Using Clustering Engine and Selectional Preference to Generate Targets in Conceptual Metonymies

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ABSTRACT. *The finding of the target for conceptual metonymy is critical for natural language understanding. We make use of the character of concept metonymy: it often occurs on the objects of verbs under the mode of "relevant vehicle instead of target". The difficulties lie in this relevance of vehicle and target is embodied in real-world knowledge or subjective experience. We applied an integrated model for generating the targets of metonymies. First, clustering engine is queried to get the related words of the vehicle word. Second, word similarities between the verb-noun selectional restrictions and the related words are calculated to locate the target words. The experiments on typical metonymies achieved 0.67 and 0.79 for the precision and recall when the top3 candidates are evaluated.*

Keywords: metonymy, selectional restriction, clustering engine, word similarity

1 **Introduction**. Metonymy uses one entity to refer to another that is related to it. It is widely used in texts and communications, and conceptual metonymy (nominal metonymy) is the most important type of it. In the following three sentences(1)-(3), "piano" stands for sound or music, "Shakespeare" stands for his works, and "Beethoven" stands for his wonderful music.

(1) She heard the piano. (target: sound or music from piano)
(2) I am reading Shakespeare. (target: Shakespeare's works)
(3) He loves to listen to Beethoven. (target: Beethoven's music)

Conceptual metonymy is traditionally treated in two ways by linguists. The first way is to take the vehicle and target as high related entities. According to [1], metonymies allow speaker to use one entity to stand for another. [2] defines metonymy in terms of the highlighting of parts of a domain. As in sentence (1), the piano highlights the sound/music, because piano and sound/music are closely related. In the work of [3], the authors summarize the types of metonymies, like whole-part, form-concept, and producer-product, which describing the relations between the vehicle and target.

The second is proposed by [4]. He does not agree that the metonymy is only caused by nouns, but also the predicates which determine the highlighted facets of nouns in context. He takes the process as "active zone analysis". When it is used to explain sentence (1), "piano" has many facets like "can be played", "can make sound/music", "have a keyboard" etc. It is the predicate "heard" that activates the sound/music facet of piano.

Combining the two ways, [5] proposes a ranking algorithm for detecting the target of Chinese conceptual metonymy in sentences by using selectional restriction (SR) to get the target noun from the relevant words. The model works well on 5 Chinese words. It gets the target of metonymies of 5 words in sentences, such as 红领巾 (*red scarf*) for 少先队员 (*Young Pioneer*), 大盖帽 (*peaked hat*) for 警察 (*policeman*) and 贝多芬 (*Beethoven*) for 交响乐 (*symphony*). However, they do not give an integrated formula for their model, and the clustering engine for obtaining relevant words has been shut down at 2009. In this paper, we want to make a clearer description and evaluation measure of the algorithm, and extend the work to detect the target of English conceptual metonymies.

The article is organized as follows: section 2 outlines the related works; section 3 implements the algorithms in detail; and section 4 experiments on 12 nouns, the results are analyzed. At last section 5 draws the conclusions.

2 Related Work. There are three ways to understand metonymy automatically. [6] classifies the literal use, metaphor use and metonymy use of nouns in English by the SR of the verbs to its arguments. [7] gets the selectional restriction from large scale corpus for the recognition of metonymy use. [8-9] model the relationship between the vehicle and target as word sense disambiguation. [10] organizes the first metonymy resolution contest for country names and organization names. All of these computational works take the metonymy understanding as classification tasks, and thus could not generate the target in noun metonymies. However, all of them use the selectional restriction as a basic method which is similar to Langacker's "active zone analysis". If the semantic class of noun phrase mismatches the SR of the predicate in a sentence, then the noun phrase does not hold its literal meaning but the metaphor or metonymy use. As in sentence(1), the SR of the verb "hear" is sound or information, while the semantic class of the "piano" is instrument which disobeys the SR of "hear". Thus the verb-object phrase "hear piano" is beyond the literal meaning. [5] combines this method with word relevance and proposes a intergraded model for the generation of the target in conceptual metonymies. First, they get the relevant words by the clustering engine (www.bbmao.com, which has been shut down in June 2009.).

Secondly, they get the verb-noun SR applying the semantic hierarchy of HowNet (ver 2000). Thirdly, they compute the similarities between the SR and relevant words based on HowNet. We describe the model as formula (1).

$$TARGET(p, vc) = \arg\max_{n_j} SR(p, c_i) * WR(vc, n_j) * sim(c_i, n_j) \quad (1)$$

Selectional Restriction Set $\{c_i\}$ ($i \in [1,m]$), where p is the predicate, c_i is the semantic class of the SR of a predicate. The function SR calculates the strength of the SR. Relevant Words Set $\{n_j\}$ ($j \in [1,n]$), where n_j is the relevant words of the vc(vehicle). Function WR calculates the relevance of the words. Function Sim gets the similarity value between the semantic class of SR and the vehicle.

However, it is not easy to get SR and WR. First, the automatic extraction of selectional restriction often gets semantic classes at high level on a hierarchy tree[11]. Second, the relevant words of a word often change with domain and time. Then, The model draws back to a simplified one in formula (2), which ignores the values of the two functions.

$$TARGET(p, vc) = \arg\max_{n_j} sim(c_i, n_j) \quad (2)$$

Here, c_i is the representative word of the semantic class, like “human” for the class “human”, and n_j is the relevant word returned by clustering engine. This simplified model works well on Chinese metonymy sentences in [5]. We want to test it on English sentences of metonymies.

3 **Algorithm Implementation.** For the purpose of adapting the model on English metonymies, we used another clustering engine to get the relevant words, and compute the word similarities based on WordNet 3.0.

3.1 **Relevant Words Acquisition.** A word may be related to many words on many relations, but the relevant value must be high when it is used as a vehicle. Besides, the relevance may change with time. There are many studies and systems on acquiring relevant words. Among them, clustering search engine (CE) is an efficient tool to gain related words in real time. CE is a kind of meta-search engine which supplies the clustered results of ordinary search engines like Google and Bing. The most famous CE are vivisomo (www.vivisimo.com) and Carrot^2 [12]. Carrot^2 is an open source CE, which applies two clustering algorithms, Lingo and STC. The former gives longer phrases as clustered labels, while the latter gives short ones. Carrot^2 also allows users to set some parameters for clustering, while we just use the default settings of STC. Table 1 shows the top 15 clustered labels for 6 nouns. The numbers of the pages are listed in the brackets. Search date: 1-15-2011.

The clustering labels are the relevant words or phrases of the 6 words. The labels can be divided into 4 types. First, there are the full names or carrier of the word like “Ludwig van Beethoven”. Second, the target words of metonymies, which are in italic like “symphony”. Third, words high related to the persons, like “arts”. And there are many other labels supplying extra links like “YouTube” and “Wikipedia”. We use all these labels as candidates to compute the possibilities of being the targets.

TABLE 1. Top15 Clustering Labels of 6 Words by Carrot[2]

Beethoven	Shakespeare	Piano	Headphone	McDonald	Bottle
Ludwig van Beethoven(34)	William Shakespeare(37)	***Music***(26)	Pair of Small Loudspeakers (5)	Job and Career(3)	Baby Bottle Tooth Decay(9)
1770(9)	Shakespeare's Globe Theatre(5)	Piano Lessons(13)	Headphone(21)	McDonald's Corporation(8)	Mouth(10)
Music(21)	Shakespeare's(23)	Musical Instrument(9)	Stereo Headphones (11)	Restaurant Locator(5)	Bottles(20)
Beethoven's (21)	Works of William Shakespeare(6)	Play(13)	***Audio***(20)	McDonald Born(7)	Glass(15)
Bonn(13)	William Shakespeare 1564 1616(3)	Sheet Music(6)	Noise Cancelling(7)	Restaurant(11)	Plastic(13)
German Composer(5)	***Complete Works***(7)	Musical(10)	Sennheiser(18)	***Food***(11)	Bottle Cap(6)
Film(8)	***Works***(12)	Learn(9)	Wireless(18)	Information(10)	***Water***(9)
Symphony(11)	***Plays***(11)	Pianos(9)	High(9)	Wikipedia(9)	Plastic Bottles(5)
Composer(10)	Web(11)	Keyboard(9)	***Noise***(13)	Restaurants(9)	Water Bottles(4)
Classical(9)	Open Source Shakespeare(3)	World(6)	Reviews(12)	***Fast Food***(4)	***Wine***(7)
Works(9)	Shakespeare Fishing Tackle(3)	Learn how to Play(3)	***Music***(12)	McDonalds.com (7)	Information(7)
Classical Music(4)	Company(10)	Mp3(5)	Earphones(12)	Nutrition(6)	Container(6)
Ludwig van Beethoven's (4)	Theatre(10)	Course(5)	***Sound***(12)	Restaurant Chain(3)	Glass Bottles(3)
Work(7)	Information(8)	Information(5)	Sony(11)	Encyclopedia(5)	Early Childhood(3)
YouTube(7)	***Shakespeare's Plays***(4)	Play the Piano(5)	Products(10)	World(5)	2010(5)

3.2 **Selectional Restriction.** Usually the selectional restriction (SR) of a verb is described with semantic labels(classes or features) by linguists. For example, the verb “eat” determines “food” as its object. The classes or features may vary according to different semantic taxonomies or different linguists. However, we can use the word “food” as the SR label of “eat”. It benefits a lot when we could not be sure which one is the best semantic label for the description of the SR, especially when the labels are synonyms. Table 2 shows the SR to objects of 5 predicates. Take the verb phrase "listen to" for an instance, its SR may be given as "sound" or "information". We compare the word similarities of 2 SR labels (see Table 3) for "listen to Beethoven". Both got "music" and "classical music" as targets.

TABLE 2. Selectional Restrictions of Predicates to Object Nouns

Predicate	Selectional Restriction	Noun
listen to	sound	Beethoven, Mozart, headphone
hear	sound	piano, guitar, violin
read	information	Shakespeare, Mark Twain
eat	food	McDonalds, KFC
drink	liquid	bottle, Rémy Martin

TABLE 3. Similarities between Cluster Labels and Selectional Restrictions of Beethoven

Labels	sound-WN	information-WN	Labels	sound-WN	information-WN
Ludwig van Beethoven(34)	0.080773	0.083231	Composer(10)	0.074671	0.085991
1770(9)	-1	-1	Classical(9)	0.078949	0.121499
Music(21)	***0.867544***	***0.186278***	Works(9)	0.074109	0.083519
Beethoven's(21)	-1	-1	Classical Music(4)	***0.867544***	***0.186278***
Bonn(13)	0.055857	0.061958	Ludwig van **Beethoven**'s(4)	-1	-1
German **Composer**(5)	0.074671	0.085991	Work(7)	0.159969	0.165525
Film(8)	0.106296	0.115978	YouTube(7)	-1	-1
Symphony(11)	0.066382	0.094087			

3.3 **Word Similarity.** Word similarity is calculated by lexical semantic taxonomies like [13] or distributional patterns [14]. We use Jiang's algorithm to measure the similarity (from 0 to infinity) between any two words with WordNet 3.0. For the clustered labels composed of over 2 words, we used the last word in it to get the similarity. When a word is not included in WordNet 3.0, a value of -1 is given as its similarity (see Table 3).

4 **Experiment Results and Analysis.** We test the algorithm on 12 nouns which are typically used as vehicles of metonymies. For each noun, the top15 clustered labels of it are

scored by the similarity with the selectional restriction word. Thus, we get a rank of the similarities for each noun.

4.1 **Experiment Results.** To evaluate the results, three graduates of linguistics are invited to make their judgments on which labels are acceptable or unacceptable as targets from the top15 clustered labels. Table 4 shows the top3 clustered labels whose similarities are most high, and the recall rate of the top3. Star means the labels are unacceptable as targets among all the 12 nouns, the first labels are all correct except "Shakespeare". So the average precision and recall rate for the first label is 0.92/0.50. For top 2 and top 3 the labels are 0.75/0.67 and 0.67/0.79.

TABLE 4. Top3 Labels for the Metonymy Targets of 12 Nouns

Noun	**SR**	**1st Label**	**Similarity**	**2nd Label**	**Similarity**	**3rd Label**	**Similarity**	**Recall**
Beethoven	sound	Music	0.867544	Classical Music	0.867544	Works	0.159969	3/4
Mozart		Music	0.867544	*Life	0.095625	*Musical	0.083406	1/1
Headphone		Audio	Infinity	Noise	1.343291	Music	0.867544	3/4
Piano		Music	0.867544	*Sheet Music	0.867544	*Play The Piano	0.160329	1/1
Guitar		Music	0.867544	*Bass	0.180375	*Learn How To Play	0.103811	1/1
Violin		Music	0.867544	*International Violin Competition	0.113004	*Play	0.103811	1/1
Shakespeare	infor-mation	*Information	Infinity	Works	0.165525	Plays	0.132858	2/4
Mark Twain		Works	0.165525	*Writer	0.098789	*American	0.094087	1/3
Mcdonalds	food	Food	Infinity	Fast Food	0.95364	Nutrition	0.108369	3/3
KFC		Food	Infinity	Fast Food	0.251672	Kentucky Fried Chicken	0.144671	3/4
Bottle	liquid	Water	0.27759	Wine	0.13365	*Glass	0.12409	2/2
Rémy Martin		Cognac	0.083536	Fine Champagne Cognac	0.083536	Heart Of Cognac	0.083536	3/6

4.2 **Analysis and Discussion.** The results of the experiment are very encouraging because the first label whose similarity is most high is almost the target of the metonymy. Together with [5]'s experiment on Chinese, the method testify the arguments on which factor determines the metonymy, relevant or selectional restriction. The results support the integrated model considering both the two factors. It is worthwhile to notice that the cluster labels to serve as different targets for different verbs. For example, in "repair the piano", the label "Musical Instrument" and "Keyboard" can be explicit meaning of what is repaired. Nevertheless, there are still some problems with the model.

First, not all the predicates have strict selectional restrictions on its objects. The verbs like "look", "love" and "buy" can be followed by nearly all kinds of nouns. However, this could not deny the effectiveness of the model, because the restriction to the nominal phrase is not only by its predicate, but also by other words in larger contexts. So the experiment can be extended to other metonymies in other syntax structures.

Second, WordNet is not very suitable for similarity computation. In our experiment, the lowest recall word is "Mark Twain". There are another 3 good targets in the top 15 clustering labels "Huckleberry Finn", "Mississippi River" and "Tom Sawyer" which are not included in WordNet. In the future, we may use other resources and algorithms for the calculation of word similarities.

Third, the model needs a prior process classifying the sentences to be metonymies. Thus, there are two choices for the development for our model. On one hand, we can add a single preprocess to do the classification work, or we may design a more integrated model for metonymy understanding.

5. **Conclusions and Future Works.** In this paper, we extend [5]'s work to generate the target of metonymies in English, by ranking the similarities between the selectional restriction and the labels gained from clustering engine. Cluster engine supplies world knowledge for the relevance of words, and selectional restrictions filter the relevant words by the similarities, which simulates the human understanding process of metonymies. The experiments on 5 predicates and 12 nouns get the precision of 0.75 and recall rate of 0.79 for the top 3 candidates.

In the future, we will conduct more experiments on more metonymy instances, find better means to calculate the word similarities, and to develop a higher integrated model for conceptual metonymy understanding.

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