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Aspect-Object Alignment Using Integer Linear Programming

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Outline

- Introduction
- Related Work
- Method
- Experiments
  - Experimental Setup
  - Results and Discussion
- Conclusion and Future work

Introduction

- Target Extraction
  - composed of object and aspect

> I bought [Canon 600D]^{o} yesterday, its [photos]^{a} are amazing.
>
> Target: <photos, Canon 600D>

- Problem
  - Object-ignoring
- Two subtasks of target extraction
  - Aspect/object extraction
  - Aspect-Object Alignment
    - Find the correct, corresponding object for each aspect

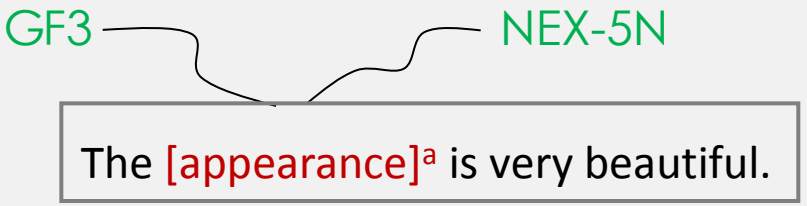
Introduction

- Importance of Aspect-Object Alignment
  - Co-occurrence of aspects and objects in a same sentence
    - 10% aspects can explore its objects in the same sentence

    - SHOULD explore the objects for most aspects in other sentences

Motivation

- Initial Idea
  - Binary classification
    - <aspect, object> candidates
  - Drawback
    - Each decision independently of previous ones in a greedy way



- How to solve?
  - Post-processing
  - Integer Linear Programming as an optimization problem
    - Intra-sentence constraints
    - Inter-sentence constraints

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Related work

- Aspect extraction
  - Rule-based method
  - Supervised method
  - Topic model based method
- Entity assignment task
  - assign objects to each sentence
- Coreference resolution
  - aspect can be treated as anaphor, and object can be treated as entity

few researchers are studying on the aspect-object alignment task

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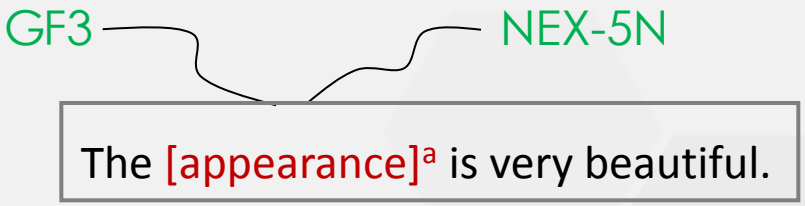
Method

- Two steps
  - Learning an aspect-object alignment classifier
    - To estimate the probability for each pair of aspect and object
  - Problem
    - Objects assigned to aspects in a sentence often contradict each other
      - each aspect has only one object



  - ILP inference
    - Use ILP as an inference procedure to make a final decision that is consistent with the constraints
    - Achieve an optimal global result by considering specific special constraints

Step1: aspect-object alignment classifier

- Generate the Cartesian product of all the aspects and objects in each review into a pair-wise vector <*a*, *o*>
- Classify each <*a*, *o*> into true or false
- We use a maximum entropy model for the aspect-object alignment classifier

Step1: aspect-object alignment classifier

- Features

Category	In detail
Basic Features	Sentence type feature
	Comparative sentence feature
	Object feature
Relational Features	Distance between present and previous sentence
	Distance between present and nearest sentence
	Consistency between the object in previous sentence and the candidate object in <a, o>
	Consistency between the object in nearest sentence and the candidate object in <a, o>
Special Target Features	First appearing object in the review
	Most frequent object in the review

After Step1

- In an ideal setting
  - Has a perfect aspect-object alignment classifier, each aspect can obtain the correct object according to the classifier's prediction
- In reality
  - Objects assigned to aspects in a sentence often contradict each other

Step2: ILP Inference

- Formally,
  - aspect set: A = {a_1, a_2,……, a_n}
  - object set: O = {o_1, o_2, ……, o_m}
  - the resulting object set for the aspects in A: S = {s_1, s_2, ……, s_n}
- Maximizing the overall score of the aspects in a review
  - Aspect-object assignment classifier attempts to assign object from *O* for each a_i in set *A*

optimal result ← $\hat{S} = argmax \sum_{i=1}^{n} p(a_i, s_i)$ → likelihood of assigning label s_i for aspect a_i

Step2: ILP Inference

optimal result

$$\hat{S} = argmax \sum_{i=1}^{n} p(a_i, s_i)$$

likelihood of assigning label s_i for aspect a_i

a set of binary indicator variables is introduced

$$\hat{Z} = argmax \sum_{i=1}^{n} \sum_{j=1}^{m} p_{ij} z_{ij}$$

represents the probability of the pair of the i^{th} aspect in A and j^{th} object in O.

binary indicator variables $z_{ij} \in \{0, 1\}$

Subject to

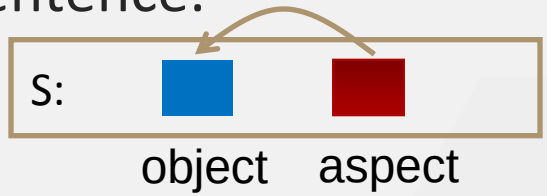
Constraint 1

$$\sum_{j=1}^{m} z_{ij} = 1, \qquad \forall z_{ij} \in Z$$

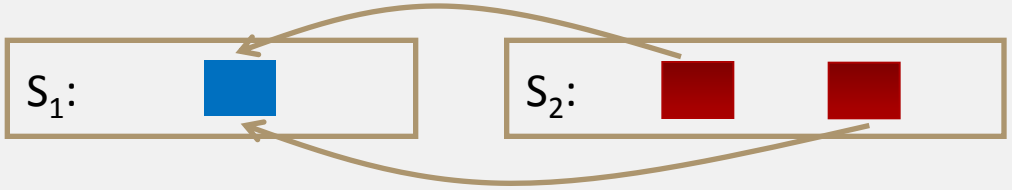
each aspect can take only one object

Constrains

- intra-sentence constraints
  - They describe the constraints between objects and aspects or between two aspects, where the objects and aspects appear in a same sentiment sentence.



- inter-sentence constraints
  - They describe the constraints between objects and aspects or between two aspects, where the objects and aspects appear in different sentiment sentences.



Intra-sentence Constraints

- Constraint 2
  - If the aspect a_p and a_q are in the same sentence s, and no object appears in the sentence, then a_p has the same object as a_q has.

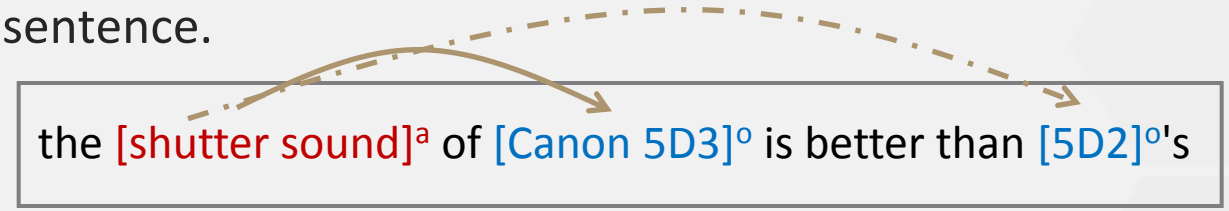
=

It has a good [resolution]^a and a good [LCD screen]^a

$$\forall j \in \{1, ..., m\}: \quad z_{pj} = z_{qj},$$

Intra-sentence Constraints

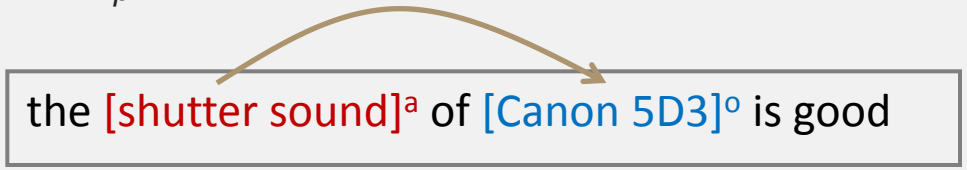
- Constraint 3
  - This constraint is available only when the given sentence *s* can satisfy three conditions: (1) *s* is a comparative sentence; (2) *s* contains two objects o_k and o_t, which appear on both sides of the comparative word; and (3) only one aspect a_p appears in this sentence. Then the corresponding object for a_p is one of the two appearing objects in the given sentence.



$$z_{pk} + z_{pt} = 1,$$

Intra-sentence Constraints

- Constraint 4
  - This constraint is available only when the given sentence *s* can satisfy two conditions: (1) *s* contains only one aspect a_p and one object o_k; and (2) this sentence is a normal sentence. Then the corresponding object for a_p is the object o_k.



$$z_{pk} = 1,$$

Inter-sentence Constraints

- Many previous research illustrate that adjacent sentences in a review have particular sentiment relationships.
  - The sentiment orientations for two adjacent sentences are always the same or totally different (because of the usage of transitional words, such as “but”), which is named as “sentiment consistency.”
- This idea is also very useful for the aspect-object alignment task.

Inter-sentence Constraints

- Constraint 5
  - This constraint is available only when the given sentence s_g can satisfy three conditions: (1) s_g only contains an aspect a_p, but no object; and (2) the previous sentence s_p is a normal sentence, which contains an aspect a_0 and an object o_k; and (3) the sentiment orientation of s_g is the same as that of s_p. Then the corresponding object for a_p is the object o_k in the previous sentence s_p.

$$z_{pk} = 1,$$

Inter-sentence Constraints

- Constraint 6
  - This constraint is available only when the given sentence can satisfy two conditions: (1) the given sentence s_g contains an aspect a_p, but no object; and (2) the previous sentence s_p is a comparative sentence, and contains two objects ok and o_t, which appear on both sides of the comparative word and ok is in front of o_t. If the given sentence shows the same sentiment orientation as the previous sentence, then the corresponding object for a_p is the object ok in the previous sentence. However, if the given sentence shows a different sentiment orientation with the previous sentence, the object for a_p is o_t.

the [shutter sound]^a of [Canon 5D3]^o is better than [5D2]^o's. The [picture quality]^a is good, too."

$$z_{pk} = 1, \quad if\ polarity(s_g) = polarity(s_p)$$
$$z_{pt} = 1, \quad if\ polarity(s_g) = -polarity(s_p),$$

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Experimental Setup

- Corpus
  - http://ww.xitek.com/
  - http://www.fengniao.com/

Table 1. Statistics for the corpus

No.	Types	Digital camera
1	# of reviews	200
2	# of sentences	8,042
3	# of aspects	2,017
4	Average # of object for each review	2.82
5	# of pairwise $\langle a, o \rangle$	9,161

Experimental Setup

- Baselines
  - Baseline1: a cascading rule-based approach, which is similar to the method of Ding et al.
  - Baseline2: the aspect-object alignment classifier without the ILP inference

Results

Table 2. Comparative results of our method and two baselines

Method	*Accuracy*(%)
Baseline1: cascading rule-based	78.04
Baseline2: aspect-object alignment classifier	81.80
Our ILP inference method	**83.69**

Results

Table 3. Results of aspect-object alignment with different ILP constraints

Constraints	ILP constraints	*Accuracy* (%)
Intra-sentence constraints	ILP-c1	81.80
	ILP-c2	81.85
	ILP-c3	81.90
	ILP-c4	82.65
Inter-sentence constraints	ILP-c5	82.45
	ILP-c6	82.05
All constraints	ILP-c1-6	**83.69**

Conclusion

- We propose a novel and important sentiment analysis task, aspect-object alignment, which aims to resolve the “object ignoring” problem in target extraction.
- We propose a two-step framework for this task, including an aspect-object alignment classifier and an ILP inference.

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Thanks Q&A