Aspect Extraction Using Conditional Random Fields

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Aspect-based sentiment analysis task

A. Extract explicit aspects from the offered review

B. Extract all the aspects from the offered review

C. Perform sentiment analysis of the aspects

D. Categorize the aspects terms by predefined categories

E. Sentiment classification of the whole review on aspect categories
SentiRuEval-2015

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E. Sentiment classification of the whole review on aspect categories
Major approaches to extract aspects

- Frequency of nouns and/or noun phrases (Hu and Liu, 2004)
- Simultaneous extraction of both sentiment words (user opinions) and aspects
- Supervised machine learning (HMM, Jin et al., 2009 and CRF, Jakob and Gurevych, 2010)
- Unsupervised machine learning or topic modeling (Titov and McDonald, 2008; Brody and Elhadad, 2010)
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Conditional Random fields (CRF)

CRFs are a type of discriminative undirected probabilistic graphical model. It is used to encode known relationships between observations and construct consistent interpretations.
Conditional Random fields (CRF)

Let $G$ be a graph such that $Y = (Y_v)_{v \in V}$, so that $Y$ is indexed by the vertices of $G$. Then $(X, Y)$ is a conditional random field when the random variables $Y_v$, conditioned on $X$, obey the Markov property with respect to the graph

$$P(y_v \mid Y \setminus \{v\}, X) = P(y_v \mid Y_{o(v)}, X),$$
Conditional Random fields (CRF)

\[ P(Y|X) = \frac{1}{Z(X)} \exp( \sum_{c} \sum_{c} f_c(y_c, X)) \]

Where \( Z(x) \) is normalization factor, 
\( C \) – set of all graphs’ cliques, 
\( f_c \) – set of features, 
\( \lambda i \) – factors.
CRF advantages

- Relaxation of the independence assumptions
- CRFs avoid the label bias problem
System description

Pre-processing

“s-e” – start of an explicit aspect term,
“c-e” – continuation of an explicit aspect term,
“s-i” – start of an implicit aspect term,
“c-i” – continuation of an implicit aspect term,
“s-f” – start of an implicit aspect term,
System description

Pre-processing

To extract syntactic features (e.g. POS, lemma) we used TreeTagger for Russian (Sharoff, 2008)

We also converted all the capital letters into lowercase
System description

features

Word

POS

Lemma
Very friendly place where pretty staff meet from the threshold, warm and cozy interior and incendiary music
System description

example

w[0]=очень  w[-1]=null  w[1]=дружелюбное  pos[0]=r O  
w[0]=дружелюбное  w[-1]=очень  w[1]=место  pos[0]=a O  
w[0]=место  w[-1]=дружелюбное  w[1]=null  pos[0]=n s-e  
w[0]=c  w[-1]=null  w[1]=порога  pos[0]=s O  
w[0]=порога  w[-1]=c  w[1]=встречают  pos[0]=n O  
w[0]=встречают  w[-1]=порога  w[1]=симпатичные  pos[0]=v s-e  
w[0]=симпатичные  w[-1]=встречают  w[1]=работники  pos[0]=a O  
w[0]=работники  w[-1]=симпатичные  w[1]=тёплый  pos[0]=n O  
w[0]=тёплый  w[-1]=работники  w[1]=уютный  pos[0]=a O  
w[0]=уютный  w[-1]=тёплый  w[1]=интерьер  pos[0]=a O  
w[0]=интерьер  w[-1]=уютный  w[1]=и  pos[0]=n s-e  
w[0]=и  w[-1]=интерьер  w[1]=зажигательная  pos[0]=c O  
w[0]=зажигательная  w[-1]=и  w[1]=музыка  pos[0]=a O  
w[0]=музыка  w[-1]=зажигательная  w[1]=null  pos[0]=n s-e
System description

**System 1:** CRF with all the above-mentioned labels. We used s-e, c-e and O labels for explicit aspect extraction to perform Task A and s-e, c-e, s-i, c-i, s-f, c-f, O to extract all the aspects for Task B.

**System 2:** Combination of the results of two CRFs — CRF for extraction of explicit aspect terms and CRF for extraction of implicit aspect terms + sentiment facts terms (not explicit).

Task A was performed using System 1 and Task B — using both systems.
Results

F-measure

Exact matching and partial matching.

Macro F1-measure means in this case calculating F1-measure for every review and averaging the obtained values.

Micro F – partial matching, the intersection between gold standard and extracted term was calculated.
Results

Task A restaurant domain in comparison to baseline

Exact matching

Partial matching
Results

Task A restaurant domain in comparison to the best results

Exact matching

Partial matching

Graphs showing precision, recall, and F-measure for exact and partial matching in the restaurant domain. The graphs compare baseline results with improvements from №1, №2, Word+POS, and +lemma methods.
Results

Task A car domain in comparison to baseline

Exact matching

Partial matching

<table>
<thead>
<tr>
<th></th>
<th>Precision</th>
<th>Recall</th>
<th>Fmeasure</th>
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</thead>
<tbody>
<tr>
<td>baseline</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Word+POS</td>
<td></td>
<td></td>
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<tr>
<td>+lemma</td>
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Results

Task A car domain in comparison to the best results

Exact matching

Partial matching

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Graphs showing precision, recall, and F-measure for exact and partial matching.
Results

Task B restaurant domain in comparison to baseline

Exact matching

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<td>№1</td>
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<tr>
<td>№2</td>
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<tr>
<td>+lemma</td>
<td></td>
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<tr>
<td>+lemma2</td>
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Partial matching

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Task B restaurant domain in comparison to the best results

Exact matching

Partial matching

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</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td>№1</td>
<td>System 1 Word+POS</td>
<td>baseline</td>
<td>№1</td>
<td>System 1 Word+POS</td>
</tr>
<tr>
<td>№2</td>
<td></td>
<td>System 1 Word+POS</td>
<td>№2</td>
<td></td>
<td>System 1 Word+POS</td>
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<tr>
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</tr>
<tr>
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<td></td>
<td>System 1 Word+POS</td>
<td>+lemma2</td>
<td></td>
<td>System 1 Word+POS</td>
</tr>
</tbody>
</table>
Results

Task B car domain in comparison to baseline

![Graphs showing Precision, Recall, and Fmeasure for Exact matching and Partial matching.](image)

- **Exact matching**
  - Baseline
  - №1
  - №2
  - System 1 Word+POS +lemma
  - System 2 Word+POS +lemma2

- **Partial matching**
  - Baseline
  - №1
  - №2
  - System 1 Word+POS +lemma
  - System 2 Word+POS +lemma2
Results

Task B car domain in comparison to the best results

![Graphs showing performance metrics (Precision, Recall, F-measure) for exact and partial matching with different systems and features.](https://via.placeholder.com/150)
Error Analysis

- Not recognized
- excessively recognized

- additional unconscious repetitive errors
## Error distribution

<table>
<thead>
<tr>
<th></th>
<th>Restaurants</th>
<th>Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not recognized</td>
<td>67.1%</td>
<td>63%</td>
</tr>
<tr>
<td>excessively recognized</td>
<td>32.9%</td>
<td>37%</td>
</tr>
</tbody>
</table>
Error types

1. Technical errors
   1.1 Special symbols:
   Etalon: Салат "цезарь"
   System: Салат "цезарь"

1.2 Lower case:
Can’t recognize ie “TO” (technical maintenance in car domain) and “то” (the particle)
Error types

2. Not recognized

2.1 Shortness

Рублей → руб. → р. (rubles → rub → R.)

2.2 listings

Овощи, салаты «Цезарь», лосось
(Vegetables, salads "Caesar", salmon)
Error types

3. Partly recognition
   3.1. Before head word
   “Добавляла вина” (pour wine)
   “Официант хамил” (The waiter was rude)

3.2. After head word
   “местечко в углу” (a place in the corner)

4. Excessively recognized
   4.1 Not always good deal with named entities
   Александр (Alexander)
Conclusion

• The performance of our systems was comparable to the best results of SentiRuEval participants.

• Realization of these systems demonstrated that the use of lemmas for the Russian language as a CRF feature improves the overall F-measure.

• Subsequently we are going to add statistical methods as a CRF feature.
Thank you!

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