A Semi-supervised Type-based Classification of Adjectives: Distinguishing Properties and Relations

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Motivation: Using Adjectives for Ontology Learning (1)

1. Learning Ontological Knowledge from Adjectives:

- **attributes**
  
  \[ \text{grey donkey} \equiv \text{COLOR(donkey)} = \text{grey} \]

- **roles**, i.e. ”founded” attributes (cf. Guarino, 1992)
  
  \[ \text{fast car} \equiv \text{SPEED(car)} = \text{fast} \]

- **relations**
  
  \[ \text{economic crisis} \equiv \text{AFFECT(crisis, economy)} \]

Different types of adjectives require different ontological representations!
Motivation: Using Adjectives for Ontology Learning (2)

2. Using Adjectives for Clustering Nouns into Concepts:

Clustering Features (pattern-based):

- attribute nouns:
  - the ATTR of the NOUN
- adjectives denoting properties of the noun:
  - the ADJ NOUN

Results:

- best results by combination of attribute and adjective features
- problem: attributive position is too unrestrictive for identifying property-denoting adjectives

(Almuhareb, 2006)
Hypothesis: Classification is a prerequisite for ontology learning from adjectives.

We adopt an adjective classification scheme from the literature that reflects the ontological information we are interested in:

- **attributes** ≡ **basic** adjectives
  - e.g.: *grey donkey*
- **roles** ≡ **event-related** adjectives
  - e.g.: *fast car*
- **relations** ≡ **object-related** adjectives
  - e.g.: *economic crisis*

(Boleda 2007; Raskin & Nirenburg 1998)
Overview

1 Background & Motivation

2 Annotation Experiment
   - Initial Classification Scheme: BEO
   - Task Description
   - First Results
   - Results after Re-Analysis

3 Automatic Classification
   - Methodology
   - Experimental Settings
   - Evaluation Results

4 Conclusions
BEO Classification Scheme (1)

Basic Adjectives

- adjective denotes a value of an attribute exhibited by the noun
- values are either discrete or predications over a range of several values (depending on the concept being modified)

Examples

- red carpet $\Rightarrow$ COLOR(carpet)=red
- oval table $\Rightarrow$ SHAPE(table)=oval
- young bird $\Rightarrow$ AGE(bird)=[?,?]
BEO Classification Scheme (2)

Event-related Adjectives
- there is an event the referent of the noun takes part in
- adjective functions as a modifier of this event

Examples
- **good knife** ⇒ *knife that cuts well*
- **fast horse** ⇒ *horse that runs fast*
- **interesting book** ⇒ *book that is interesting to read*
### BEO Classification Scheme (3)

#### Object-related Adjectives
- The adjective is morphologically derived from a noun $N/ADJ$.
- $N/ADJ$ refers to an entity that acts as a semantic dependent of the head noun $N$.

#### Examples
- **environmental destruction**
  
  $N$  
  $\Rightarrow$ destruction$_N$ [of] the environment$_N/ADJ$  
  $\Rightarrow$ destruction$(e, \text{AGENT: } x, \text{PATIENT: environment})$

- **political debate**
  
  $N$  
  $\Rightarrow$ debate$_N$ [about] politics$_N/ADJ$  
  $\Rightarrow$ debate$(e, \text{AGENT: } x, \text{TOPIC: politics})$
Annotation Study: Task Description and Methodology

Data Set
- list of 200 high-frequency adjectives from the British National Corpus
- random extraction of five example sentences from the written part of the BNC for each of the 200 adjectives

Methodology
- three annotators
- task: label each of the 1000 items with BASIC, EVENT, OBJECT or IMPOSSIBLE
- instructions: short description of the classes plus examples
**BEO Classification: Fundamental Ambiguities**

**BASIC vs. EVENT**

- ***fast horse***
  - BASIC reading: \( \text{SPEED}(\text{horse}) = \text{fast} \)
  - EVENT reading: *horse that runs fast*

- ***good knife***
  - BASIC reading: \( \text{QUALITY}(\text{knife}) = \text{good} \)
  - EVENT reading: *knife that cuts well*

**Additional Instructions: Differentiation Patterns**

If one of the following patterns holds for an ambiguous item, this indicates a property that is **founded** on an EVENT:

- ENT’s property of being **ADJ** is due to ENT’s ability to EVENT.
- If ENT was unable to EVENT, it would not be an ADJ ENT.
Category-wise Annotator Agreement

|       | BASIC | EVENT | OBJECT |
|-------|-------|-------|--------|
| \( \kappa \) | 0.368 | 0.061 | 0.700  |

Table: Category-wise \( \kappa \)-values for all annotators

- overall agreement: \( \kappa = 0.4 \) (Fleiss 1971)
- separating the OBJECT class is quite feasible
- Can poor overall agreement be traced back to the ambiguities between BASIC and EVENT class?
Cases of Disagreement

|                | BASIC | EVENT | OBJECT |
|----------------|-------|-------|--------|
| 2:1 agreement  | 283   | 21    | 66     |
| 3:0 agreement  | 486   | 5     | 62     |

**Table:** Cases of Agreement vs. Disagreement

|                | 1 voter |       |       |
|----------------|---------|-------|-------|
|                | BASIC   | EVENT | OBJECT|
| 2 voters       |         |       |       |
| BASIC          | −       | 172   | 16    |
| EVENT          | 18      | −     | 1     |
| OBJECT         | 54      | 10    | −     |

**Table:** Distribution of Disagreement Cases over Classes

BASIC/EVENT ambiguity is the **primary source of disagreement**!
People have substantial difficulties in distinguishing BASIC from EVENT adjectives!

Re-analysis: **binary classification scheme**
- adjectives denoting **properties** (BASIC & EVENT)
- adjectives denoting **relations** (OBJECT)

overall agreement after re-analysis: \( \kappa = 0.69 \)

|       | BASIC+EVENT | OBJECT |
|-------|-------------|--------|
| \( \kappa \) | 0.696       | 0.701  |

**Table:** Category-wise \( \kappa \)-values for all annotators (after re-analysis)
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Methodology

- **task**: automatically classify adjectives according to their denotation: *properties* (ATTR) vs. *relations* (REL)
- **features**: set of *lexico-syntactic patterns* capturing systematic differences of these adjective classes in certain grammatical constructions
- **overcome feature sparsity**:
  - classification on the **type level**
  - **semi-supervised** approach: acquire enough training material on the type level by heuristic annotation projection
Features for Classification

| Group | Feature                              | Pattern                                    |
|-------|--------------------------------------|--------------------------------------------|
| I     | as                                   | as JJ as                                   |
|       | comparative-1                        | JJR NN                                     |
|       | comparative-2                        | RBR JJ than                                |
|       | superlative-1                        | JJS NN                                     |
|       | superlative-2                        | the RBS JJ NN                              |
|       | extremely                             | an extremely JJ NN                         |
|       | incredibly                            | an incredibly JJ NN                        |
|       | really                                | a really JJ NN                             |
|       | reasonably                            | a reasonably JJ NN                         |
|       | remarkably                            | a remarkably JJ NN                         |
|       | very                                  | DT very JJ                                 |
| II    | predicative-use                       | NN (WP|WDT)? is|was|are|were RB? JJ |
|       | static-dynamic-1                     | NN is|was|are|were being JJ |
|       | static-dynamic-2                     | be RB? JJ                                  |
| III   | one-proform                           | a/an RB? JJ one                            |
| IV    | see-catch-find                        | see|catch|find DT NN JJ                             |
|       |                                       | they saw the sanctuary desolate            |
|       |                                       | Baudouin’s death caught the country unprepared |
| VI    | morph                                | adjective is morphologically derived from noun economy ← economy |

Table: Set of features used for classification
Experimental Settings

Data Set

- manually annotated seed data ($A_s$): 164 property-denoting, 18 relational adjective types
- heuristic annotation projection:
  - extract 5,000 sentences per type from ukWaC corpus ($A_{acq}$)
  - for every adjective token in $A_{acq}$: project unanimous class label from the corresponding type in $A_s$

Evaluation

- several feature configurations:
  - all-feat: all features individually
  - all-grp: all features, collapsed into groups
  - no-morph: all features individually, without morph feature
- 10-fold cross validation
- baseline: label all instances with majority class (ATTR)
Experimental Results

| ATTR | REL |
|------|-----|
|      | P   | R   | F   | P   | R   | F   | Acc |
| all-feat | 0.96 | 0.99 | 0.97 | 0.79 | 0.61 | 0.69 | 0.95 |
| all-grp | 0.96 | 0.99 | 0.97 | 0.85 | 0.61 | 0.71 | 0.95 |
| no-morph | 0.95 | 0.96 | 0.95 | 0.56 | 0.50 | 0.53 | 0.91 |
| Baseline | 0.90 | 1.00 | 0.95 | 0.00 | 0.00 | 0.00 | 0.90 |

Table: Precision, recall and accuracy scores for Boosted Learner (10-fold cross-validation)

- high precision for both classes
- recall on the REL class lags behind
- morph-feature is highly valuable for REL class
- boosting benefits from collapsing sparse features into groups
Selective Evaluation of Class Volatility

| Type               | ATTR Tokens | REL Tokens | IMPOSS Tokens |
|--------------------|-------------|------------|---------------|
| beautiful (ATTR)   | 50          | 0          | 0             |
| black (ATTR)       | 35          | 7          | 8             |
| bright (ATTR)      | 45          | 1          | 4             |
| heavy (ATTR)       | 42          | 0          | 8             |
| new (ATTR)         | 50          | 0          | 0             |
| civil (REL)        | 0           | 49         | 1             |
| commercial (ATTR)  | 5           | 44         | 1             |
| cultural (REL)     | 2           | 48         | 0             |
| environmental (REL)| 0           | 48         | 2             |
| financial (REL)    | 0           | 46         | 4             |

Table: Volatility of prototypical class members

- average class volatility on the token level: 8.6%
- rough estimate of the error introduced by raising the classification task to the type level
Prospects of adjective classification for ontology learning:

- attribute/role distinction on the basis of adjectives alone is difficult even for human judges
- property-denoting and relational adjectives can be automatically distinguished at high precision for both classes
  - even with small and skewed training data
  - even in the absence of a morphological lexicon (see paper)

What else?

- classification on the type level is justified by tolerable degree of class volatility
- shallow feature set should be easily applicable to specialized domains and adaptable to different languages
Thank you for your attention!
Any questions?