A Sentimental Education: Sentiment Analysis Using Subjectivity Summarization Based on Minimum Cuts

Thierry Goeckel

Department of Computational Linguistics

November 25, 2010

Outline

1. Introduction
2. Method
   - Architecture
   - Context and Subjectivity Detection
   - Cut-based classification
3. Evaluation Framework
4. Experimental Results
   - Basic Subjectivity extraction
   - Incorporating context information

Why Sentiment Analysis

- Opinion rather than facts
- Useful for companies and recommender systems to create subjective summaries

Why Sentiment Analysis

- Opinion rather than facts
- Useful for companies and recommender systems to create subjective summaries

Document Polarity Classification

- Polarity in movie review: “thumbs up” or “thumbs down”
- Previous approaches focused on selecting indicative lexical features as in “good” or “bad”

Document Polarity Classification

- Polarity in movie review: “thumbs up” or “thumbs down”
- Previous approaches focused on selecting indicative lexical features as in “good” or “bad”

Subjectivity Approach

1. Labeling of sentences as either subjective or objective
2. Apply a standard machine-learning classifier to the extract

Subjectivity Approach

- Irrelevant or even potentially misleading text is not considered
- Subjectivity extracts accurately represent the sentiment in a compact form
- Results show statistically significant improvement or maintain the same level with a lot less data
- Minimum cut formulation provides an efficient, intuitive and effective means for integrating inter-sentence-level contextual information with traditional bag-of-words features.

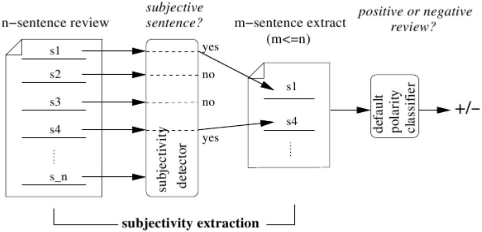
Outline

1. Introduction
2. Method
   - Architecture
   - Context and Subjectivity Detection
   - Cut-based classification
3. Evaluation Framework
4. Experimental Results
   - Basic Subjectivity extraction
   - Incorporating context information

Subjectivity Detector

- Determines whether sentence is subjective or not
- Combination of sentence-level subjectivity detection with document-level sentiment polarity

Subjectivity Detector



Outline

1. Introduction
2. Method
   - Architecture
   - Context and Subjectivity Detection
   - Cut-based classification
3. Evaluation Framework
4. Experimental Results
   - Basic Subjectivity extraction
   - Incorporating context information

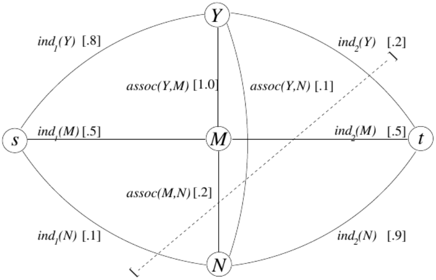
Context and Subjectivity Detection

- *Coherence*: sentences not classified in isolation
- Achieved by an efficient and intuitive algorithm relying on finding *minimum cuts*

Outline

1. Introduction
2. Method
   - Architecture
   - Context and Subjectivity Detection
   - Cut-based classification
3. Evaluation Framework
4. Experimental Results
   - Basic Subjectivity extraction
   - Incorporating context information

Concepts



- *Classes* $C_1$and C_2: positive and negative classes
- *Individual* scores $ind_j(x_i)$: non-negative estimate of each item x_i's preference for being in C_j
- *Association* scores $assoc(x_i, x_k)$: non-negative estimate of how important it is that x_i and x_k be in the same class.

Partition Cost

$$\sum_{x \in C_1} ind_2(x) + \sum_{x \in C_2} ind_1(x) + \sum_{\substack{x_i \in C_1, \\ x_k \in C_2}} assoc(x_i, x_k).$$

Definition

A cut *(S, T) of G is a partition of its nodes into sets $S = \{s\} \cup S'$ and $T = \{t\} \cup T'$, where $s \notin S'$, $t \notin T'$. Its* cost *cost(S, T) is the sum of the weights of all the edges crossing from S to T. A* minimum *cut of G is one of minimum cost.*

Practical Advantages

- Co-ordination of algorithms deriving the individual scores and methods assigning the association scores.
- Use of *maximum-flow* algorithms with polynomial asymptotic running times

Default Polarity Classifiers

- Test data contains 1000 positive and 1000 negative reviews of movies released pre-2002
- Default popularity classifiers
  - Tested: support vector machines (SVMs)
  - Tested: naive Bayes (NB)

  - Used: Unigram-presence features

Default Polarity Classifiers

- Test data contains 1000 positive and 1000 negative reviews of movies released pre-2002
- Default popularity classifiers
  - Tested: support vector machines (SVMs)
  - Tested: naive Bayes (NB)

  - Used: Unigram-presence features

Subjectivity Dataset

- Web mining on rottentomatoes.com and imdb.com
  - Subjective data: 5000 “snippets” from rottentomatoes.com
  - objective data: 5000 sentences of plot summaries from imdb.com
  - “snippets” and sentences at least ten words long and from movies released after 2001 (to prevent overlap with polarity dataset)

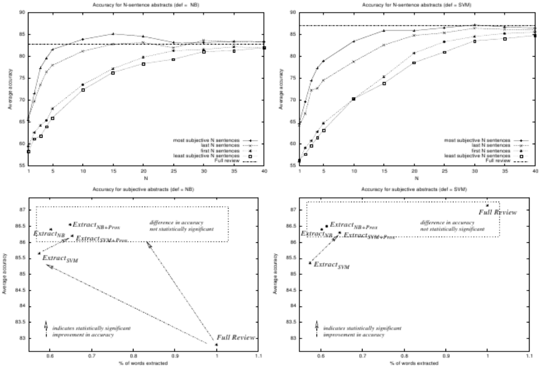
Subjectivity Detectors

- Polarity classifiers as “basic” sentence-level subjectivity detectors
  →to produce extracts of original reviews
- Creation of a family of cut-based subjectivity detectors
  →determine the subjectivity status of all the sentences per-item and pairwise relationship information
  - Using either Naive Bayes or SVMs
  - Association scores set either to zero
  - or to degree of proximity controlled by three parameters:
    - Threshold T: maximum distance of two sentences to be still “proximal”
    - Non-increasing function $f(d)$: decay of influence of proximal sentences with respect to distance d
    - The constant c: controls the relative influence of the association scores

Experiments

- First, the basic subjectivity extraction algorithms (on sentence-level) are examined
- Second, the more sophisticated form of subjectivity extraction with context information is evaluated (using min-cut paradigm)
  →Subjectivity extracts improve polarity classification, otherwise at least same accuracy as with the full review
  →The created extracts are both smaller and more effective as input to a default polarity classifier than the original text

Results


Accuracy for N-sentence abstracts (def = NB)
Average accuracy
N
90
85
80
75
70
65
60
55
1
5
10
15
20
25
30
35
40
most subjective N sentences
last N sentences
first N sentences
least subjective N sentences
Full review
Accuracy for N-sentence abstracts (def = SVM)
Average accuracy
N
most subjective N sentences
last N sentences
first N sentences
least subjective N sentences
Full review
Accuracy for subjective abstracts (def = NB)
Average accuracy
% of words extracted
87
86.5
86
85.5
85
84.5
84
83.5
83
0.6
0.7
0.8
0.9
1
1.1
Extract_NB+Prox
Extract_NB
Extract_SVM+Prox
Extract_SVM
difference in accuracy
not statistically significant
indicates statistically significant
improvement in accuracy
Full Review
Accuracy for subjective abstracts (def = SVM)
Average accuracy
% of words extracted
Full Review
Extract_NB+Prox
Extract_NB
Extract_SVM+Prox
Extract_SVM
difference in accuracy
not statistically significant
indicates statistically significant
improvement in accuracy

Outline

1. Introduction
2. Method
   - Architecture
   - Context and Subjectivity Detection
   - Cut-based classification
3. Evaluation Framework
4. Experimental Results
   - Basic Subjectivity extraction
   - Incorporating context information

Basic Subjectivity Extraction

- NB produces better results than SVM method
- Achieves 86,4% (vs. 82,8% without extraction)
  →Extracts preserve (and even clarify) the sentiment underlying the original document
- Subjectivity extracts are much more compact than original reviews
  →about 60% of the source's words
- Tests with varying lengths and positions in the text
  →Extracts containing as few as 5to 15 sentences are almost as informative as the full review

Outline

1. Introduction
2. Method
   - Architecture
   - Context and Subjectivity Detection
   - Cut-based classification
3. Evaluation Framework
4. Experimental Results
   - Basic Subjectivity extraction
   - Incorporating context information

Incorporating context information

- Context-aware graph-based subjectivity detectors create more informative extracts
- But: extracts are longer
- Further tests: reduce the association scores for sentences in different paragraphs
  →Graph-cut formulation produces better results than standard classifiers

Summary

- Relation between subjectivity detection and polarity classification shows that the former can compress reviews and still retain polarity information
- Using contextual information via the minimum-cut framework leads to an improvement in polarity-classification accuracy

References I

Pang, Bo and Lillian Lee
A sentimental education: Sentiment analysis using subjectivity summarization based on minimum cuts.
In *Proceedings of the 42nd ACL*. 271–278, 2004.