Recognition of Hyponymy and Meronymy Relations in Word Embeddings for Polish

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Agenda

- Need, contradiction, goal
- Classification for hyponymy recognition
- Experiments
  - Corpora and training-testing dataset
  - Scheme
  - Tests
- Results
- Conclusions
Need, contradiction, goal

Need
- Even in a very large wordnet some relation instances can be omitted
- Corpus-based *Measures of Semantic Relatedness* express many different lexico-semantic relations

Contradiction
- In several works, classifiers were applied to MSR to recognise hypernymy instances, e.g. (Fu et al., 2014)
- (Levy et al., 2015) convincingly claim that this is not possible (sic!)

Goal
- to check these contradictory points of the view on large corpora and comprehensive wordnet for Polish
- to expand this research with *meronymy* – a more difficult relation
Classification for hypernymy recognition

- Wordnet or thesaurus as source of hyponymy instances: \( \langle x, y \rangle \)
  - \( x \) – a hyponym, and \( y \) – a hypernym,
  - are lemmas belonging to two separate synsets
- \( \langle x, y \rangle \) represented by \( x - y \)
  - \( x, y \) – word embedding vectors
- Hypernymy projection (Fu et al., 2014):
  a linear projection of the vector \( x \), i.e. \( \Phi x \), on a vector \( y' \)
- Automatically clustering \( x - y \) into \( n \) groups by \textit{k-means}
- Separated classifier was trained by the linear regression method for each cluster
Experiments
Corpora and training-testing dataset (1)

- Limitations of the semantic representation based on word embeddings
  1. the whole model can be biased by the particular selection of texts
     → large corpus needed
  2. senses of polysemous words are merged together
     → separate experiments for monosemous and polysemous lemmas
  3. and the representation of less frequent words and senses can be blurred by the statistical noise
     → words with more than 1,000 occurrences
Experiments

Corpora and training-testing dataset (2)

- **Gold standard:** plWordNet – a very large wordnet of Polish
- **Corpus:** plWordNet Corpus 10
  - more than 4 billion words: several corpora supplemented with text acquired from the Web, only text in Polish, automated elimination of duplicates
- **Vectors**
  - `word2vec` (Mikolov et al., 2013), *Gensim* implementation (Rěhůřek and Sojka, 2010)
  - all words with the minimal frequency \( \geq 8 \) (min_count=8)
  - vector size: 300
- **Number of clusters**
  - dataset divided into: *training*, *testing* and *development* in the ratio 6:2:2
  - automated optimisation on a *development* subset
Two types of data sets for the experiments

1. *random* division into subsets,
2. *lexical train/test splits* rule proposed by (Levy et al., 2015)

- positive cases: direct hypernyms & cannot include hypernyms from the training set
- negative cases: excluding indirect hypernyms &

\[
T_x^+ = \{ x \mid (x, y) \in T^+ \} \tag{1}
\]
\[
T_y^+ = \{ y \mid (x, y) \in T^+ \} \tag{2}
\]
\[
S = (T_x^+ \times T_y^+) \setminus T^+ \tag{3}
\]

where \( T^+ \) is a set of word pairs belonging to the given relation
Experiments

Tests

**Hypo-Mono** – hyponymy recognition, monosemous words: 6k positive pairs, 6k negative; two variants: *random & lexical split*; the vector size: 100.

**Hypo-Poly** – 20k hyponymy pairs including polysemous words; 20k negative, two variants; the vector size: 100

**Hypo-Mono300** – as in Hypo-Mono but the vector size: 300, only *lexical split*

**Hypo-Poly300** – as above, but 20k hyponymy pairs including polysemous words, 20k negative pairs by the *lexical split*, the vector size was: 300.

**Mero-Poly** – 7,900 meronymy pairs (only *part of*), 8,000 negative pairs: not connected or connected by paths longer than 3 links, the *lexical split*, the vector size: 100.
## Results

| Experiment   | Acc  | P    | R    | F    | Err  | Type  | Vec. Size |
|--------------|------|------|------|------|------|-------|-----------|
| Hypo-Mono    | 85.22% | 78.91% | 96.27% | 86.72% | 27.91% | Rnd   | 100       |
| std. dev.    | 0.64% | 1.00% | 0.65% | 0.65% | 1.92% | Rnd   | 100       |
| Hypo-Mono    | 84.98% | 78.90% | 95.18% | 86.27% | 28.05% | Split  | 100       |
| std. dev.    | 0.61% | 1.59% | 0.79% | 0.91% | 2.22% | Split  | 100       |
| Hypo-Poly    | 78.94% | 74.35% | 88.35% | 80.74% | 31.63% | Rnd   | 100       |
| std. dev.    | 0.65% | 0.41% | 1.70% | 0.79% | 1.78% | Rnd   | 100       |
| Hypo-Poly    | 77.23% | 73.83% | 84.66% | 78.85% | 30.54% | Split  | 100       |
| std. dev.    | 0.79% | 1.40% | 2.39% | 1.04% | 2.25% | Split  | 100       |
| Hypo-Mono300 | 73.31% | 65.16% | 98.20% | 78.32% | – | Split  | 300       |
| std. dev.    | 1.11% | 1.82% | 0.39% | 1.31% | – | Split  | 300       |
| Hypo-Poly300 | 82.54% | 84.51% | 94.72% | 89.32% | – | Split  | 300       |
| std. dev.    | 1.01% | 1.11% | 0.69% | 0.73% | – | Split  | 300       |
| Mero-Poly300 | 79.95% | 74.66% | 90.43% | 81.77% | – | Split  | 100       |
| std. dev.    | 1.05% | 1.71% | 1.38% | 0.99% | – | Split  | 100       |
Results

![Graph showing the relationship between dataset size and measure values (Accuracy, Precision, Recall, F-measure).]
Results

Ration: matching error vs recall for the hyponymy recognition by SVM
### Results

#### Examples of clusters

| Hypernym                | Hyponym                                         | Cluster ID |
|-------------------------|-------------------------------------------------|------------|
| wyziew ‘vapour’         | spaliny ‘engine exhausts’                       | 973        |
| usługa ‘service’        | przewóz ‘transport’                            | 973        |
| usługa ‘service’        | fryzjerstwo ‘hairdressing’                      | 973        |
| usługa ‘service’        | outsourcing ‘outsourcing’                       | 973        |
| usługa ‘service’        | usługa powszechna ‘common service’              | 973        |
| usługa ‘service’        | usługa telekomunikacyjna ‘telecom. service’     | 973        |
| usługa ‘service’        | produkt bankowy ‘bank product’                  | 973        |
| nudziarz ‘bore’         | sztywniak ‘staffed shirt’                       | 973        |
| dysputa ‘≈debate’       | polemika ‘polemic’                              | 1101       |
| dostojnik ‘high official’| podsekretarz ‘undersecretary’                   | 1101       |
| dostojnik ‘high official’| wiceminister ‘vice-minister’                    | 1101       |
| dygnitarz ‘dignitary’   | wiceminister ‘vice-minister’ 1                   | 1101       |
| oficjel ‘high-up’       | wiceminister ‘vice-minister’                    | 1101       |
| dostojnik ‘high official’| vicepremier ‘deputy prime minister’            | 1101       |
| dygnitarz ‘dignitary’   | vicepremier ‘deputy prime minister’             | 1101       |
| oficjel ‘high-up’       | vicepremier ‘deputy prime minister’             | 1101       |
| dezaprobata ‘disapproval’| wotum nieufności ‘vote of censure’              | 1101       |
Conclusions

- Good results in the recognition of hyponymy
  - contrary to the claim of (Levy et al., 2015) that are learning in fact that one of the words is a prototypical hypernym
  - the lexical split selection of negative samples caused the decrease of the results, but only $\approx 1 - 2\%$, not significant
  - classifiers are not deviating to prototype recognition
  - this substantial discrepancy of our findings can be also caused by the choice of different classification methods – clustering & linear regression vs SVM in (Levy et al., 2015)
  - we showed that in some settings SVM classifier can produce much worse results for this particular task

- Lower results for longer embedding vectors of 300 are surprising, but can be caused by insufficient number of training examples
Conclusions

- Manual selective analysis of clustering revealed that
  - Clusters do not represent different realisations of hyponymy, contrary to (Ruiji et al., 2014), but rather group difference vectors according to the more general lemmas
  - Pairs related to different top hypernyms, e.g. ‘animal’ and ‘furniture’ were linked together only in later stages of hierarchical clustering
  - Negative pairs first were merged together and only after this their subbranches were linked with other clusters

- Very good result for meronymy were achieved
Thank you very much for your attention!

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