Knowledge Representation for Interrogatives in E-HowNet

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Abstract

In order to train machines to 'understand' natural language, we proposed a universal concept representational mechanism called E-HowNet to encode lexical semantics. In this paper, we take interrogative constructions as examples, i.e. concepts or sentences for asking questions or making inquiries, to demonstrate the mechanisms of semantic representation and composition under the framework of E-HowNet. We classify the interrogative words into five types according to their semantic distinctions, and represent each type with fine-grained features and operators. The process of semantic composition and the difficulties of the representation, such as word sense disambiguation, will be addressed. Finally, we'll show how machine discriminates two synonymous sentences with different syntactic structures and surface strings to prove that machine understanding is achievable.

Keywords: semantic representation, interrogatives, E-HowNet

1. Introduction

To understand natural language by machines, lexical semantic representation and composition are the most important techniques. In this paper, we will take the interrogatives as examples to demonstrate the mechanism of lexical semantic representation and composition in E-HowNet (Chen et.al., 2004). E-HowNet uses the word sense definition mechanism of HowNet (Dong, 1988) and the vocabulary of WordNet (Fellbaum,1998) synsets to describe concepts.[1] Its goal is to achieve near canonical semantic representation,

[1] The advantage of using WordNet synsets is that each synset has unique sense and sense similarity between two synsets can be measured through WordNet ontology. But there is disadvantage of WordNet-like ontologies, for example, each concept class in WordNet has limited linking to other concepts. The major links are hyponymy relations which limit inheritance and inference capability to the classes on the taxonomy. So we adopt similar

that is, two sentences with different surface forms or in different languages may achieve similar E-HowNet representations. Take sentences (1) and (2) as examples:

(1) 我能否拍照？Is it OK for me to take pictures?

(2) 我可不可以照相？Can I take photos?

Although the syntactic structure and surface strings of (1), (2) are very different, by using lexical sense definitions in E-HowNet, we hope machine can 'understand' that they are synonymous sentences.

Analysis of interrogative constructions is of great interest to linguists, as well as to computer scientists, for example, those who engaged in QA techniques. Interrogative constructions have played a central role in the development of modern syntactic theory. Ginzburg & A.Sag (2000) have pointed that interrogative has been at the heart of work in generative grammar, also in government and binding (GB) and head-driven phrase structure (HPSG). Nonetheless, to date most syntactic work has taken place quite separately from semantic and pragmatic work on interrogatives. Taking questions in Mandarin Chinese as example, Shao (1996) has summed up the current study of interrogatives and listed the main research themes as follows: the types of question, interrogative particles, querying focus and its answer, degree of doubt and special interrogative sentences pattern etc.. Most of the above themes are purely grammatical analysis. To build a frame-based entity-relation knowledge representation model, we find interrogative construction a good and challenging example, for it is feature-structured, free formed, and demanding for story comprehension. In other words, it combines problems of syntax, semantics and pragmatics. Our approach is to find a framework to represent interrogatives, therefore, semantic distinction of interrogatives is our focus.

In E-HowNet, we made distinctions between content sense and relational sense and

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mechanism in HowNet to define word sense, which represents concepts in more accurate way by not restricting the definition vocabulary to a closed set of primitives only, i.e., any well-defined concepts can be used to define a new concept. The detail discussions can be seen at (Chen et al., 2005).

represent senses of content words and senses of function words in different ways. For instance, we represent phrase ‘bathe with cold water’ as (3)

(3) bathe with cold water

bathe def: {clean|使淨: patient={body|身體}}
with def: instrument={}
cold water def: {water|水: temperature={cold|冷}}}.
composition: {clean|使淨: patient={body|身體},
instrument={water|水:
temperature={cold|冷}}}.

In this case, content words ‘bathe’ and ‘cold water’ are represented differently from function word ‘with’, for the latter plays the role of linking concepts. In much the same way, interrogative words have more relational sense than content sense, so they are defined by semantic role to denote relational sense and the operator ‘.Ques.’ to mark the querying focus that is the object or its discrimination features which speakers want to know.

In the following section, we’ll briefly describe the previous work for interrogatives. Then, we introduce our analysis of type classifications for interrogatives and their representation in E-HowNet. Next, we present the composition of interrogative sentences and the difficulties encountered. We conclude the paper by discussing our results and future works.

2. Background

Questions in Chinese studies traditionally attributed to mood category of syntactics.[2] Most of linguists consider there are four grammatical devices that explicitly mark an utterance as an interrogative. [3]First is question which can be answered by ‘yes’ or ‘no’, called factual question, true and false interrogative or yes/no interrogative. Second is question which includes Wh-words such as ‘who’, ‘what’ or ‘when’ and so forth, called Wh-word

[2] Ma (1989）wrote the first grammar book for Mandarin Chinese. He classified interrogative words into mood category. Later, Li (1930) and Lv (1942) have carried forward his viewpoint and influenced on modern research of questions deeply.
[3] Such as Lv (1942), Li & Thompson (1997), Tang (1983), Lu (1984), Shao (1996),etc..

interrogative, or information seeking interrogative. Third is question which mentions two or more possible alternative answers, called disjunctive interrogative or either/or interrogative. Fourth is question which is composed of a statement followed by an *A not A* form, such as *dui bu dui* 'right not right', *xing bu xing* 'Ok not Ok' etc., called *A not A* interrogative or tag interrogative.[4] From different analytical perspective, these four question devices may have different hierarchy. For example, Lv (1942) framed them as (4) while Lu (1984) structured them as (5):

(4) interrogative – Wh-word interrogative
– true/false interrogative – *A not A* interrogative
– disjunctive interrogative

(5) interrogative – true/false interrogative
– non true/false interrogative – Wh-word interrogative
– disjunctive interrogative
– *A not A* interrogative

Generally speaking, true and false interrogative and Wh-word interrogative are regarded as basic types.

3. Semantic Representation

3.1 Our classification of interrogatives

As we focus on knowledge representation, we are more concerned about semantic discriminations for different interrogative sentences. Therefore, we take a sense-based approach to create a hierarchical classification which is guided by a layered semantic hierarchy of answer types, and eventually classifies interrogative sentences into fine-grained classes, shown as (6):

[4] Tag interrogative is formed by adding a short *A* not *A* question form of certain verbs as a tag to a statement. In this paper, we regard it as a general *A* not *A* question device due to the same semantic performance.

(6) interrogative –(A) true/false interrogative

– (B) Wh-interrogative –(a) asking factual information

– (b) asking relationship

– (c) asking opinion

– (d) option choosing

According to different querying focus, we separate (A) true/false interrogative from (B) Wh-interrogative. Take sentences (7), (8) as examples:

(7) 你喜不喜歡這個遊戲？

Do you like this game?

(8) 有誰知道我可以在哪裡找到這個遊戲？

Who knows where I can find this game?

Sentence (7) belongs to the former question device because the entire statement is a querying focus. Dissimilarly, sentence (8) indicates two querying focuses by using different interrogatives 'who' and 'where'. In other words, the true/false interrogative asks truth value of the whole sentence. And the Wh-interrogative is used to ask information. By analyzing the querying focus, the latter can be further divided into four types: (B-a) asking factual information, such as time, location, quantity and so forth; (B-b) asking relationship, such as kinship; (B-c) asking opinion or attitude, such as possibility, capacity, volition etc.; and the last, (B-d) asking to choose an option. Sentence (8) refers to the type (B-a). For each of the remaining types, we give an example as follows:

(9) 她是你的什麼人？

What is the relationship between you and her?

(10) 他可不可以吃辣椒？

Can he eat hot peppers?

(11) 淘米水是酸性還是鹼性？

Rice washing water is acidic or alkaline?

Here, two distinctions have to be made. First, sentence (9) refers to type (B-b), but why need we separate it from type (B-a) when they both use 'what' to make questions? In sentence (9), the question word '什麼 *what*' ask for relationship but not the type of a frame element or the value of a semantic role.[5] Chen et. al. (2004) proposed a complex relation description, i.e. a representation denotes the relation between head and semantic role specifically. In general, E-HowNet semantic representation model presumes the relations variables is the head, for example, 'white cloud' will be define as (12):

(12) white cloud
def:{cloud|雲: color(~)={white|白}}

In the definition, '~' indicates the head 'cloud', and normally be omitted in the expression. Conversely, word indicates complex relation always has another relation variable apart from the head, so the variable needs to be marked clearly. For example, we express 'mother in law' as (13):

(13) mother in law
def:{human|人=mother(spouse(x:human|人))}

According to the representation model, when our querying focus is complex relation, we put question mark before the relation role, such as mother, spouse, parents etc. to make the interrogative definition. It makes the difference between interrogative type (B-a) and (B-b). See more examples in section 4.

Second, some may argue that there is no distinction between type (A) and (B-b). Comparing sentence (7) and (10), we find they both have a yes/no answer.

(7) 你喜不喜歡這個遊戲？

Do you like this game?

(10) 他可不可以吃辣椒？

Can he eat hot peppers?

But, further considering sentence (14):

[5] The disambiguation of '什麼 what', see section 4.1.1.

(14) 他吃不吃辣椒？

Does he eat hot peppers?

We can still find the slight difference between a yes/no question and an information seeking question. However, modal words like 'can', 'shall', 'will' bring richer meaning then general verbs. They are not used to ask truth value but ask opinion or attitude. In Mandarin Chinese, '可不可以 *can not can*' and '喜不喜歡 *like not like*' are both with a *A not A* form, in syntactical considerations, they are often assigned to the same type. But from the semantic point of view, we decide they belong to both types.[6]

3.2 Knowledge Representation for Interrogatives

According to the classification above, we represent each type of interrogative as follows:

(15) true/false interrogative def: truth={.Ques.}

Wh-word interrogatives

asking factual information def: role={.Ques.}

asking relationship def:. Ques.RelationRole()

asking opinion def: ModalityRole={.Ques.}

option choosing def: role={.Option.{{x}.or.{y}}}

We use two operators, .Ques. and .Option., to denote querying focus or optional items. The real examples are shown in the following table 1.

[6] Shao (1996) has classified *A* not *A* form into five classes according to *A*'s part of speech, shown as follows: (1) *A* is a copula. e.g. 是不是 'be not be' (2) *A* is a modal word e.g. 好不好 'ok not ok' (3) *A* is an auxiliary e.g. 肯不肯 'willing not willing' (4) *A* is a verb e.g. 懂不懂 'understand not understand' (5) *A* is an adjective e.g. 美不美 'beautiful not beautiful'. From the semantic perspective, we merge (1),(4),(5) and (2),(3) to re-divide these five categories into two categories, i.e. modal *A* not *A* interrogatives and other *A* not *A* interrogatives.

Table 1. The Type Classification and Semantic Representation of Interrogatives

Question devices	**Examples**
true/false interrogatives	嗎*ma*;[7]是否;有沒有;是不是;不是嗎;*A not A* def: truth={.Ques.};
Wh-word interrogatives: asking factual information	誰 def: participant={animate:.Ques.}; 幾點鐘 def: time={.Ques.}; 什麼 def: participant={inanimate:.Ques.}; 什麼(車) def: formal={.Ques.}; 爲何,何以 def: reason={.Ques.}; 哪裡,哪兒 def: location={.Ques.}; 哪些 def: quantifier={.Ques.}; 怎麼 def: manner={.Ques.}; 怎麼 def: means={.Ques.}; 多 def: degree={.Ques.}; 多少 def: quantity={.Ques.}
asking relationship	
asking opinion	可不可以 def: allowance={.Ques.}; 好不好 def: willingness={.Ques.}; 能不能 def: capacity ={.Ques. }; 莫非 def: possibility ={.Ques. }
choosing options	還是;或 def: role={.Option.{{x}.or.{y}}}

The interrogatives above are gathered from Li & Thompson's analysis, and integrated by checking over 1000 question titles manually in *Baidu knows* (http://zhidao.baidu.com/).

4. Semantic Composition

The previous discussion is about logical representation of events. To establish a formal system to handle the task requiring language understanding, we also need to address the issue of semantic composition. Through segmentation and parsing process, we get coarse-grained arguments and the head of the sentence. Take sentence (16) as an example:

(16) 資料因何漏失？

Why is the data missing?

[7] In this paper, our focus is semantic representation, so we don't discuss the interrogative words '啊*a*'; '吧*ba'* or '呢*ni*'. Because it depends on the tone to decide they are interrogative words or not.

The segmentation and parsing result of (16) is:

Theme[NP:資料 *data*]+ reason[Dj:因何 *why*]+Head[VJ3:漏失 *lose*]

Then, we try to map surface syntax onto semantic structure for establishing truly integrated semantic relations. In example (16), we get the head 'lose' from segmentation and parsing process, and base on E-HowNet, the arguments of event 'lose' are 'possessor' and 'possession', we thus know the 'data' here is the possession of 'lose'. Therefore, the composition is as follows:

def:{lose|失去:possession={information|訊息},reason={.Ques.}}

The other types of interrogative words also can be combined into different sentences, shown as follows:

true/false interrogative

(17) 他病了嗎？

Is he sick?

def:{sick|病:experiencer={he|他},truth={.Ques.}}

(18) 你是否曾說過謊？

Have you lied before?

def:{lie|說謊:agent={listener|聽者},time={past|過去}, truth={.Ques.}}

Wh-word interrogative:

asking factual information

(19) 衣服上的墨水怎麼洗掉？

How to wash away ink stains on cloth?

def:{wash|洗掉:patient={ink|墨水:place={clothes|衣服}},means={.Ques.}}

(20) 哪些桌子壞掉？

Which tables are broken?

def:{OutOfOrder|壞:theme={table|桌子:quantifier={.Ques.}}}

asking relationship

(21) 她是你的什麼人？

What is the relationship between you and her?

def:{he|他=.Ques.kinship(listener|聽者)}

asking opinion

(22) 莫非這是鬼城？

Is it possible a ghost town?

def:{be|是:relevant={this|這},content={ghost town|鬼城}, possibility ={.Ques. }}

(23) 由你開車行不行？

Is it ok for you to drive?

def:{drive|開車:experiencer={listener|聽者},willingness ={.Ques. }}

choosing options

(24) 他在這兒還是那兒住？

Does he live here or there?

def:{live|住:agent={he|他},location={.Option.{{here|這兒}.or.{there|那兒}}}}

(25) 他跪下來還是站在那裡求張三？

Does he kneel on the ground or stand there to beg ChangShan?

def:{beg|求:agent={be|他}，target={ChangShan|張三}，means={.Option.{{stand|站}.or.{kneel 跪}}}}

4.1 Disambiguation

To achieve the goal of automatic composition, we have to face the challenge of sense ambiguities. In Chinese, '什麼 *she me*', '怎麼 *ze me*' and '多 *duo*' are most frequently used interrogatives with ambiguous senses. Their sense disambiguation rules and representations are discussed below:

4.1.1 什麼

'什麼 *what*' plays the grammatical functions of adjective and pronoun. For each function, there are two senses. Accordingly, we generalize four rules to disambiguate the word sense of '什麼', and the details are shown in the table 2:

Table 2. Disambiguous Rules of '什麼'

Rules of disambiguation	**E.g. & E-HowNet representation**
adjective 1: 什麼 '*what*' +semantic role: ask the value of the semantic role	**什麼 N role={.Ques.}** 什麼時間 '*what time*' time={.Ques.} 什麼價錢 '*what price*' price/cost={.Ques.} 什麼地點 '*what place*' location={.Ques.} 什麼狀況 '*what situation*' condition={.Ques.} 什麼顏色 '*what color*' color={.Ques.}
adjective 2: 什麼 '*what*'+entity (nominalized verbs are included): ask the type/restriction of a frame element/ participant role	**什麼 N participant={entity:formal={.Ques.}}** 什麼人 '*what person*' participant={human|人: formal={.Ques.}} 什麼汽車 '*what car*' participant={car|汽車:formal={.Ques.}} 什麼變化 '*what change*' participant={change|變化:formal={.Ques.}} 什麼不同 '*what difference*' participant={difference|不同:formal={.Ques.}}
pronoun 1: use as an interrogative pronoun: function as NP	**V 什麼 {event:participant={.Ques.}}** 吃什麼 '*eat what*' {eat|吃: patient={.Ques.}} 說什麼 '*talk what*' {speak|說:content={.Ques.}}
pronoun 2: use as an indefinite pronouns: function as NP, the played role is either coindexed or univarsal quantified.	**V 什麼；什麼 V {event:participant={x}}** **or{event:participant={entity: quantity={all}}}** 拿什麼都可以 *'It's OK to get anything'* {hold|拿:patient={entity: quantity={all}}} 什麼也不怕 *'Be afraid of nothing'* {.not.fear|害怕:cause={entity: quantity={all}}}

4.1.2 怎麼

'怎麼*how*/*how come*' plays the role of adverb. It asks the value of an adverbial type of semantic role including mean/method (How) and reason (Why). Two meanings 'how' and 'why' can roughly be discriminated by the telicity of matrix verbs. That is, '怎麼'in a sentence with telic verb or verb phrase refers to event that have endpoints means 'why'. Contrarily, '怎麼'in an atelic sentence means 'how'. Take sentence (26), (27) as an example:

(26) 怎麼來

def:{come|來:means={.Ques.}}

(27) 怎麼來了

def:{come|來:reason={.Ques.}}

In short, we conclude the disambiguation rule as follows:

(28) 怎麼(How)+event[-telic]

怎麼(Why)+event[+telic]

4.1.3 多

'多 *how*' also plays the role of adverb. It's usually followed by an attribute value, such as '甜 *sweet*', '聰明 *smart*', '遠 *far*', '大 *big*' and so forth. It can be used to express the feelings of exclamation or doubt. We can not simply distinguish these two senses by the context, but need to rely on the tone. For this reason, we will deal only with the senses of doubt. Incidentally, it is always possible to turn a declarative statement into a question by using a slightly rising intonation pattern. For the same reason, we do not deal with such sentences and few interrogative words such as '啊 *a*'; '吧 *ba'* ; '呢 *ni*' as well.

'多 *how*' with interrogative sense can be represent as below:

(29) 多+attribute value def:{attribute value: degree={.Ques.}}

The real examples are:

(30) 多甜 *'how sweet'* def:{sweet|甜:degree={.Ques.}} = def: sweetness={.Ques.}

多聰明 *'how smart'* def:{smart|聰明:degree={.Ques.}}= def: smartness={.Ques.}

多遠 *'how far'* def:{far|遠:degree={.Ques.}} = def: distance={.Ques.}

多大 *'how big'* def:{big|大:degree={.Ques.}} = def: size={.Ques.}

5. Conclusion and Future Works

To achieve near canonical semantic representation, we study the semantic representation and composition of interrogatives. According to the semantic classification of interrogative, we

represent interrogatives in a hierarchy as follows:

true/false interrogative	def: truth={.Ques.}
Wh-word interrogative	
asking factual information	def: role={.Ques.}
asking relationship	def:. Ques.RelationRole()
asking opinion	def: ModalityRole={.Ques.}
choosing options	def: role={.option.{{x}.or.{y}}}

We have cited two examples (1),(2) earlier to illustrate what is the 'understanding' of machine towards natural language. After the discussion above, let's see the result of this work:

(1) 我能否拍照？Is it OK for me to take pictures?

Representation:

我	def:{speaker|說話者}
能否	def:allowance={.Ques.}
拍照	def: {TakePicture|拍攝}

Composition:

def: {TakePicture|拍攝:agent={speaker|說話者}, allowance={.Ques.}}

(2) 我可不可以照相？Can I take photos?

Representation:

我	def:{speaker|說話者}
可不可以	def:allowance={.Ques.}
照相	def: {TakePicture|拍攝}

Composition:

def: {TakePicture|拍攝:agent={speaker|說話者}, allowance={.Ques.}}

Although the syntax surface of (1),(2) is different, we find the result of composition is the same. It means through the analysis of E-HowNet model, machine can judge the similarity of sentences, i.e. machine understand the sentences. However, this is only an example with

simple sentence structure. For future researches, we will implement a parsing system incorporated with E-HowNet model to demonstrate semantic composition process for more complex sentences. To achieve this goal, apart from sense disambiguation, discordance between synthetic structure and semantic relations is another critical problem. Take sentence (31) as an example:

(31) 長途旅行不是很辛苦嗎？ Isn't it hard for Long-distance travel?

Its parsing result is:

Theme[VP:(manner[A: 長 途 *long distance*]+Head[VA4: 旅 行 *travel*])]+negation[Dc: 不 *not*]+epistemics[Dbaa:是 *be*]+degree[Dfa:很 *very*]+Head[VH16:辛苦 *hard*]+particle[Td:嗎 *ma*]

Let's see the E-HowNet definition of (31) first:

def:{hard| 辛 苦 :theme={travel| 旅 行 :distance={far| 遠 }},degree={very| 很},truth={.Ques.}}

Comparing the semantic representation with syntactic structure, we find rhetorical interrogative '不是嗎 *Isn't it* ' is segmented into three words in syntax analysis, but in semantic point of view, they are integrated into one word and represented as 'truth={.Ques.}'. There are still many types of discordance between synthetic structure and semantic relations need to be studied. That is, we have to find out the mapping rules and match coarse-grained syntactic arguments to fine-grained semantic relations in the future. These rules should be able to use both on declarative sentences and interrogative sentences, because most of interrogative sentences are transformed from declarative sentences. Additionally, this study is also useful to question-answering system for it not only represents the sense of question, but also marks the focused information to be answered. As for the application on QA technologies, it'll be our future task as well.

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