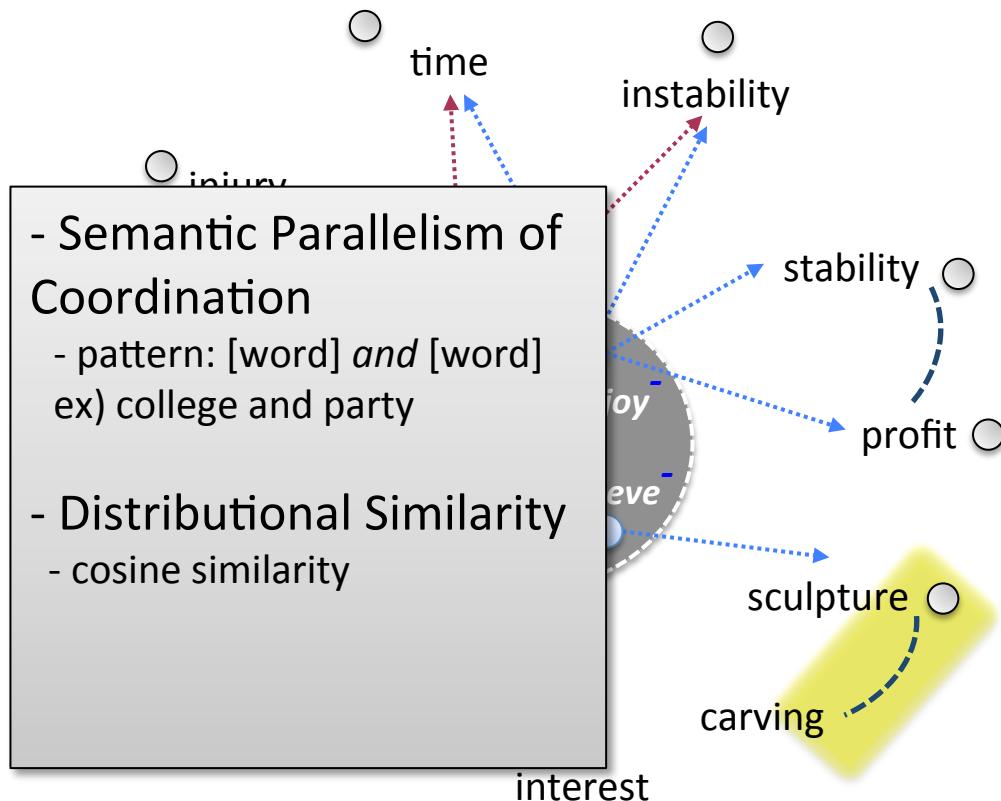
Nodes

- seed(pred)
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Edges

- seed - word
- word – word

parallelism



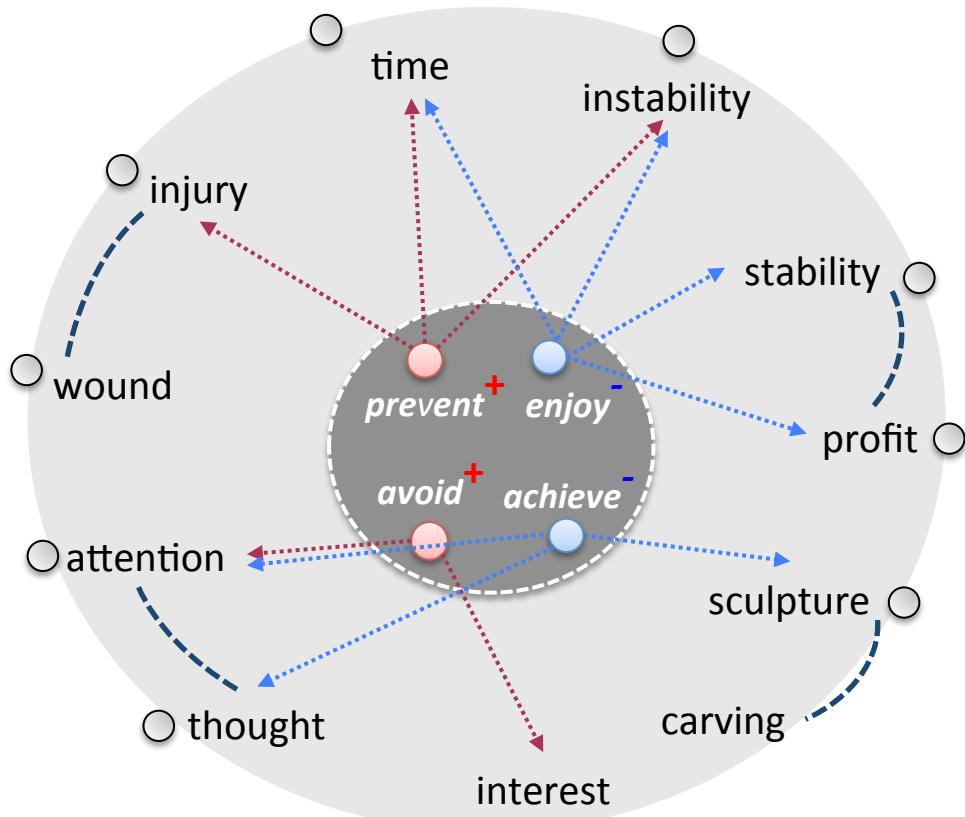
Graph Construction

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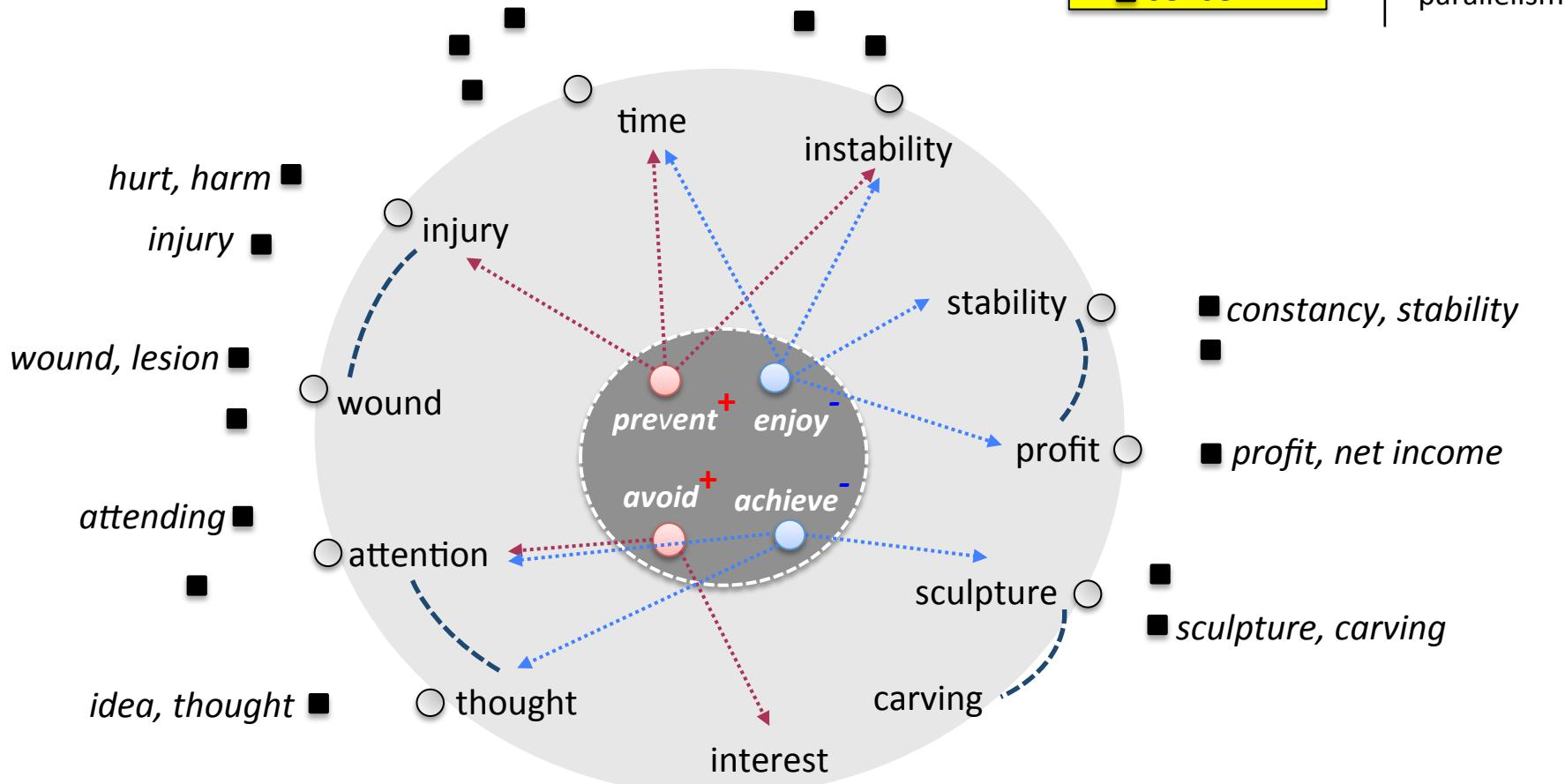
- seed(pred)
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Edges

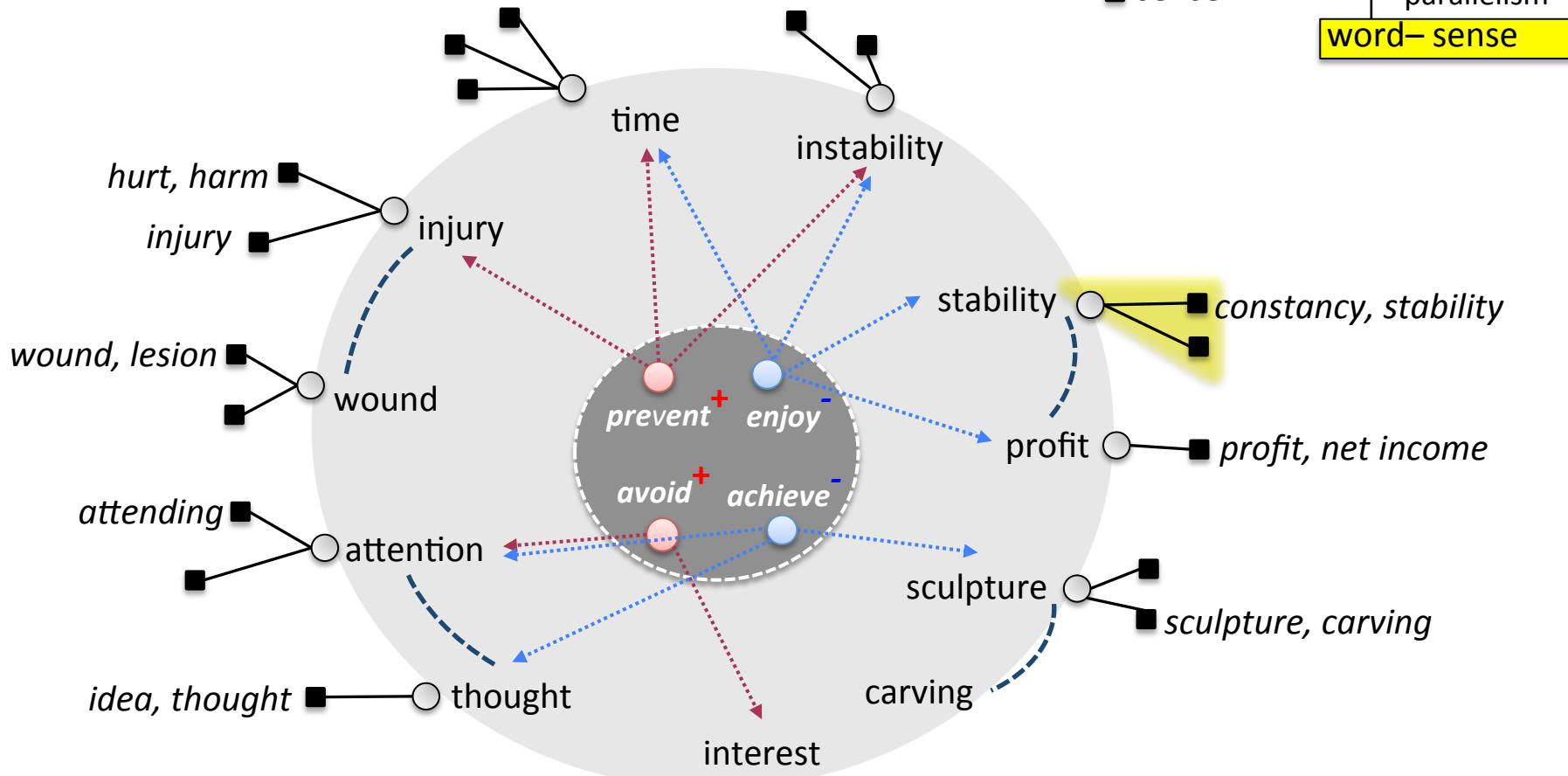
- seed - word
- word – word
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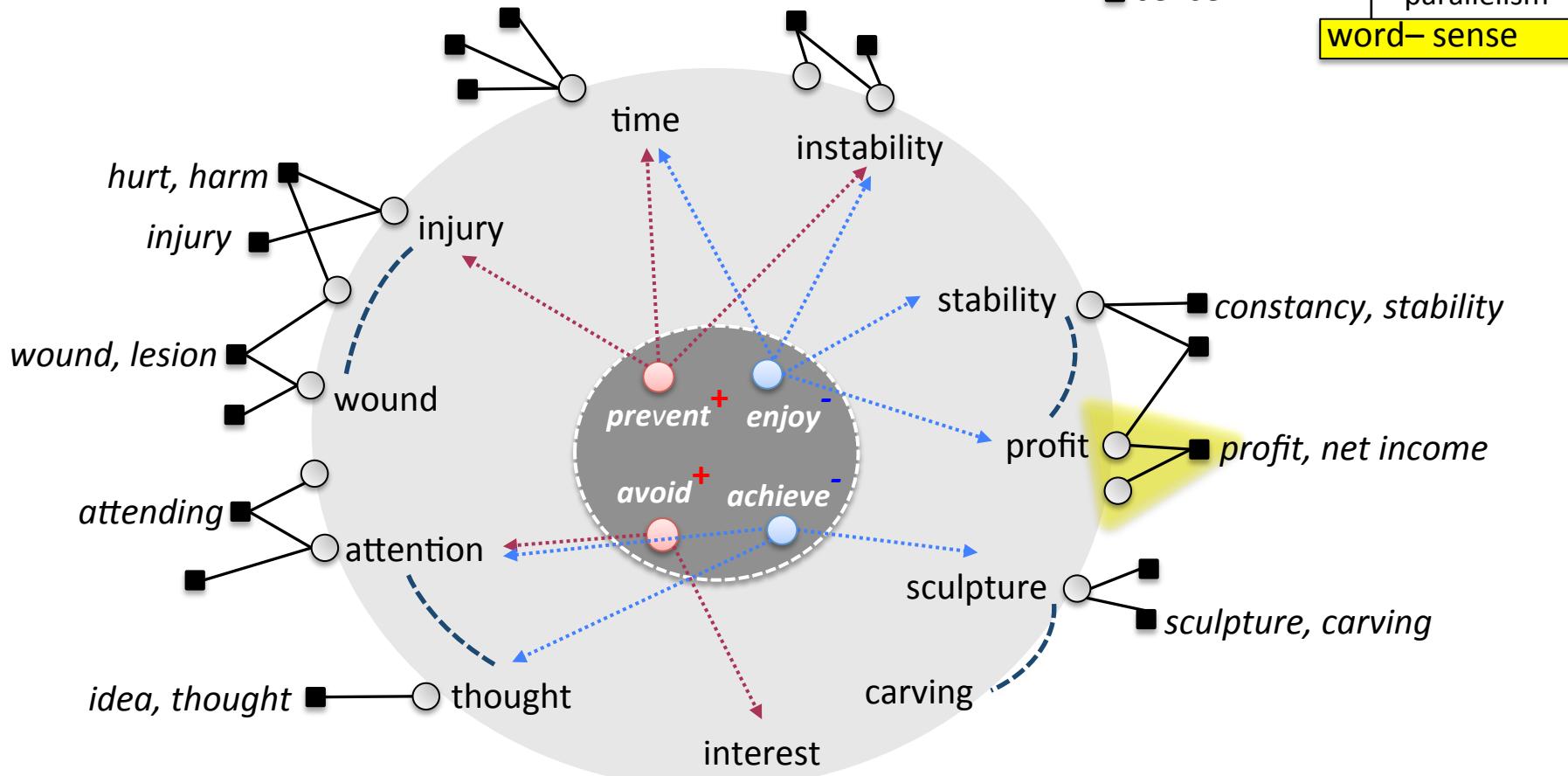
Graph Construction



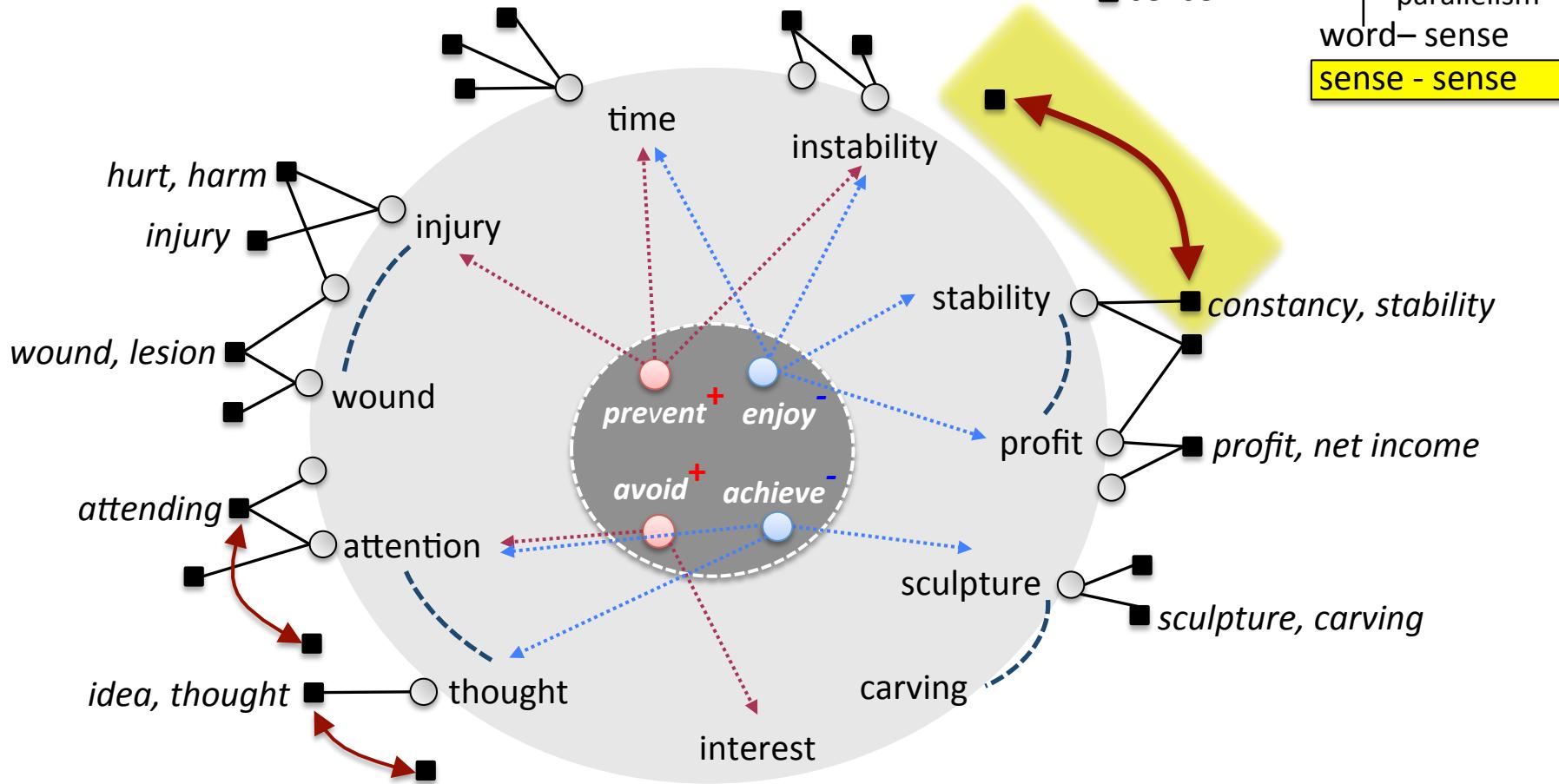
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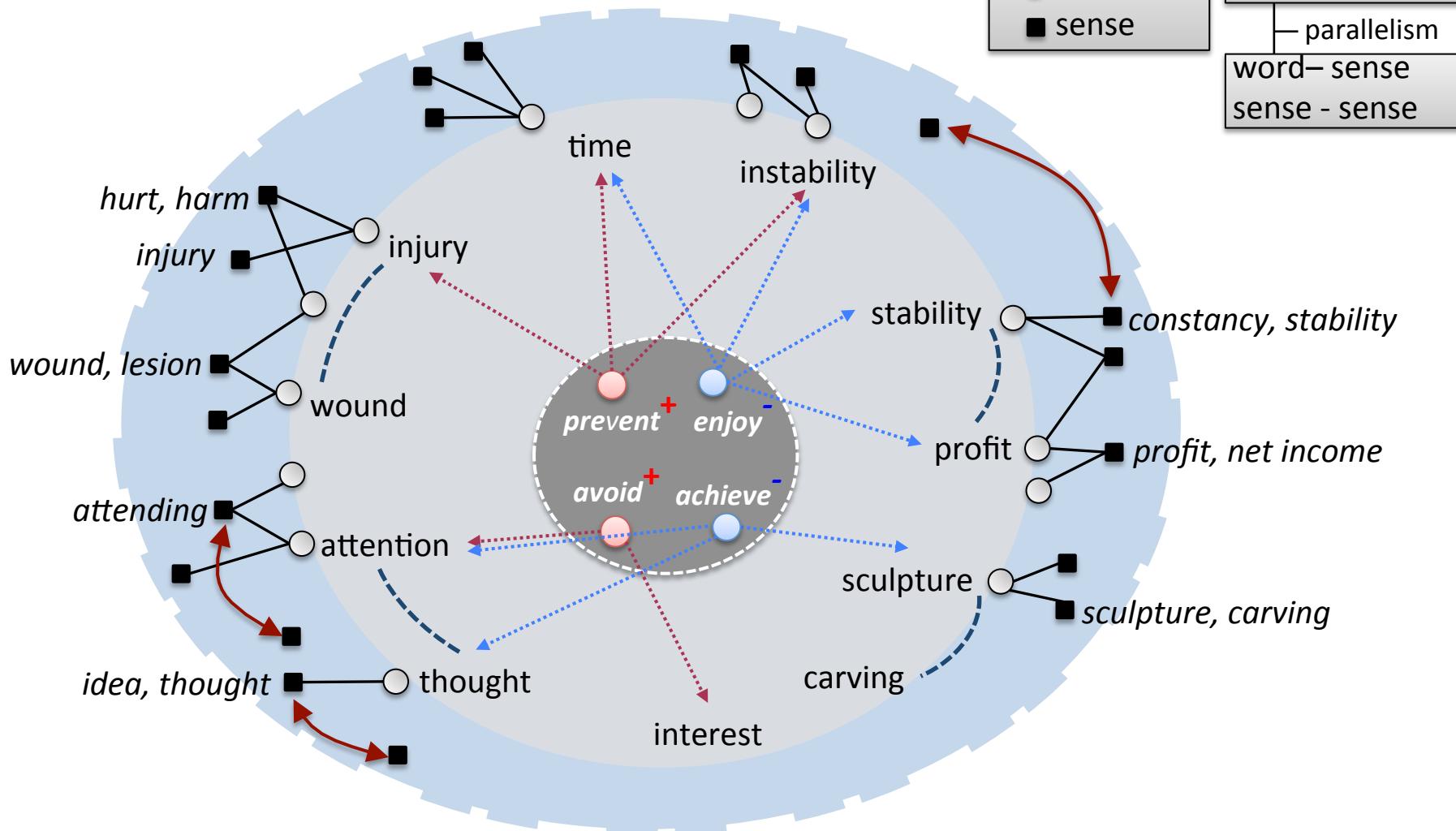
Nodes

- seed(pred)
- word
- sense

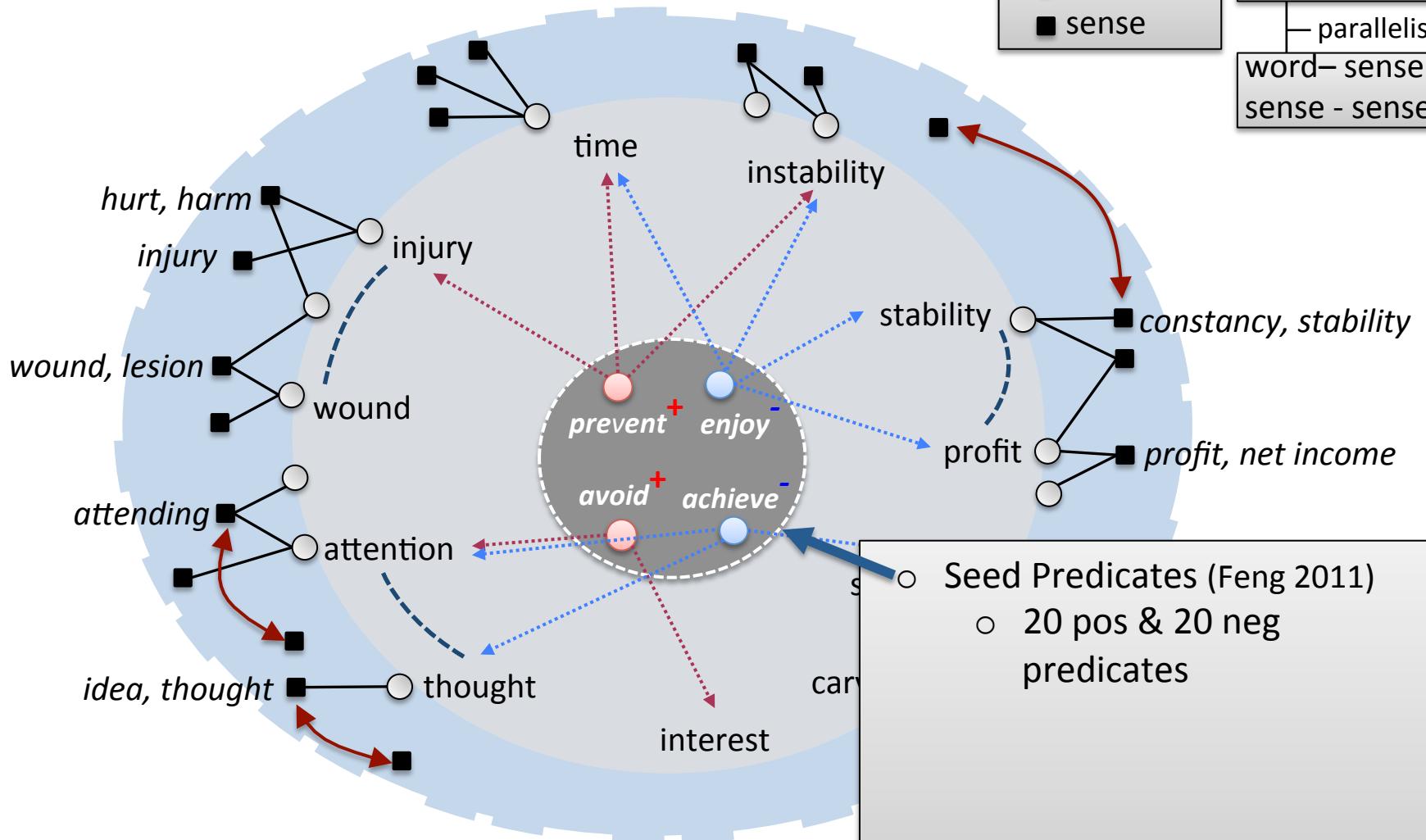
Edges

- seed - word
- word – word
- parallelism
- word– sense
- sense - sense

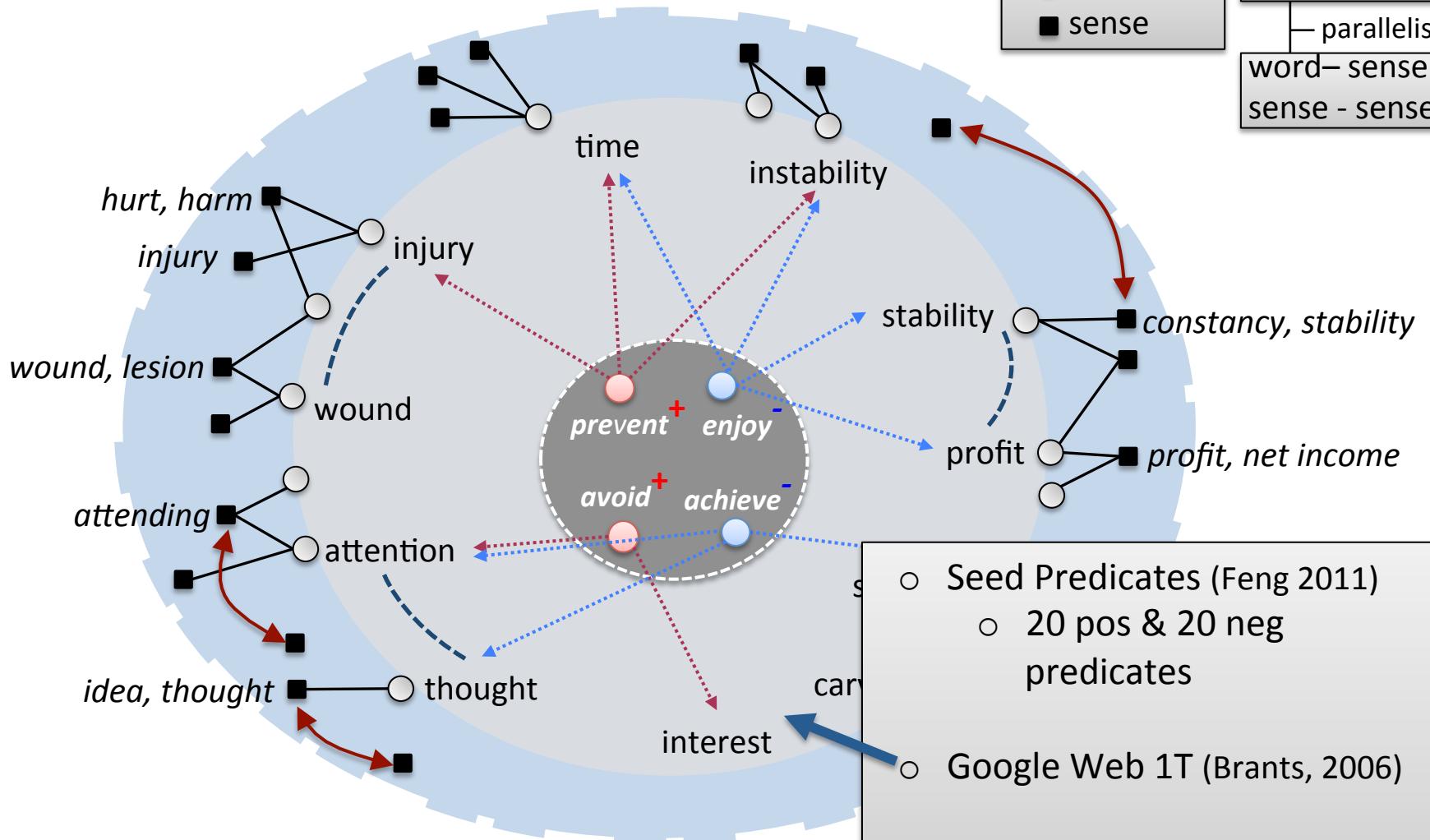
Graph Construction



Datasets

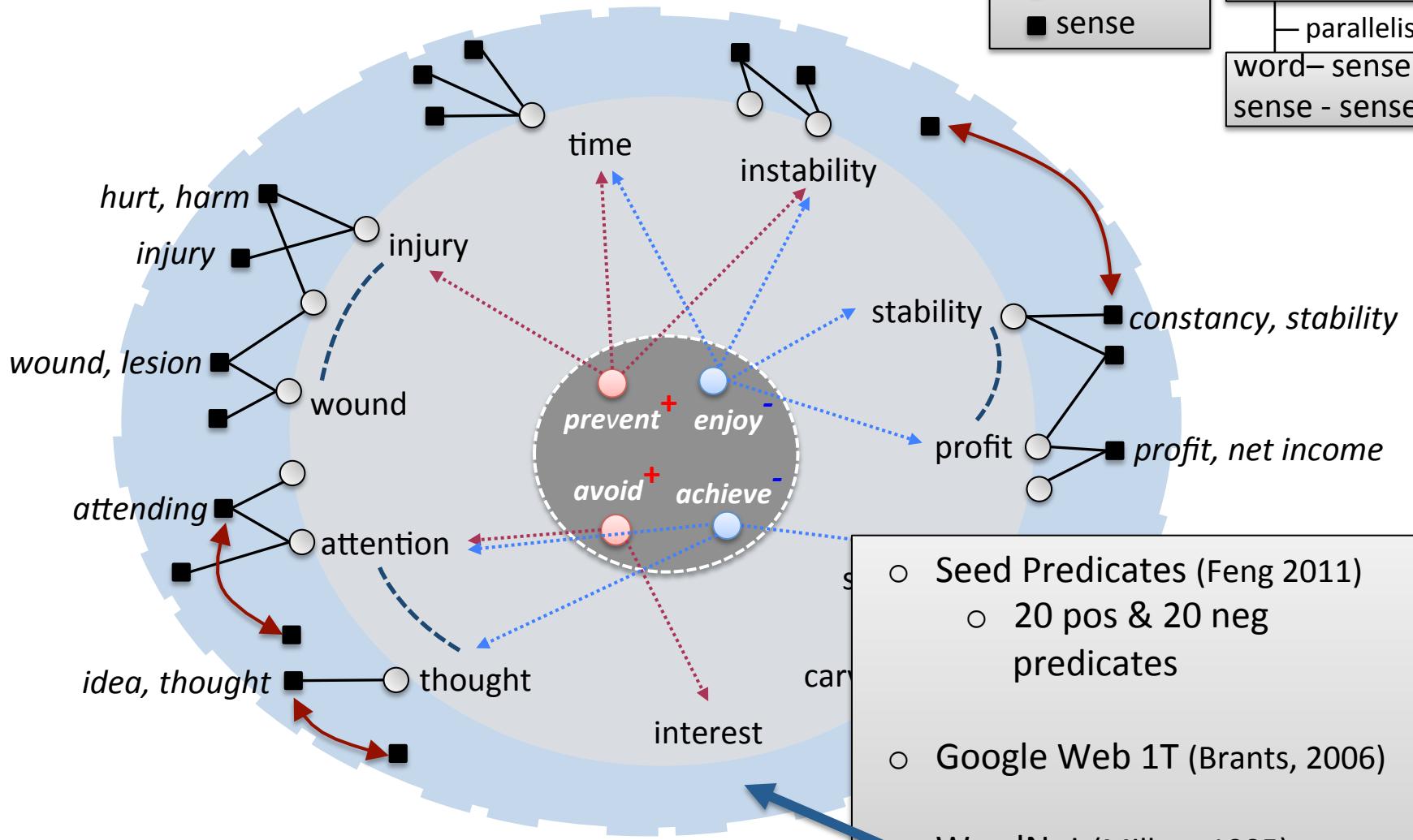


Datasets



- Seed Predicates (Feng 2011)
- 20 pos & 20 neg predicates
- Google Web 1T (Brants, 2006)

Datasets



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Markov Random Field

(Kindermann & Snell, 1980)

- Objective function

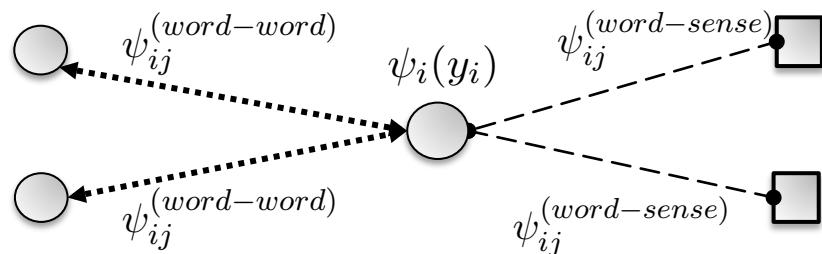
Maximize:

$$P(\mathbf{y}|\mathbf{x}) = \frac{1}{Z(\mathbf{x})} \prod_{Y_i \in \mathcal{Y}} \psi_i(y_i) \prod_{e(Y_i, Y_j) \in E} \psi_{ij}^t(y_i, y_j)$$

Node labels as random variables: $\{+, -\}$

node potentials

compatibility potentials



edge types	
pred	○ → ○ word
word	○ ← ○ word
word	○ ● - - - ○ sense
sense	○ - - - ○ sense

Loopy Belief Propagation

- Approximate inference algorithm *linearly scalable* with network size (Pearl, 1982)
- Iteratively talk to neighbors, passing *messages*
 - “**I believe you** are in these states with these likelihoods.”
- Computes *belief* when reached to the consensus



Loopy Belief Propagation

– Message

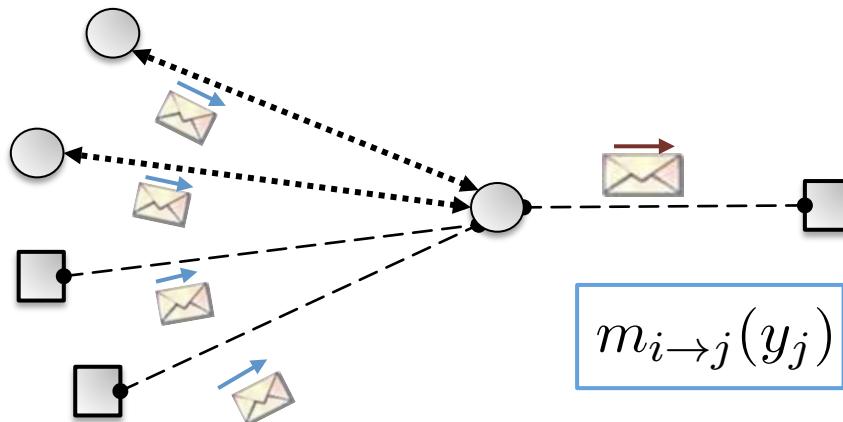
$$m_{i \rightarrow j}(y_j) = \alpha \sum_{y_i \in \mathcal{L}} \left(\psi_{ij}^t(y_i, y_j) \psi_i(y_i) \prod_{Y_k \in \mathcal{N}_i \cap \mathcal{Y} \setminus Y_j} m_{k \rightarrow i}(y_i) \right), \quad \forall y_j \in \mathcal{L}$$

compatibility
potentials

prior potentials

– Belief

$$b_i(y_i) = \beta \psi_i(y_i) \prod_{Y_j \in \mathcal{N}_i \cap \mathcal{Y}} m_{j \rightarrow i}(y_i), \quad \forall y_i \in \mathcal{L}$$



• Compatibility Potentials

	Word	
Pred	+	-
+	$1-\epsilon$	ϵ
-	ϵ	$1-\epsilon$

pred-word

	Word	
Word	+	-
+	$1-2\epsilon$	2ϵ
-	2ϵ	$1-2\epsilon$

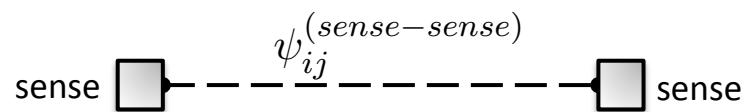
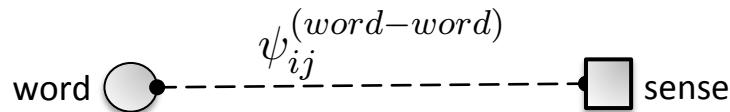
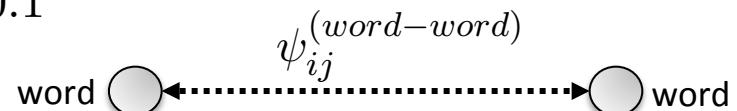
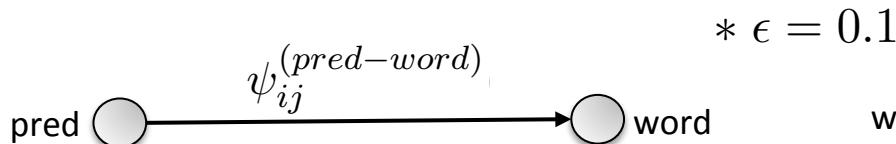
word-word

	Word	
Sense	+	-
+	$1-\epsilon$	ϵ
-	ϵ	$1-\epsilon$

word-sense

	Sense	
Sense	+	-
+	ϵ	$1-\epsilon$
-	$1-\epsilon$	ϵ

sense-sense



- Quantifies the compatibility of the labels of nodes connected by edges
- Edges are *heterogeneous*
 - Different potentials for each type

• Compatibility Potentials

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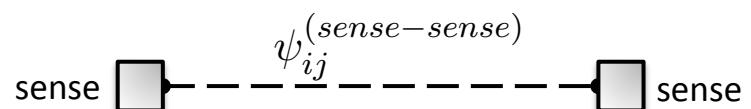
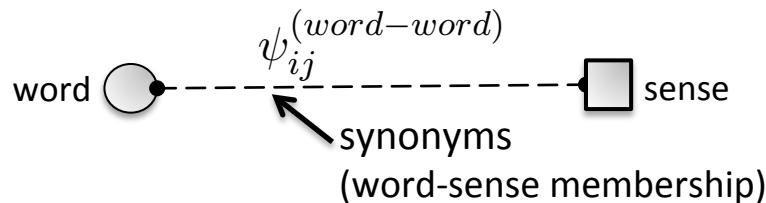
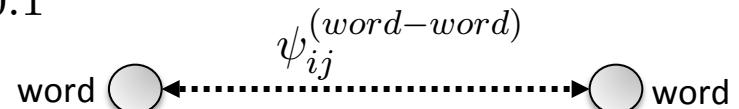
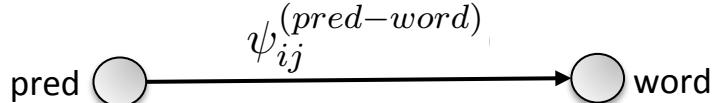
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Sense	+	-
+	$1-\epsilon$	ϵ
-	ϵ	$1-\epsilon$

word-sense

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Sense	+	-
+	ϵ	$1-\epsilon$
-	$1-\epsilon$	ϵ

sense-sense

$$* \epsilon = 0.1$$



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 - Different potentials for each type
- Homophilic relations:
 - *High compatibility* if both nodes of an edge have the *same label*

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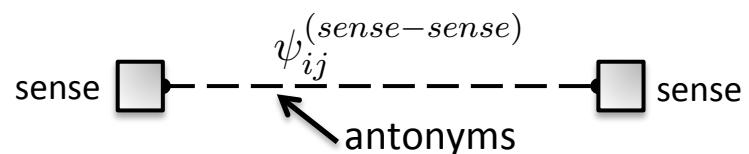
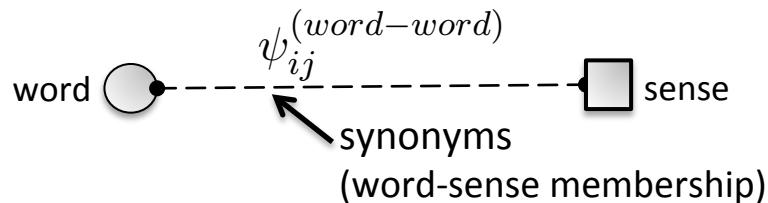
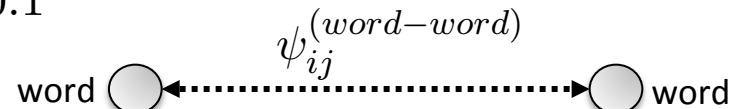
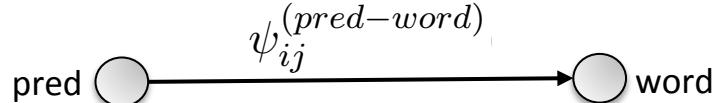
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sense-sense

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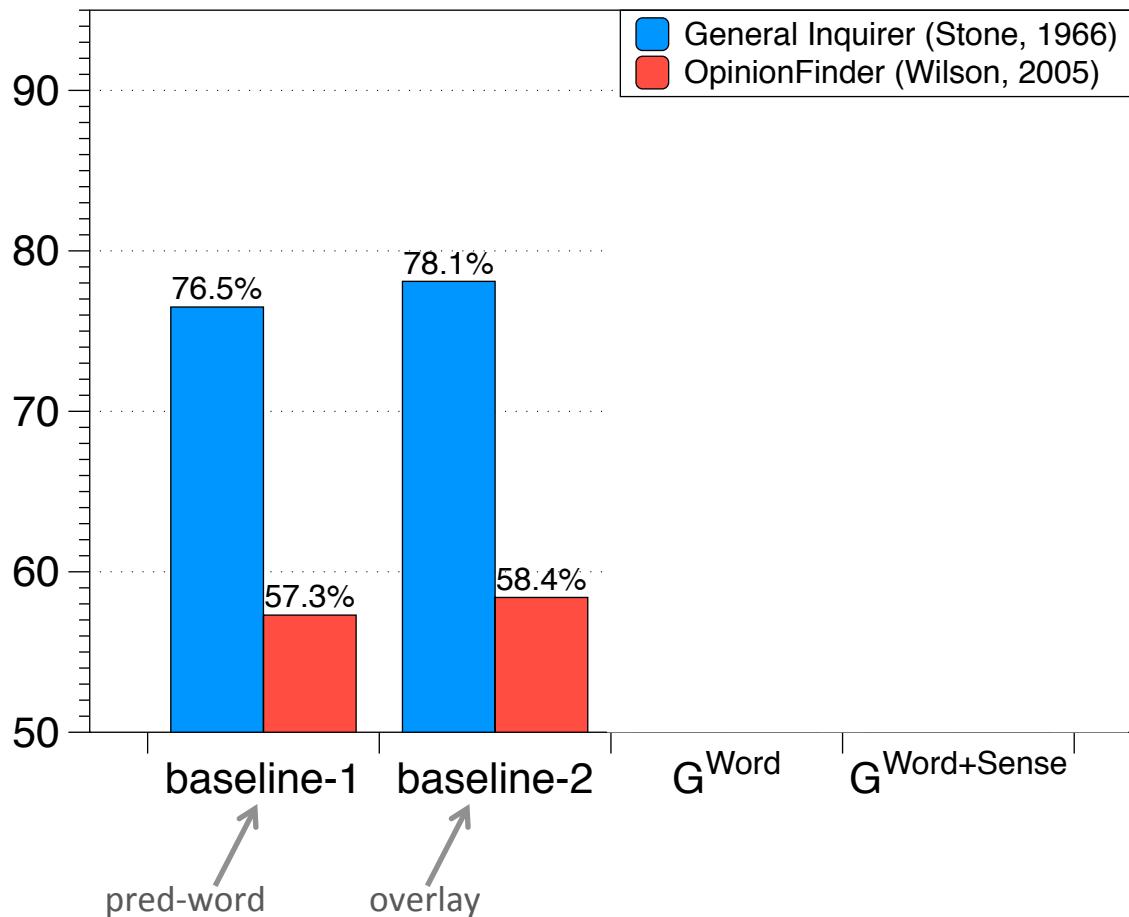


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- Edges are *heterogeneous*
 - Different potentials for each type
- Homophilic relations:
 - *High compatibility* if both nodes of an edge have the *same label*
- Heterophilic relations:
 - *High compatibility* if two nodes have *different labels*

Evaluation 1

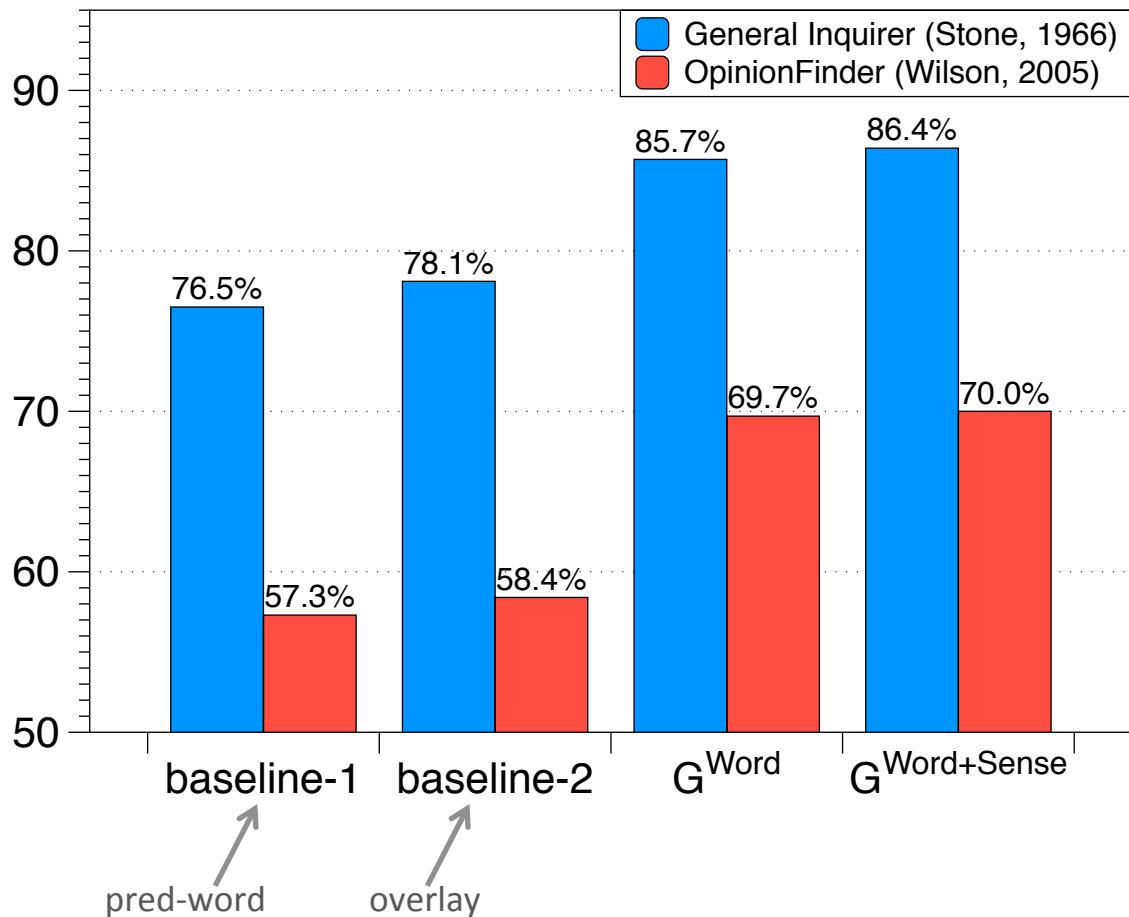
AGREEMENT WITH SENTIMENT LEXICONS

Agreement with Sentiment Lexicons



- baseline-1/2
 - Sub graphs of G^{Word}
- G^{Word}
 - without senses
 - synonyms, antonyms
- $G^{\text{Word+Sense}}$

Agreement with Sentiment Lexicons

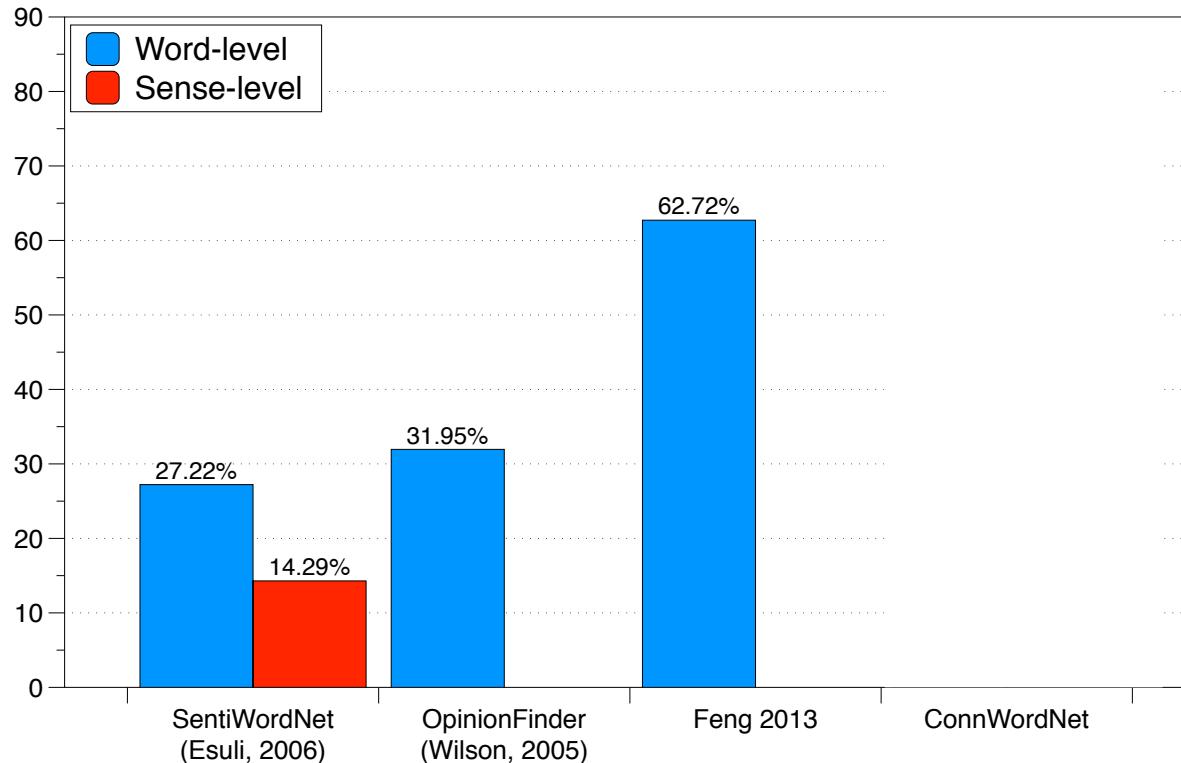


- baseline-1/2
 - Sub graphs of G^{Word}
- G^{Word}
 - without senses
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Evaluation 2

AGREEMENT WITH HUMAN JUDGES

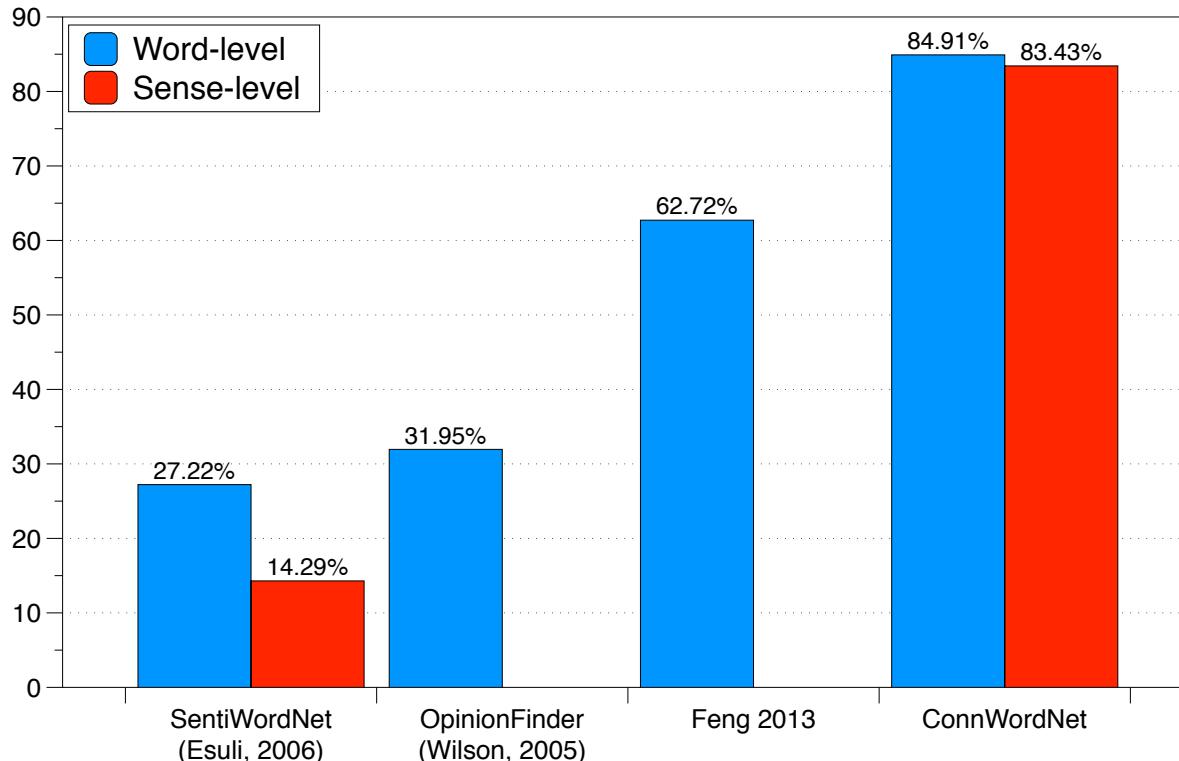
Agreement With Human Judges



word-level polarity scores	inferable	available	available	
sense-level polarity scores	available	n/a	n/a	

* Polarity agreement with human judge (5 judges)

Agreement With Human Judges



word-level polarity scores	inferable	available	available	available
sense-level polarity scores	available	n/a	n/a	available

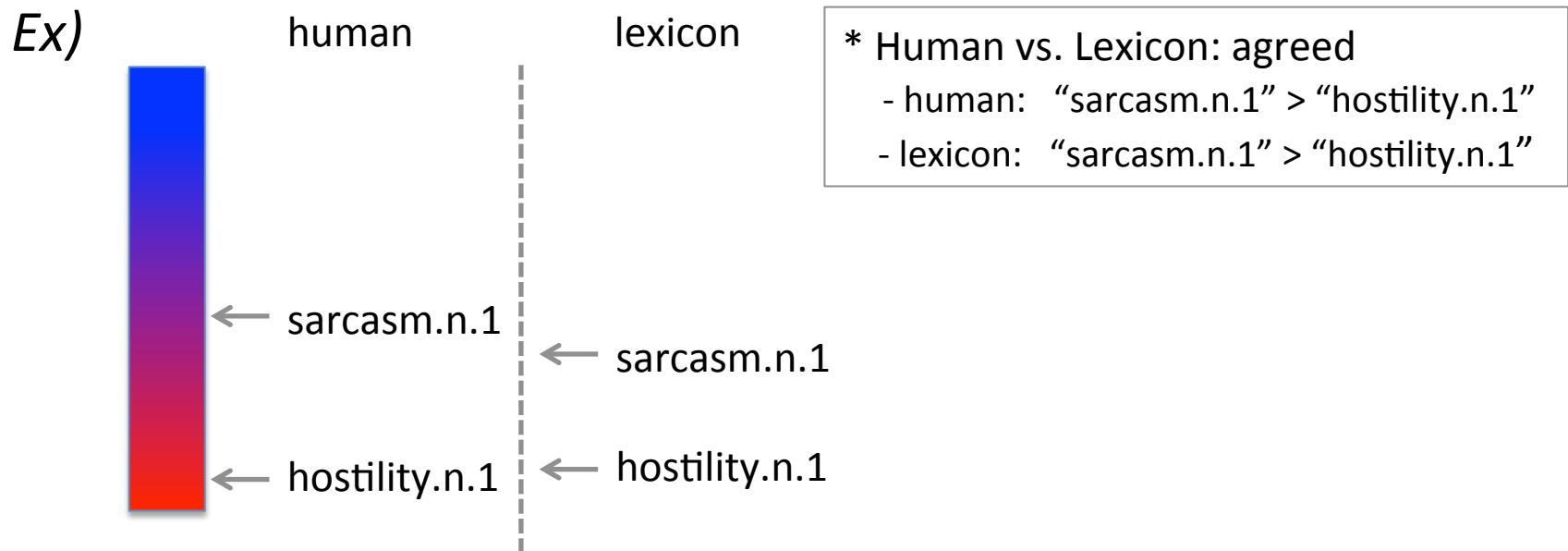
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Evaluation 3

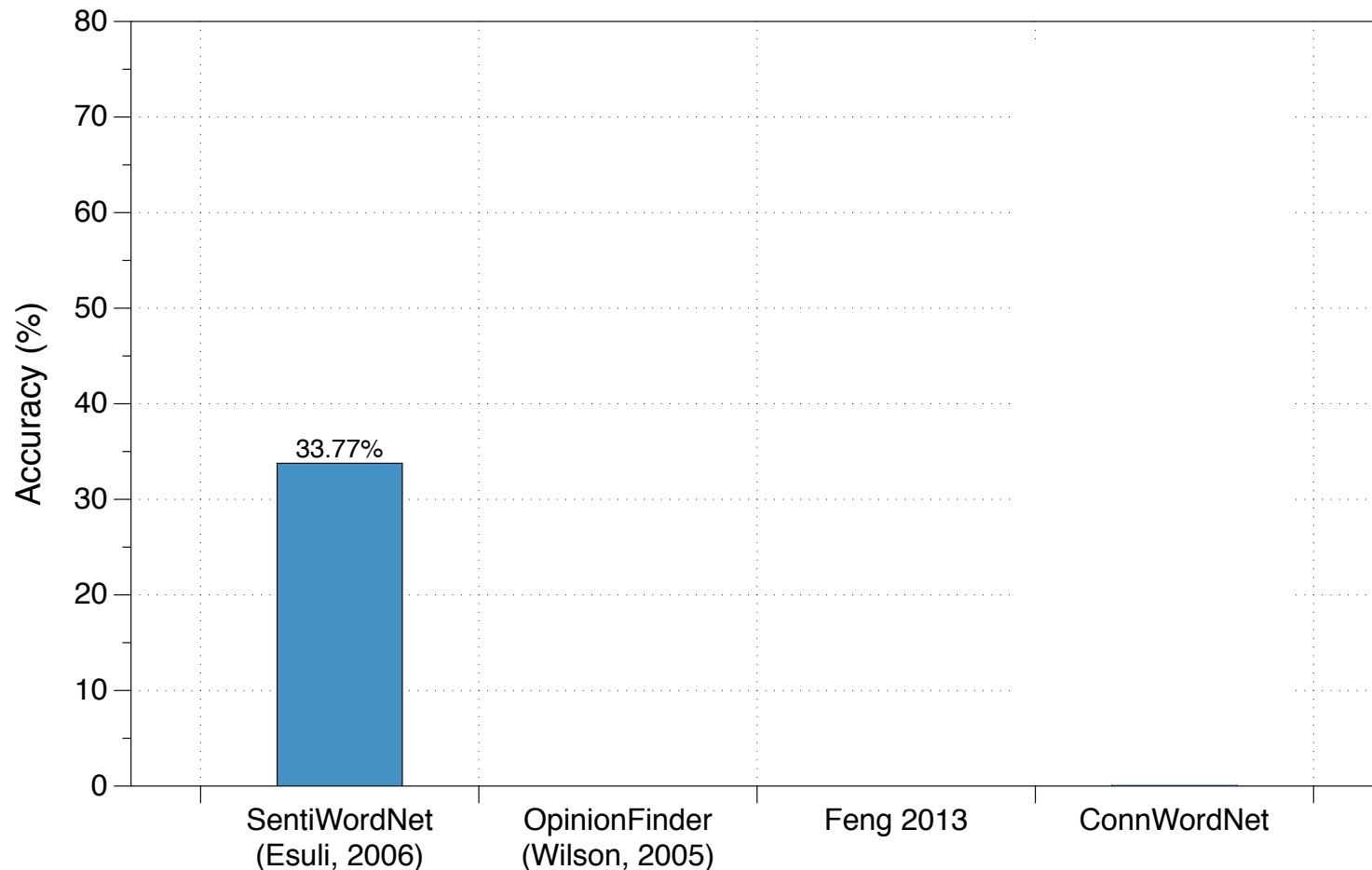
PAIRWISE INTENSITY RANKING

Pairwise Intensity Ranking

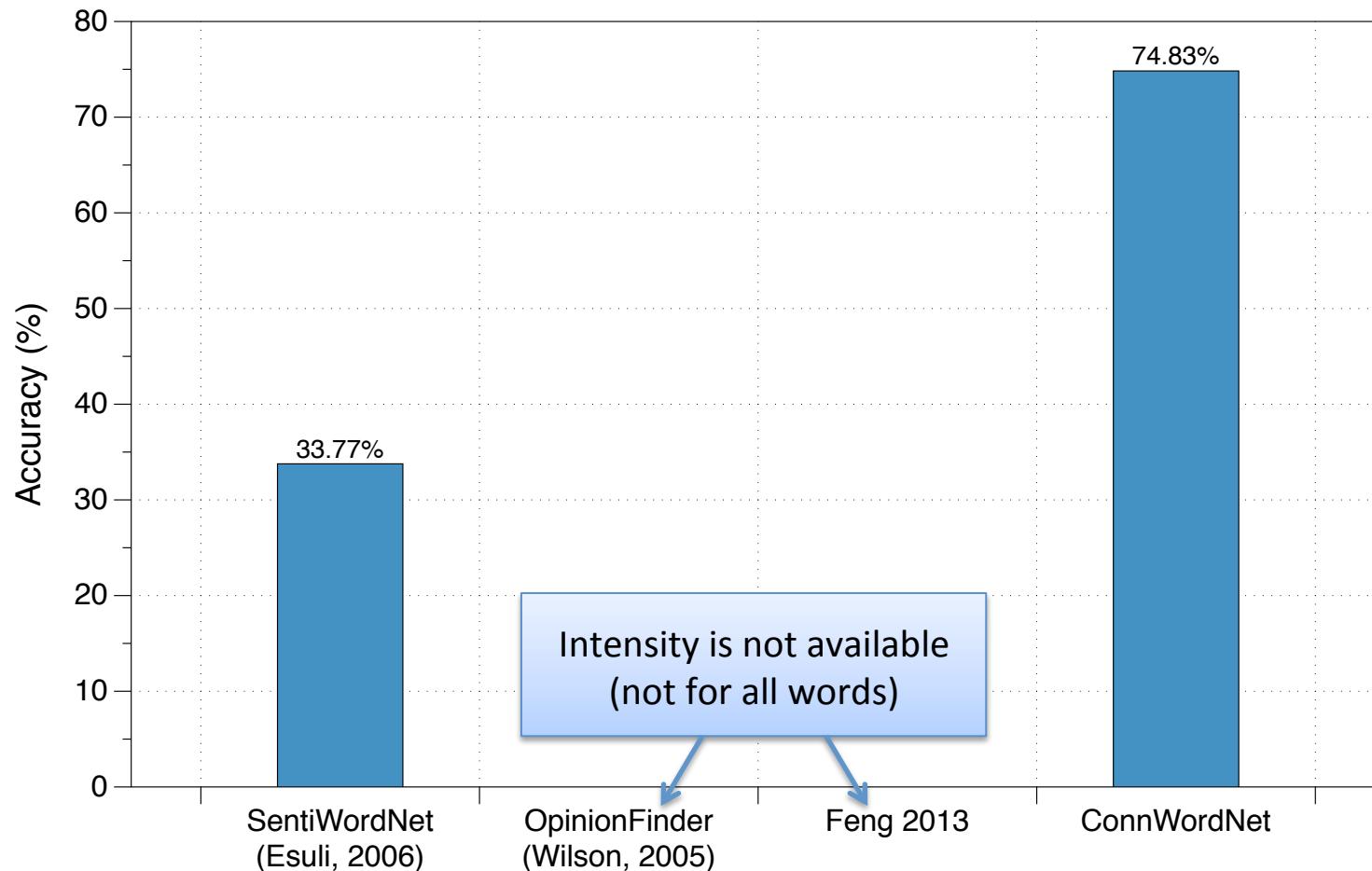
- Between a pair of senses, which one is more positive?
 - *polarity scores from Human judges*
 - *intensity scores from a lexicon*



Pairwise Intensity Ranking



Pairwise Intensity Ranking



Evaluation 4

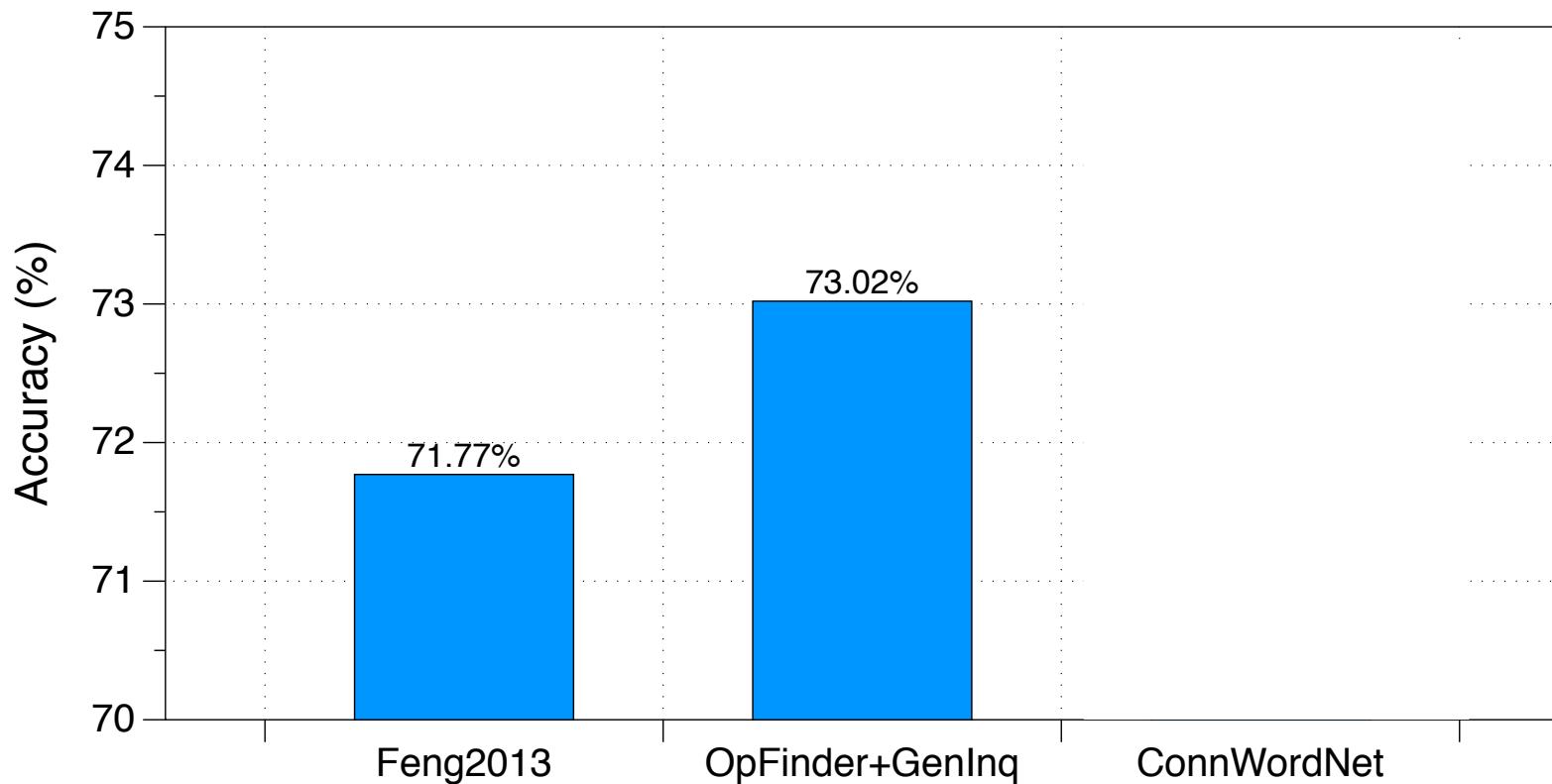
PREDICTING GOOD/BAD NEWS:

ConnotationWordNet in Action

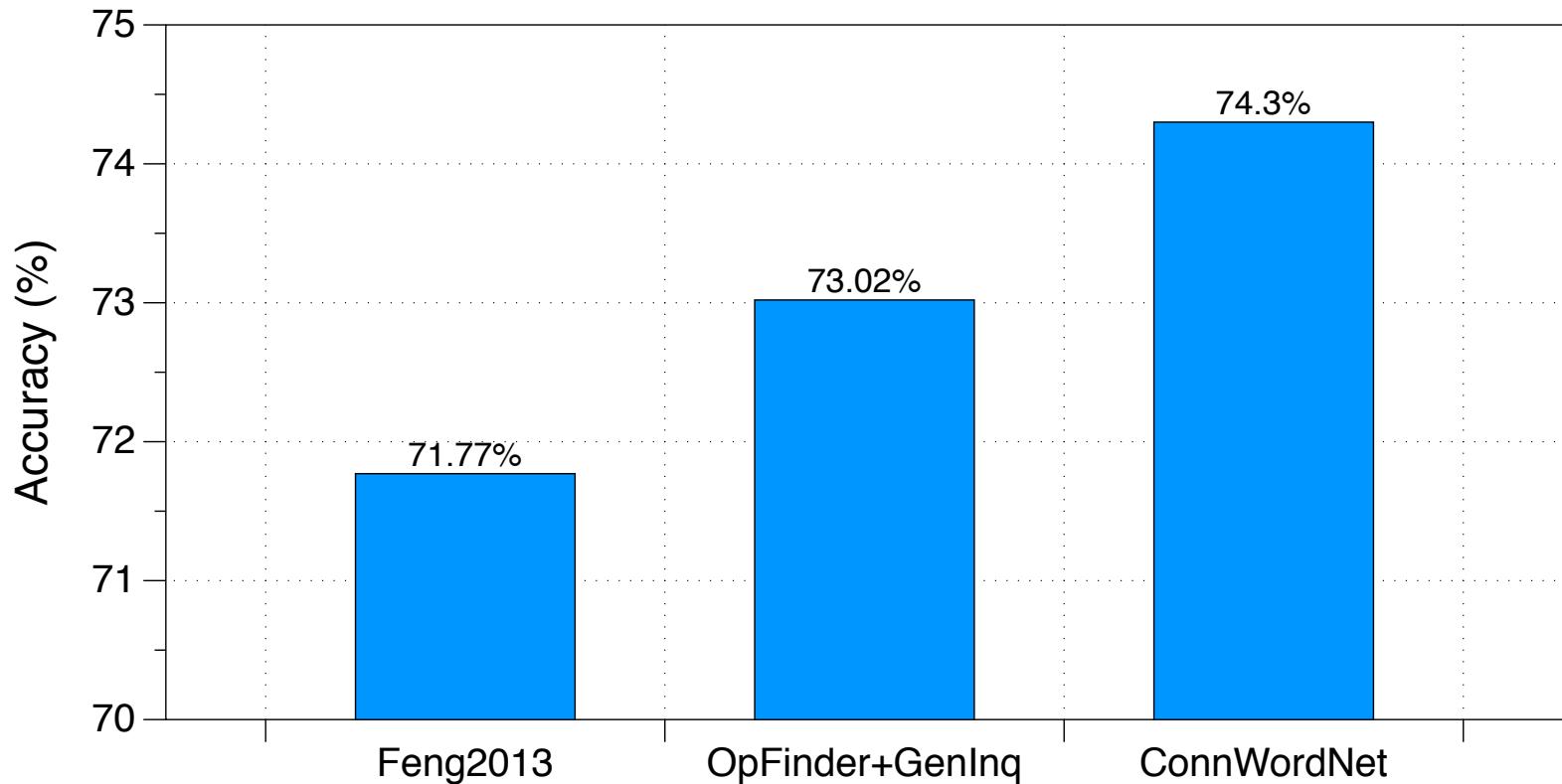
Predicting Good/Bad News using ConnotationWordNet

- SemEval dataset (Strapparava and Mihalcea, 2007)
- Human labeled news headlines (good/bad)

Predicting Good/Bad News using ConnotationWordNet



Predicting Good/Bad News using ConnotationWordNet



Conclusion

- A noble formulation of lexicon induction over word + sense network
 - Introduction of Loopy Belief Propagation over pairwise MRF as a lexicon induction algorithm
 - Expressive enough to encode various types of knowledge and lexicon relations
- ConnotationWordNet
- First lexicon that has polarity labels on *both words & senses*
 - Publically available
 - http://www.cs.stonybrook.edu/~junkang/connotation_wordnet

Lexicon Size Comparison

