Creating Lexical Resources through Manual Annotation and Bootstrapped Machine Learning

Marc Schulder
Thesis Defense

Spoken Language Systems
Department of Language Science and Technology
Saarland University

Supervisors:
Prof. Dietrich Klakow
Dr. Michael Wiegand

Committee:
Prof. Alexander Koller (chair)
Prof. Dietrich Klakow
Prof. Ingo Reich
Prof. Augustin Speyer
Dr. Thomas Kleinbauer

Date of Presentation:
14 August 2019
Sentiment Polarity Shifters

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That young girl is one of the least benightedly unintelligent organic life forms it has been my profound lack of pleasure not to be able to avoid meeting.
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Organic life forms: 😞
That young girl is one of the least benightedly unintelligent organic life forms it has been my profound lack of pleasure not to be able to avoid meeting.

Organic life forms: ☹️

That young girl: 😊
It has been my profound lack of pleasure not to be able to avoid meeting (idiots).
It has been my profound lack of pleasure not to be able to avoid meeting (idiots).

**Polarity Classification Requirements:**
It has been my profound lack of pleasure$^+$

not to be able to avoid meeting (idiots)$^-$.

**Polarity Classification Requirements:**

- Polar Words
Sentiment Polarity

It has been my profound lack of pleasure\(^+\) not to be able to avoid meeting (idiots)\(^-\).

**Polarity Classification Requirements:**

- Polar Words
- Negation
It has been my profound lack of pleasure\(^+\) not to be able to avoid meeting (idiots)\(^-\).

**Polarity Classification Requirements:**

- Polar Words
- Negation
  - Negation Words
Sentiment Polarity

It has been my profound lack of pleasure\textsuperscript{+} not to be able to avoid meeting (idiots)\textsuperscript{−}

Polarity Classification Requirements:

• Polar Words
• Negation
  • Negation Words
Sentiment Polarity

It has been my profound lack of **pleasure**

**not** to be able to avoid meeting **(idiots)**.

**Polarity Classification Requirements:**

- Polar Words
- Negation
  - Negation Words
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**Polarity Classification Requirements:**

- Polar Words
- Negation
  - Negation Words
- Polarity Shifters
It has been my profound lack of pleasure to not avoid meeting (idiots).

Polarity Classification Requirements:

- Polar Words
- Negation
  - Negation Words
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Polarity Classification Requirements:
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Polarity Classification Requirements:

- Polar Words
- Negation
  - Negation Words
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⇒ Sentence Polarity
Sentiment Polarity

It has been my profound lack of pleasure –
not to be able to avoid meeting (idiots).

Polarity Classification Requirements:

- Polar Words
- Negation
  - Negation Words
- Polarity Shifters

⇒ Sentence Polarity

You may also be interested in

- Shifter Morphemes
- Connectives (but, although)
- Modal operators (if, would)
## Types of Negation

<table>
<thead>
<tr>
<th>Negation Words</th>
<th>Examples</th>
<th>Word Type</th>
<th>Individual Frequency</th>
<th>Vocabulary Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>not, no, without,…</td>
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</tr>
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# Types of Negation

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Create Polarity Shifter Resources
Goal

Create Polarity Shifter Resources

High Quality
Goal

Create Polarity Shifter Resources

   High Quality
   Wide Coverage
Create Polarity Shifter Resources

- High Quality
- Wide Coverage
- Low Annotation Effort
Goal

Create Polarity Shifter Resources

High Quality
Wide Coverage
Low Annotation Effort
Create Polarity Shifter Resources

High Quality
Wide Coverage
Low Annotation Effort

⇩

Expert Annotation
Goal

Create Polarity Shifter Resources

- High Quality
- Wide Coverage
- Low Annotation Effort

Expert Annotation
Create Polarity Shifter Resources

High Quality
Wide Coverage
Low Annotation Effort

Expert Annotation + Machine Learning
Create Polarity Shifter Resources

- High Quality
- Wide Coverage
- Low Annotation Effort

Expert Annotation + Machine Learning = Bootstrapping Pipeline
Create Polarity Shifter Resources

High Quality
Wide Coverage
Low Annotation Effort

Expert Annotation +
Machine Learning =
Bootstrapping Pipeline

First Step: Create a list of English Verbs
Bootstrapping a Lexicon

Small Lexicon
- alleviate ✔
- colonise ✘
- give up ✔
- ...

2000 Verbs
304 Shifters

Missing Words
- break apart ?
- break even ?
- damage ?
- encrypt ?
- lose ?
- ...

8581 Verbs

Machine Learning

Large Lexicon
- alleviate ✔
- break apart ✔
- break even ✘
- colonise ✘
- damage ✔
- encrypt ✘
- give up ✔
- lose ✔
- ...

11581 Verbs
Bootstrapping a Lexicon

Small Lexicon
- alleviate ✓
- colonise ✘
- give up ✓

2000 Verbs
304 Shifters

Missing Words
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304 Shifters
8581 Verbs
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Bootstrapping a Lexicon

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11581 Verbs
1043 Shifters or False Positives
Bootstrapping a Lexicon

Machine Learning

Small Lexicon
- alleviate ✔
- colonise ✘
- give up ✔
... 2000 Verbs
304 Shifters

Missing Words
- break apart ✗
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... 8581 Verbs

Large Lexicon
- alleviate ✔
- break apart ✔
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- encrypt ✗
- give up ✔
- lose ✔
... 11581 Verbs

Shifter Verification

PhD Defense: Marc Schulder
Saarland University
Bootstrapping a Lexicon

Small Lexicon
- alleviate ✔
- colonise ❌
- give up ✔
...

2000 Verbs
304 Shifters

Machine Learning

Missing Words
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...

8581 Verbs

Large Lexicon
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- lose ✔
...

11581 Verbs

Shifter Verification

PhD Defense: Marc Schulder
Bootstrapping a Lexicon

**Small Lexicon**
- alleviate ✔️
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... 2000 Verbs 304 Shifters

**Missing Words**
- break apart
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- lose
... 8581 Verbs

**Large Lexicon**
- alleviate ✔️
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- break even ✘
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- damage ✔️
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- lose ✔️
... 11581 Verbs

**Machine Learning**

**Shifter Verification**
- 1043 Shifters

**2000 Verbs 304 Shifters**

PhD Defense: Marc Schudler
Saarland University
Bootstrapping a Lexicon

Small Lexicon
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2000 Verbs
304 Shifters

Missing Words
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8581 Verbs

Machine Learning

Shifter Verification
676 Shifters
367 False Positives

Large Lexicon
- alleviate ✔
- break apart ✔
- break even ✘
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- damage ✔
- encrypt ✘
- give up ✔
- lose ✔
- ...

11581 Verbs

PhD Defense: Marc Schulder
Bootstrapping a Lexicon

Small Lexicon
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Missing Words
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Machine Learning

Shifter Verification
- alleviate ✔
- break apart ✔
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- give up ✔
- lose ✔
... 676 Shifters 367 False Positives

Large Lexicon
- alleviate ✔
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... 11581 Verbs 676 Shifters
Bootstrapping a Lexicon

Small Lexicon
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... 2000 Verbs 304 Shifters

Missing Words
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Large Lexicon
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- damage ✔
- encrypt ✗
- give up ✔
- lose ✔
... 11581 Verbs 980 Shifters

Shifter Verification
- 676 Shifters
- 367 False Positives

Machine Learning
Features

☐ **Generic Features**
   Established features for sentiment tasks.
   Extracted from semantic resources.

☐ **Task-specific Features**
   New linguistically informed features.
   Extracted from text corpora.
Features

☑️ Generic Features
   • WordNet: Glosses
     Hypernyms
     Supersenses
   • FrameNet: Frames

☐ Task-specific Features
   New linguistically informed features.
   Extracted from text corpora.
Features

☑️ Generic Features
  • WordNet: Glosses
    Hypernyms
    Supersenses
  • FrameNet: Frames

☑️ Task-specific Features
  • Polarity Clashes
  • Co-occurrence with “any”
    • Distributional Similarity to Negation Words
  • Verb Particles
  • +/-Effect
  • Anti-Shifter-Heuristic
Polarity Clashes

Hypothesis: When a verb and its object have opposing polarities, this indicates shifting.

Example: [[Abandon]$^-\text{ all } [\text{hope}]^+$]$^-$, ye who enter here.
Co-occurrence with “any”

Hypothesis: *Negative Polarity Items* (NPI) like “any” often occur together with negation words (Giannakidou, 2008).

⇒ “any” probably indicates that polarities are shifted, even in the absence of a negation word.

Example:

They *did not give us any [help]+*.

They *denied us any [help]+*.
Evaluation: Classifier

Small Lexicon
- alleviate ✔
- colonise ✘
- give up ✔
- ...

2000 Verbs
304 Shifters

Machine Learning

Shifter Verification

Large Lexicon
- alleviate ✔
- break apart ✔
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Missing Words
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8581 Verbs
**Evaluation: Classifier**

**Gold Standard**

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>alleviate</td>
<td>✔</td>
</tr>
<tr>
<td>colonise</td>
<td>✘</td>
</tr>
<tr>
<td>give up</td>
<td>✔</td>
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<tr>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>

2000 Verbs  
304 Shifters  

Machine Learning  

?
**Task:** Can word cause shifting or not?

**Evaluation:** 10-fold cross validation

**Metric:** Macro F-Score
# Evaluation: Classifier

<table>
<thead>
<tr>
<th>Macro F1</th>
<th>Majority Label</th>
<th>Graph Clustering</th>
<th>SVM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>ANY+ANTI</td>
<td>All Features</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No labeled training</td>
<td>Supervised</td>
</tr>
</tbody>
</table>

- **Macro F1**: Accuracy of the classifier across different categories.
Evaluation: Classifier

- Majority Label
  - Baseline
- Graph Clustering
  - ANY+ANTI
  - No labeled training
- SVM
  - All Features
  - Supervised

Macro F1
- 0.25
- 0.40
- 0.55
- 0.70
- 0.85
- 1.00

0.46
Evaluation: Classifier

- **Macro F1**
  - Majority Label (Baseline): 0.46
  - Graph Clustering (ANY+ANTI): 0.68 (No labeled training)
  - SVM (All Features): 0.00 (Supervised)

Saarland University
Evaluation: Classifier

- Majority Label Baseline: 0.46
- Graph Clustering ANY+ANTI (No labeled training): 0.68
- SVM All Features Supervised: 0.79
Norah Jones’ smooth voice could soothe any savage beast.
Evaluation: Use Case

Norah’s Back!
April 12, 2019
Format: Audio CD | Verified Purchase

Norah Jones’ smooth voice could soothe any savage beast.
13 people found this helpful

Gold Data: Amazon Product Review Corpus (Jindal and Liu, 2008)
**Gold Data:** Amazon Product Review Corpus (Jindal and Liu, 2008)
- Extract 2631 verb phrases.
Evaluation: Use Case

Norah Jones’ smooth voice could soothe any savage beast.

Polar Noun

Gold Data: Amazon Product Review Corpus (Jindal and Liu, 2008)
  • Extract 2631 verb phrases.
  • Must contain polar noun.
Evaluation: Use Case

Norah Jones’ smooth voice could soothe any savage beast.

Gold Data: Amazon Product Review Corpus (Jindal and Liu, 2008)
- Extract 2631 verb phrases.
- Must contain polar noun.
- Maximise variety of verbs.
**Gold Data:** Amazon Product Review Corpus (Jindal and Liu, 2008)

- Extract 2631 verb phrases.
  - Must contain polar noun.
  - Maximise variety of verbs.
  - Annotate polarity of noun and verb phrase.
Evaluation: Use Case

Norah Jones’ smooth voice could soothe any savage beast.

Gold Data: Amazon Product Review Corpus (Jindal and Liu, 2008)
- Extract 2631 verb phrases.
  - Must contain polar noun.
  - Maximise variety of verbs.
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## Evaluation: Use Case

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<th>Majority Label Baseline</th>
<th>RNTN Neural Network Compositional Implicit Negation</th>
<th>LEX Shifter Lexicon Explicit Negation</th>
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<td>Macro F1</td>
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Socher et al. (2013)
Evaluation: Use Case

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<tr>
<th>Method</th>
<th>Macro F1</th>
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<td>Majority Label Baseline</td>
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<td>RNTN  Compositional</td>
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<tr>
<td>RNTN  Implicit Negation</td>
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<td>Socher et al. (2013)</td>
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Evaluation: Use Case

- **Majority Label** Baseline: 0.44
- **RNTN** Neural Network Compositional *Implicit Negation* (Socher et al. 2013): 0.51
- **LEX** Shifter Lexicon *Explicit Negation*: 0.44
Evaluation: Use Case

- **Majority Label**
  - Baseline
  - Macro F1: 0.44

- **RNTN**
  - Neural Network
  - Compositional
  - Implicit Negation
  - Macro F1: 0.51

- **LEX**
  - Shifter Lexicon
  - Explicit Negation
  - Macro F1: 0.85

---

**References**

- Socher et al. (2013)
Shifter Lexicon

IJCNLP 2017

English Verbs
Shifter Lexicon

IJCNLP 2017

English Verbs

More POS
Shifter Lexicon

*IJCNLP 2017*

English Verbs

More POS

More Languages
Shifter Lexicon

IJCNLP 2017
English Verbs

More POS  More Languages  More Details
Shifter Lexicon

IJCNLP 2017

English Verbs

More POS

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JNLE (in review)

Nouns

Adjectives
More POS

**IJCNLP 2017**

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**COLING 2018**

German Verbs

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Shifting Directions
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LREC 2018
- Word Senses
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Word Senses
Scope
Features

☑️ **Generic Features**
- GermaNet: Glosses
  - Hypernyms
  - Supersenses
- Salsa: Frames

☑️ **Task-specific Features**
- Polarity Clashes
- Co-occurrence with “jeglich”
- Distributional Similarity to Negation Words
- Verb Particles
- +/-Effect
- Anti-Shifter-Heuristic
Features

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☐ Cross-lingual Features
  Leverage the English shifter lexicon.
**Hypothesis:** German translations of English shifters are also shifters.

**Method 1: Bilingual Dictionary**

**Example:**

<table>
<thead>
<tr>
<th>English</th>
<th>German</th>
</tr>
</thead>
<tbody>
<tr>
<td>lose</td>
<td>verlieren</td>
</tr>
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</table>
**Hypothesis:** German translations of English shifters are also shifters.

**Method 1: Bilingual Dictionary**

**Example:**

<table>
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Cross-lingual Features

**Hypothesis:** German translations of English shifters are also shifters.

**Method 2: Bilingual Word Embeddings**

**Input:** Unrelated text corpora
Hypothesis: German translations of English shifters are also shifters.

Method 2: Bilingual Word Embeddings

Input: Unrelated text corpora

Example:
**Hypothesis:** German translations of English shifters are also shifters.

**Method 2: Bilingual Word Embeddings**

**Input:** Unrelated text corpora

**Example:**

- forfeit
- shed
- leak
- give up
- fail
- beat
- misplace
- lose
- verlieren
- fail
- beat
Features

☑️ Generic Features
  • GermaNet: Glosses
    Hypernyms
    Supersenses
  • Salsa: Frames

☑️ Task-specific Features
  • Polarity Clashes
  • Co-occurrence with “jeglich”
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  • Verb Particles
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  • Anti-Shifter-Heuristic

☑️ Cross-lingual Features
  • Bilingual Dictionary
  • Bilingual Word Embeddings
Evaluation: Classifier

<table>
<thead>
<tr>
<th>Macro F1</th>
<th>Majority Label</th>
<th>Monolingual SVM</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Generic</td>
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</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td>0.47</td>
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</table>

PhD Defense: Marc Schulder

Saarland University
Evaluation: Classifier

<table>
<thead>
<tr>
<th>Model Type</th>
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- Monolingual SVM:
  - Generic: 0.78
  - Task-specific: 0.78

- Cross-lingual SVM:
  - Generic: 0.81
  - Task-specific: 0.81
  - Cross-lingual: 0.81

PhD Defense: Marc Schulder

Saarland University
Evaluation: Classifier

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<tr>
<th>Method</th>
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<td>Translated Lexicon</td>
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</tbody>
</table>

- Monolingual SVM: Generic
- Cross-lingual SVM: Generic
  - Task-specific
  - Cross-lingual

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Evaluation: Classifier

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<tr>
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<td>0.78</td>
</tr>
<tr>
<td>Monolingual SVM (Task-specific)</td>
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<tr>
<td>Cross-lingual SVM (Generic)</td>
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<td>Cross-lingual SVM (Task-specific)</td>
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<tr>
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<tr>
<td>Translated Lexicon (Cross-lingual)</td>
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</tbody>
</table>

PhD Defense: Marc Schulder

Saarland University
Conclusion

Findings
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• There are many polarity shifters.
Conclusion

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- There are many polarity shifters.
- Shifters are relevant for polarity classification.
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  ⇒ This reduces the annotation effort by 70-94%.
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- There are many polarity shifters.
- Shifters are relevant for polarity classification.
- Shifter lexica can be created semi-automatically.
  \[ \Rightarrow \] This reduces the annotation effort by 70-94%.
- Shifter knowledge can be transferred cross-lingually.
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Contributions
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Contributions

• We introduced a bootstrap workflow.
• We introduced several task-specific features.
• We created several resources.
Questions?
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References


H. Yu, J. Hsu, M. Castellanos, and J. Han (2016). Data-driven Contextual Valence Shifter Quantification for Multi-Theme Sentiment Analysis. In Proceedings of CIKM.

Marvin, the Paranoid Android
Created by Douglas Adams
Drawing by Will Gelatko
## Created Resources

<table>
<thead>
<tr>
<th></th>
<th>English</th>
<th>German</th>
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<tr>
<td></td>
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<td>55 239</td>
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<tr>
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<td>Scope</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extrinsic Evaluation</td>
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</table>
Sentiment Polarity

Shifting can happen in either direction.
She was [denied the [scholarship]+]−. The new medication [alleviated her [pain]−]+.

Shifter words can have neutral polarity. Homework [[eats up]− all my [free time]+]−.

### Generic Features

<table>
<thead>
<tr>
<th>WordNet</th>
<th>Word</th>
<th>destroy</th>
<th>Sense 1</th>
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<tbody>
<tr>
<td>Gloss</td>
<td>“cause the destruction or undoing of”</td>
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</tr>
<tr>
<td>Hypernym</td>
<td>unmake</td>
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<tr>
<td>Supersense</td>
<td>Creation</td>
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<table>
<thead>
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<th>WordNet</th>
<th>Word</th>
<th>destroy</th>
<th>Sense 2</th>
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<tbody>
<tr>
<td>Gloss</td>
<td>“defeat soundly and humiliatingly”</td>
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<tr>
<td>Hypernym</td>
<td>overcome</td>
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<td>Supersense</td>
<td>Competition</td>
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</tr>
<tr>
<td>WordNet</td>
<td>Word</td>
<td>Lemma</td>
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<td></td>
<td>destroy</td>
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<tr>
<td><strong>Gloss</strong></td>
<td>cause, destruction, undoing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>defeat, soundly, humiliated</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hypernyms</strong></td>
<td>unmake, overcome</td>
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### Generic Features

<table>
<thead>
<tr>
<th></th>
<th>WordNet</th>
<th>FrameNet</th>
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<tbody>
<tr>
<td><strong>Word</strong></td>
<td>destroy</td>
<td>Destroying, Killing</td>
</tr>
<tr>
<td><strong>Gloss</strong></td>
<td>cause, destruction, undoing</td>
<td></td>
</tr>
<tr>
<td><strong>Bag-of-words</strong></td>
<td>defeat, soundly, humiliatingly</td>
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<td>Creation, Competition</td>
<td></td>
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**WordNet**
- **Word**: destroy
- **Gloss**: cause, destruction, undoing
- **Bag-of-words**: defeat, soundly, humiliatingly
- **Hypernyms**: unmake, overcome
- **Supersenses**: Creation, Competition

**FrameNet**
- **Frames**: Destroying, Killing
Sentiment Polarity

\[
\begin{align*}
\text{absence of pleasure}^+ & \quad - \\
\text{absence of pain}^+ & \quad + \\
\text{fear of pain}^- & \quad - \\
\text{alleviate pain}^+ & \quad + \\
\end{align*}
\]

Word Polarity ≠ Polarity Shifting

\[
\begin{align*}
\text{Lexical} \\
\text{Contextual}
\end{align*}
\]
**Sentiment Polarity**

- **lack** of pleasure
- lack of pain
- fear of pain
- alleviate pain
- there is no pleasure
- there is no pain
- there are no chairs

Word Polarity ≠ Polarity Shifting

- Lexical
- Contextual
Task-specific Features

Distributional Similarity to Negation Words

Hypothesis: If a verb is used in similar contexts as “traditional” negation words then it is likely to be a shifter.

Method: Distributional similarity via word embedding

Example:
I have had [no [pleasure]+]−.
It has been my profound [lack of [pleasure]+]−.
Task-specific Features

Verb Particles

Hypothesis: Some particles indicate "loss" (e.g. aside, down, off,...).

Example: You can [lay aside all your [worries]−]⁺.
Task-specific Features

+/-Effect

Resource: EffectWordNet (Choi and Wiebe, 2014)

Hypothesis: +/-Effect theory posits that events may have beneficial or harmful effects.
-Effects bear similarity to polarity shifters.

Example: He [betrayed\text{-effect} his [friends]\text{-}]+ for money.

Caveat: They think we [abuse\text{-effect} our [prisoners]\text{-}]-.
Anti-Shifter Heuristic

Hypothesis: If shifters are words that weaken or invert polarities, then there must be anti-shifters that strengthen a given polarity.

Heuristic: Measure the co-occurrence with adverbs that are
• attracted to verbs of creation;
• repelled by verbs of destruction.

Examples:
Black bears exclusively live on fish.
Phone keyboards were first introduced in 1997.
These buildings have been newly constructed.
They specially prepared vegan dishes for me.
Polarity Lexicon

- Subjectivity Lexicon (Wilson et al. 2005)

Word Embeddings

- **Tool:** Word2Vec (Mikolov et al., 2013)
- **Corpus:** Amazon Product Review Corpus (Jindal and Liu, 2008)
  (also used for co-occurrence counts and extrinsic eval)

Graph Ranking:

- **Tool:** Junto (Talukdar et al., 2008)
- **Algorithm:** Adsorption Label Propagation (Talukdar et al., 2008)
**Name:** Recursive Neural Tensor Network  
**Type:** Compositional Polarity Classifier  
**Output:** Constituency tree with polarities for each tree node.

**Training:** Sentiment Treebank (Socher et al., 2013)  
**Size:** 11,855 sentences;  
215,154 phrase nodes  
**Advantage:** Explicit polarities for every tree node.  
**Disadvantage:** Few or no instances of most verbs.  
⇒ Difficult to learn shifter behaviour
Classification Quality

<table>
<thead>
<tr>
<th>Classifier Confidence</th>
<th>1st Quarter</th>
<th>2nd Quarter</th>
<th>3rd Quarter</th>
<th>4th Quarter</th>
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<tbody>
<tr>
<td>Precision</td>
<td>0.93</td>
<td>0.73</td>
<td>0.62</td>
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Learning Curve

<table>
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<tr>
<th>Macro F1</th>
<th>Amount of data used for training in 10-fold cross-validation</th>
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<tbody>
<tr>
<td>0.60</td>
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<tr>
<td>0.65</td>
<td>20%</td>
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<tr>
<td>0.70</td>
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<tr>
<td>0.75</td>
<td>40%</td>
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<tr>
<td>0.80</td>
<td>50%</td>
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- SVM (all)
- SVM (generic)
- SVM (task)
- Graph Clustering