

The Knowledge Representation for Comparison Words in Extended-HowNet

Shu-Ling Huang, Yueh-Yin Shih, Keh-Jiann Chen

Institute of Information Science

Academia Sinica, Taipei, Taiwan

{josieh, yuehyin}@hp.iis.sinica.edu.tw , kchen@iis.sinica.edu.tw

Abstract

In this paper, we study the semantic representations of comparison words and comparative constructions under the frameworks of E-HowNet and to see how the mechanism of semantic composition works. Our methodology is to establish a mapping between grammatical structures and fine-grained event structures for comparative constructions. We encode event structures of comparative constructions as parts of representations of comparison words. The fine-grained semantic roles are adopted from FrameNet. A semantic composition mechanism was established to unify word sense representations under syntactic constraints. Coercion and filling semantic gaps are integral parts of the process. Fully automatic semantic composition will be our ultimate future goal.

1. Introduction

Lexical knowledge representation has become a major research area for natural language processing in recent years, because it helps to bridge gaps between string processing and conceptual processing. In this paper, we try to represent the senses of comparison words and comparative constructions under the frameworks of E-HowNet (Chen et. al., 2005) and to see how the mechanism of semantic composition works. The E-HowNet is a frame-based entity-relation knowledge representation model evolved from HowNet (Dong, 1988). E-HowNet is an on-line common-sense knowledge base which extends the word sense definition mechanism of HowNet and uses WordNet (Fellbaum,1998) synsets as vocabulary to describe concepts. In principle, the qualia structure is the major features for a nominal-type concept (Pustejovsky, 1995) and event frames are for eventive concepts (Fillmore, *FrameNet*). For instance, the concept of ‘vintage’ is defined as:

(1) vintage|佳釀

def: {drinks|飲品:

qualification={nice|良好},

telic={addict|嗜好: patient={~}}

Under the framework of E-HowNet, concepts are linked by the conventional taxonomic relations, such as synonymy, hypernymy, antonymy, meronymy and by their attribute features. In the above example, 'drinks' is the hypernymy of 'vintage'. 'Qualification' is a feature of quia structures which links the attribute 'nice' to the concept 'drinks'. And 'telic' denotes the purpose and function of 'vintage' which connects event 'addict' to 'drinks'.

In real implementation, we found that senses of content words and function words are different and should have different representations. Function words usually mark certain grammatical or semantic functions. Therefore function words have explicit relational senses and less/without content sense; on the other hand content words have implicit/without relational senses. In E-HowNet senses of function words are represented by semantic roles (Chen et. al., 2005). For instance, 'because' are defined as (2):

(2) because|因爲
def: reason={}

However representations for comparison words are even more complicated, take comparison word '比' as example, its sense is related to a comparative event frame with many event-roles as described in section 2. Also it doesn't have a hypernymy to be used as a head concept for its representation. A comparative event frame describes many conceptual roles involving comparative relations and some of conceptual roles are omitted at surface sentences. Because of the uniqueness and usefulness of comparative constructions, representations of comparison words can be considered as important aspects to attest a well defined knowledge representation system.

In general, the sentence where the comparison word occurs is called a comparative sentence. Comparative sentences are sentences which compare two items and express which of the two have more, less or equal of the quality or attribute and by how much. These core elements compose a comparative construction (CC) (Li&Thompson, 1981). Although the sentence patterns are different, almost every language uses the same elements, that is, comparative items, attribute and variance, to express comparative content. The Berkeley FrameNet project (Fillmore, 1997) integrated them into a frame called 'Evaluative_comparison' to describe a comparison state. This analysis is a semantic approach and it's an important work for construct knowledge representation for comparison words.

In section 2, we will introduce FrameNet's analysis as background works regarding comparative construction. Section 3 describes the methodology of applying comparison frame to interpret comparative sentences. Formal representation for different comparison words and sentences is addressed at section 4. Summarization and conclusion are drawn in section 5.

2. Backgrounds

Most of researches about comparative construction (CC) are focus on what is the syntactic category for comparison words. Are they clauses or complements that are linked by comparison words? And how do we recover the omitted roles of CC? (Li&Thompson, 1981; Hong Wei-mei, 1991; Hsing, 2003) They all took syntactic point of view to discuss the issues and less focused on semantic representation. The Berkeley FrameNet project adopted a semantic approach to analyze CC. It lists and describes ten frame elements (i.e. semantic roles) in a complex frame structure called Evaluative_comparison. The core frame elements include: (a) Attribute, which marks constituents that indicate in which respect Item-1 and Item-2 are contrasted with each other. (b) Profiled_Attribute, which is a particular value on a scale, and is being compared to a Standard_Item or Profiled_Attribute. (c) Profiled_Item, which is the grammatically more prominent one of the items that is compared and realized as the subject. (d) Standard_Attribute, which is used when the standard is a specific value on a scale. (e) Standard_Item, which is the grammatically less prominent element, i.e. the object or an oblique. And the five non-core elements are: (f) Comparison_set, which includes the Standard_Item and is what the Profiled_Item is judged with respect to. (g) Degree, which indicates how close the Profiled_Item and the Standard_Item are to each other on the scale evoked by the Attribute. (h) Manner. (i) Place, which is the location where the Profiled_Item rivals the Standard_Item. (j) Time, it is the time at which the Profiled_Item rivals the Standard_Item. According to the representation cited above, we can analyze sentence (3), (4) as follows:

(3) American caviar now rivals Russia's. (in quality)

Profiled_Item	American caviar
Standard_Item	Russian caviar
(implied) Attribute	quality
Time	now

(4) The current price matches the price last year.

Profiled_Attribute	the current price
Standard_Attribute	the price last year

No matter how different the syntax and sentence patterns are, almost every language shares the same elements as above mentioned.

3. Methodology

Since the schema for comparison frame has been set, it is possible for machine to catch the meaning (i.e. construction meaning) of comparative sentence. To achieve this goal, firstly, we extract the information of grammar, part of speech and thematic roles from sentences through the automatic segmented and parsing process. According to the analysis of FrameNet and (Li & Thompson, 1981), we construct the basic pattern and argument structure for comparison words in Mandarin as (5):

(5) Theme[Np,S] + Contrast [Pp[比]]+ Head[V] + Quantity[DM]

(6) E.g. 張三 比 李四 高 三公分

Zhang-San bi Li-Si gao san gong fen

ZhangSan is three centimeter taller than LiSi

Here, the Theme is referred to Profiled_Item, the fine-grained semantic role of FrameNet; the Contrast is referred to Standard_Item; the Head verb is referred to the Attribute_Value, and the Quantity is referred to the Degree.

Secondly, a mapping table which connects grammatical functions and fine-grained semantic roles is needed, which applies as a bridge that transfers the parsing result to fine-grained semantic roles of comparison frame to help machine finding the corresponding constituents in comparative sentences. The mapping table between fine-grained semantic roles and argument structure is shown in (7):

(7)

Fine-grained Semantic Roles	Thematic Roles	Grammatical Functions
Profiled_Item+(Profiled_Attribute)	Theme	Subject
Standard_Item+(Standard_Attribute) Comparison_set	Contrast	Object[PP[bi]]
Attribute_Value	Head	Verb
Degree	Quantity; Degree	Complement
Manner	Manner	Adjunct (Manner)
Place	Location	Adjunct (Location)
Time	Time	Adjunct (Time)

These semantic roles are linked in the taxonomy of semantic roles for events at E-HowNet (see figure 1). The actual operation under the mechanism will be shown in the following sections.

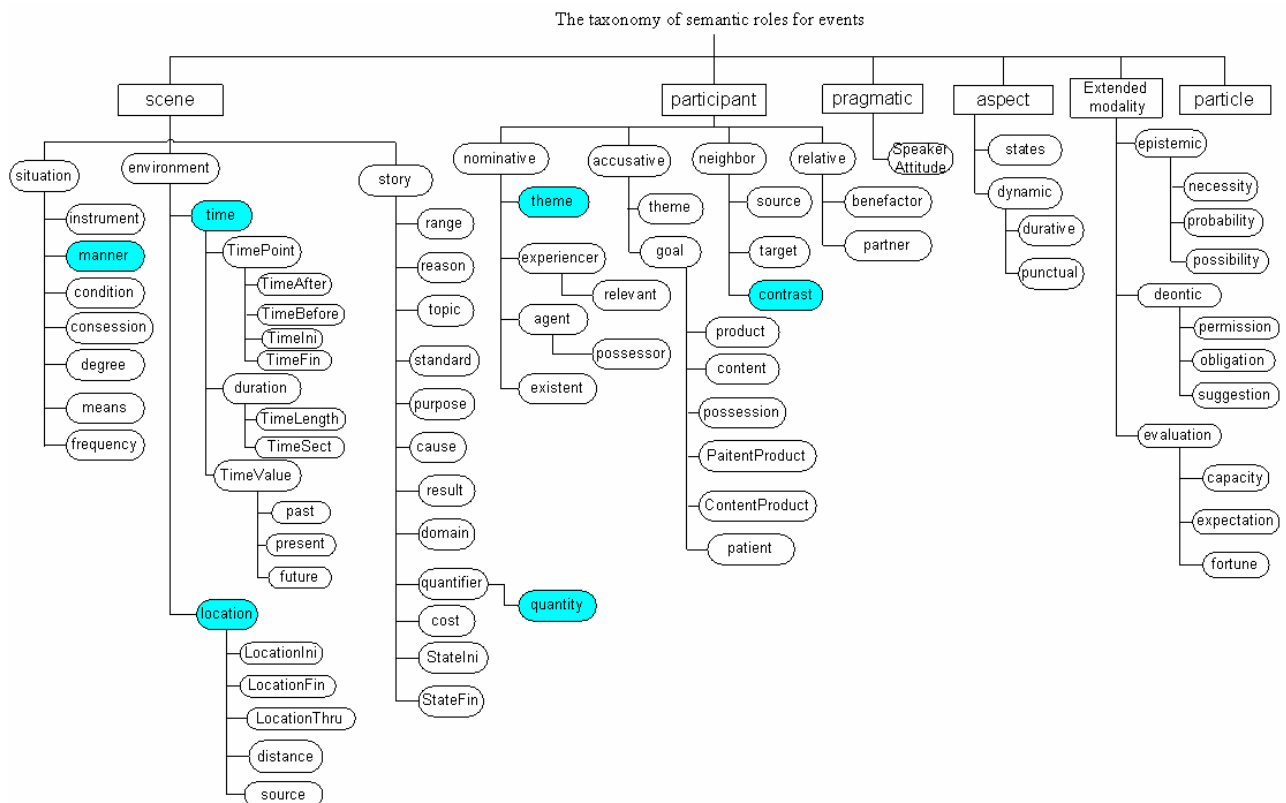


Figure 1

4. Knowledge representation for comparison words

Although there is only one single case frame (argument structure), accompanying with different comparison words, the surface structures of comparative constructions are varied. We thus classify comparison words into three groups. Firstly we discuss ‘bi 比’, the most important comparison word in Mandarin Chinese and its related words. Secondly, we mention the degree adverbs which imply comparative sense. At last, the concepts with implicit comparative relations will be addressed.

4.1 Sense representation for ‘bi 比’

Unlike other comparison words such as ‘taller 高過’, ‘bigger 大於’... etc., ‘bi 比’ doesn’t carry the meaning of comparative attribute. However it is one of the major keywords to indicate comparative constructions. We have to represent the sense of ‘bi’ by comparative event frame (argument structure) which has mentioned before. Accordingly, ‘bi’ can be defined as (8):

- (8) def: contrast={ } in {AttributeValue: theme={ },contrast={ },quantity (or degree)={ }, manner={ }, location={ },time={ }}

In real practice, the constituents of grammatical roles of the following sentences are assigned with respective semantic roles according to their syntactic structures.

(9) 我 比 他 高 一個頭

wo bi ta gao yige tou

I am one head taller than him.

Surface structure: theme[NP]+contrast[PP[比]]+Head[V]+quantity

Parsing result: {tall|高:theme={I|我},contrast={he|他},quantity={one head|一個頭}}

(10) 我 數學 比 你 多 五分

wo shuxue bi ni duo wufen

My math is five points more than yours.

Surface structure: theme[NP]+contrast[PP[比]]+Head[V]+quantity

Parsing result: {more|多:theme={my math|我數學},contrast={you|你},quantity={five points|五分}}

In fact, both sentence (9) and (10) contains ellipses and sense omissions. The restoring process is called Coercion. Coercion is a theory that it changes the compositional semantics, while it leaves the syntactic type unaltered. It's a key procedure for machine to select the right syntactic function and map it to the correct semantic role. In the following discussion, every sentence (*x*) will be assigned with fine-grained semantic roles and restored its complete event structure (*x'*) according to the mapping table (7). Both sentence (9) and (10) contains ellipses and sense omissions. The full interpretation of them are shown in (9') and (10').

(9') 我 的 身高 比 他 的 身高 高 一個頭

wo de shengao bi ta de shengao gao yige tou

My height is one head taller than his height.

def: {tall|高:Profiled_Item={I|我},Profiled_Attribute={height|身高},Standard_Item={he|他}, Standard_Attribute={height|身高},Degree={one head|一個頭}}

(10') 我 的 數學 分數 比 你 的 數學 分數 多 五分

wo de shuxue fenshu bi ni de shuxue fenshu duo wufen

My score of math is five points more than your score of math.

def: {more|多: Profiled_Item={I|我},Profiled_Attribute={score of math|數學分數},Standard_Item={you|你}, Standard_Attribute={score of math|數學分數},Degree={five points|五分}}

In example (9), although the Profiled_Attribute 'height|身高' did not explicitly expressed in the surface sentence, the mapping table (7) and the representation of 'bi' (8) indicated that there is a

missing role of Profiled_Attribute. Furthermore the head verb ‘tall|高’ implied that Profiled_Attribute is ‘height|身高’, since ‘tall|高’ indicates an attribute value of the attribute of ‘height|身高’ described in HowNet. On the contrary, in (10) the subject ‘my math|我數學’ is interpreted as Profiled_Item + Profiled_Attribute. Therefore Profiled_Item is ‘I|我’ and Profiled_Attribute is ‘score of math|數學分數’. However, the word for ‘score’ was missing in the sentence (10) and we cannot rely upon the head verb ‘more|多’ to infer the attribute ‘score’. Instead, the quantity ‘five points|五分’ is the clue to draw the conclusion of Profiled_Attribute being ‘score of math’, since it is a value for attribute ‘score’. Therefore it fills the gap that the Profiled_Attribute is ‘score of math|數學分數’.

In stead of being entities, the structure of Profiled_Item + Profiled_Attribute can be events as well. The following sentence is an example:

(11) 我 飛 得 比 獵鷹 慢
wo fei de bi lieying man
 I fly slower than eagle.

In example (11), the surface form of comparative items is not entities but events. In the case, the restoration process has to recover the complete Standard-Item before derive the full representation of the sentence and by default the attribute of Standard-Item is equal to the attribute of Profile-Item.

Surface structure: theme[S]+contrast[PP[比]]+Head[V]

Parsing results: {slow|慢:theme={fly|飛:agent={I|我}},contrast={eagle|獵鷹}}

Restore ellipsis: {slow|慢:theme={fly|飛:agent={I|我}},contrast={fly|飛:agent={eagle|獵鷹}}}

In above representation, we didn’t adjust the frame structure for ‘bi’ but add another layer under the semantic roles ‘theme’ and ‘contrast’ to show the event structure ‘I fly’ and ‘eagle flies’ and after recovering the attribute ‘speed’ by its value ‘slow’, the full interpretation of (11) become:

(11’) 我 飛 的 速度 比 獵鷹 飛 的 速度 慢
wo fei de sudu bi lieying fei de sudu man

My speed of flying is slower than eagle’s speed of flying.

def: {slow|慢:Profiled_Item={fly|飛:agent={I|我}},Standard_Item={fly|飛:agent={eagle|獵鷹}},Profiled_Attribute={speed|速度}}

Let’s take another sentence as example:

(12) 他 比 我 還 喜歡 你
ta bi wo hai xihuan ni

He likes you more than I.

Surface structure: theme[NP]+contrast[PP[比]]+degree[還,更] +Head[V]+goal[NP]

The semantic-role mapping is:

(12') 他 喜歡 你的 程度 比 我 喜歡 你的 程度 還 多
ta xihuan ni de chengdu bi wo xihuan ni de chengdu hai duo

The degree that he likes you is more than the degree that I like you.

def: {more|多 : Profiled_Item={FondOf|喜歡 :agent={he|他 },target={you|你 }},
Standard_Item={FondOf|喜歡 :agent={I|我 },target={you|你 }},Profiled_Attribute
={degree|程度 }}

In this example, the mapping table and restoration process are more complicated. We add comparative adjective 'more|多' to the sentence as its head. But it doesn't mean we add extra information to the original sentence. In fact, the word 'hai 還' implies the meaning of 'more'. And with the event 'FondOf', we know the implied profiled attribute is 'degree'. Although based on the surface structure of the sentence, the original head is 'FondOf', it apparently doesn't fit the request of CC to be an attribute value. Like 'fly' in example (11), we interpret their event structure in theme (Profiled_Item) and contrast (Standard_Item) while giving representation.

In addition, the negation of 'bi' is 'bu ru 不如' and 'mei you 沒有', we only need to add an logical operator *.NotSo.* in front of the head while we define it. Such as (13), (14):

(13) 那 本 書 沒 有 這 本 書 好
na ben shu meiyou zhe ben shu hao

That book is not better than this book.

(13') 那 本 書 的 內 容 沒 有 這 本 書 的 內 容 好
na ben shu de neirong meiyou zhe ben shu de neirong hao

That book's content is not better than this book's content.

def: {*.NotSo.nice*|良好:Profiled_Item={that book|那本書},Standard_Item={this book|這
本書},Profiled_Attribute={content|內容}}

(14) 張 先 生 不 如 我 跑 得 快
Zhang xian sheng buru wo pao de kuai

Mr. Chang doesn't run faster than I.

(14') 張 先 生 跑 的 速 度 不 如 我 跑 的 速 度 快
Zhang xian sheng pao de sudu buru wo pao de sudu kuai

Mr. Chang's speed of running isn't faster than my speed of running.

def: { .NotSo.fast|快: Profiled_Item={run|跑:agent={Mr.Chang|張先生}}, Standard_Item={run|跑:agent={I|我}}, Profiled_Attribute={speed|速度} }

In example (13), ‘nice’ indicates more than one attribute value of attributes described in HowNet, so the Profiled_Attribute can be ‘content’, ‘price’, ‘design’...etc.. The representation thus depends on the quilia structure of the Profile_Item ‘book’ to derive ‘content’ as the Profiled_Attribute.

By observing the Sinica TreeBank, we found some difficult examples which actually share the same argument structure as basic pattern (5) without exceptions. We try to represent them as follows:

(15) 枝葉 比 以前 更 茂盛 了
zhiye bi yiqian geng maosheng le

Branches and leaves are more exuberant than before.

Parsing result: {exuberant|茂:theme={branches and leaves|枝葉},contrast={past|過去},degree={more|較}}

(15') 現在 的 枝葉 比 以前 的 枝葉 更 茂盛 了
xianzai de zhiye bi yiqian de zhiye geng maosheng le

The branches and leaves now are more exuberant than the branches and leaves before.

def: {exuberant|茂:Profiled_Item={branches and leaves|枝葉:time={present|當下}}, Standard_Item={branches and leaves|枝葉:time={past|過去}}, Degree={more|較}}

(16)(16') 寫信 來 訴苦 要 比 當面 罵 他 來 得 安全 有效
xiexin lai suku yao bi dangmian ma ta lai de anquan youxiao

Complaining someone by writing is safer and more effective than scolding.

def: {safe and effective|安全有效: Profiled_Item={complain|訴苦:means={write a letter|寫信}}, Standard_Item={ExpressAgainst|譴責:target={he|他},manner={overt|公開}}}

In (15), according to the attribute value ‘exuberant’, we decide the Profiled_item is ‘branches and leaves’ but not ‘time’, then we put the time element into the same layer to describe the Profiled_Item. Because the default time is ‘now’, we then restored it into the sentence. As for (16), the difficulty is not restoring the omission part but distinguishing that the Profiled_Item and Standard_Item are asymmetric event structure.

To achieve fully automatic semantic composition for the above constructions requires further investigation.

4.2 Knowledge representation for other comparison words

Apart from ‘bi’, there are also some degree adverbs in Mandarin to form comparative constructions frequently, such as ‘more 更’, ‘too 太’, ‘very 很’...etc. Referring to Lu & Ma’s analysis (1999), we classify them into six types, shown as table 1:

degree	words	with/without Standard_Item	collocated with ‘bi 比’
High	Much:很、挺、十分、萬分、非常、異常、太、極、極端	-	-
	Most:最、最爲、頂	+	-
	More:更、更加、更爲、越發、越加、愈加、還 ₁		+
Low	Little:有點兒、有些	+	+
	Least:比較、較、較爲、還 ₂		+
	Less:稍微、稍、稍稍、多少、略微、略略	+	

Table 1

The above adverbs implicitly imply a comparative construction and Standard-Item being average standards. Lu & Ma (1999) introduced the sentence patterns of the above adverbs as following:

(17) 相比之下(比較起來), Profiled_Items+ Degree+ AttributeValue

Relatively, Profiled_Items + Degree + attribute value

(18) 跟 Standard_Item 相比(比起 Standard_Item 來), Profiled_Items+ Degree+ AttributeValue

To compare with Standard_Item, Profiled_Items + Degree+ AttributeValue

(19) 在 Comparison_Set 中/上, Profiled_Items + Degree+ AttributeValue

Among Comparison_Set, Profiled_Items + Degree+ AttributeValue

(20) Profiled_Items + bi+ Standard_Item+ Degree+ AttributeValue

Here, ‘degree’ indicates the degree adverbs listed at table 1. Among these adverbs, only ‘much’ and ‘most’ type never collocated with ‘bi’, but they still imply the comparative construction in which Standard_Item is average standards. For instance, we often use ‘the most beautiful’ or ‘very beautiful’ to describe a target without mentioning its Standard_Item, it doesn’t mean the latter doesn’t exist but they are those ordinary looking items. Lu & Ma thus add every sentence pattern listed above a ‘bi phrase’ in front to make the comparative construction clear. Let’s take some

sentences as examples:

(21) 他 最 討 厭 我

ta zui taoyan wo

He hates me the most.

(22) 這 件 褲 子 較 為 大 些

zhejian kuzi jiaowei da xie

This pants is a bit bigger.

(23) 冬 天 時 景 色 越 發 好

dongtian shi jingse yuefa hao

The scenery is better in winter.

In above comparative sentences, they use degree adverbs ‘most 最’ ‘more 較為’ and ‘more 越發’ instead of ‘bi 比’, according to Lu & Ma’s analysis, they omit the comparison words shown on (17)-(20). What we need to do is to refill the omitted comparison phrases listed above and restore the comparative frame structure of the sentences. Similar with ‘bi’, the comparison phrases on patterns (17)-(20) can be described as (8), after ellipsis restoring, sentences (21)-(23) can be defined as follows:’

(21’) 相 比 之 下 ， 他 最 討 厭 我

xiangbizhixia, ta zui taoyan wo

By comparison, he hates me the most.

def: {more|多 :Profiled_Item={disgust|厭惡 :experiencer={he|他 },target={I|我 }},Standard_Item={disgust|厭惡 :experiencer={he|他 },target={other person|其他人}},Degree={most|最},Profiled_Attribute={degree|程度}}

(22’) 在 這 些 褲 子 中 ， 這 件 褲 子 較 為 大 些

zai zhexie...kuzi zhong, zhejian kuzi jiaowei da xie

Among these pants, this pants is a bit bigger.

def: {big|大 :Profiled_Item={this pants|這件褲子},contrast={these pants|這些褲子},Degree={ish|稍},Profiled_Attribute={size|尺寸}}

(23’) 跟 夏 天 相 比 ， 冬 天 時 景 色 越 發 好

gen xiatian xiangbi, dongtian shi jingse yuefa hao

To compare with summer, the scenery is better in winter.

def: {nice|好 :Profiled_Item={winter|冬天},Standard_Item={summer|夏天},Attribute={scenery|景色},Degree={more|較}}

In this paper, degree adverbs are classified as a type of comparison words since they do imply the comparative sense. We think some degree adverbs indicate both degree and comparative sense. According to the comparative event frame, we can give them a definition to cover both senses as follow:

(24) def: degree={} in {AttributeValue: theme={},contrast={},quantity={}, manner={}, location={},time={}}

So it doesn't matter we restore the sentences (21)-(23) or not, they shall have the same definitions.

'As...as 一樣' and 'very...,more...很...更...'are not at the Lu & Ma's table, but they can also be analyzed as above degree adverbs. Let's see the following examples

(25) 後者 和 前者 一樣 重要
houzhe han qianzhe yiyang zhongyao

The latter is as important as the former.

(25') 比較起來，後者 和 前者 一樣 重要
bijiaoqilai, houzhe han qianzhe yiyang zhongyao

Relatively, the latter is as important as the former.

def: {important|重要:Profiled_Item={the former|前者},Standard_Item={the latter|後者},Degree={BeSame|一樣}}

(26) 北京 的 景山 很 高， 我 老家 的 山 更 高
Beijing de jingshan hen gao, wo laojia de shan geng gao

Mt. Jing in Peking is very tall, but the mountain at my home town is even taller.

(26') 比起 北京 的 景山 來，我 老家 的 山 更 高
biqu Beijing de jingshan lai, wo laojia de shan geng gao

To compare with Mt. Jing in Peking, the mountain at my home town is even taller.

def: {tall|高:Profiled_Item={mountain|山:location={HomeTown|老家:owner={I|我}}},Standard_Item={Mt. Jing|景山:place={Peking|北京}},Degree={more|較}}

4.3 knowledge representation for concepts with implicit comparative senses

There are few concepts, especially for those describe human relationship, imply comparative sense. Their representations thus contain comparative features as well. For example, the concept 'brother' can be defined as (27):

(27) brother|兄弟
 def: {human|人:

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gender={male|男},
qualification={BeSame|相同:
    theme={parents(X)},
    contrast={parents(~)}}}

```

For expressing ‘one man who has the same parents with someone’, we adopt ‘human|人’ as head, and use feature ‘qualification’ to connect ‘human’ with the comparative content which is lead by the comparative adjective ‘BeSame’, and followed by its theme, someone X’s parents and its contrast, the head’s (head shown as ‘~’) parents. Further, we can denote the man who is expressed by head is older than someone X by another comparative structure, shown as follow:

(28) elder brother|哥哥

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def: {brother|兄弟:age={aged|老年:theme={X},contrast={~}}}
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Expand def: {human|人: gender={male|男},

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qualification={ BeSame|相同:
    theme={parents(X)},
    contrast={parents(~)}}},
age={aged|老年:
    theme={X},
    contrast={~}}}
```

Another example is shown as follow:

(29) father’s young friend|世叔

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def: {human|人=friend(father(X)):
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age={young|青年:
    theme={father(X)},
    contrast={~}}}
```

5. Summarization and Conclusion

For building a well defined knowledge representation base, we propose a case frame representation mechanism for comparison words in Mandarin and conclude their representation as follow:

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def: contrast={} (in {AttributeValue: theme={},contrast={}, quantity={},manner={},
    location={}, time={}})
def: degree={} (in {AttributeValue: theme={},contrast={},quantity={}, manner={},
    location={},time={}})
```

The frame elements of comparative construction (i.e. Profiled_Item, Standard_Item, Attribute, Profiled_Attribute, Standard_Attribute, Comparison_Set, Degree, Manner, Place and Time) are all included in the representations. By way of building mapping table, we can connect the parsing result of sentences with the case frame to make computer understand the meaning of comparative sentences. Our goal is to establish an automatic composition mechanism which can unify every word sense representation with correct features of comparative construction. To achieve this, coercion and gap filling processes are an integral part of the mechanism, and it will be our important future researches.

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