

HIERARCHICAL CONCEPTS STRUCTURE FOR NATURAL LANGUAGE UNDERSTANDING SYSTEM

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Hierarchical concepts structure is introduced to widen acceptability of input sentences of natural language understanding system.

It consists of a set of defined concepts (SDC) and scenarios each of which is a set of scenario elements. A scenario is one utilized everywhere. In our SDC concepts are defined with another concepts related through basic semantic relations. Types of these relations are presented with some examples. As compound semantic relations are composed of basic ones it is enough to construct SDC with only basic semantic relations.

1. Hierarchical concepts structure

Instead of efficiency of inference, use of scenarios¹⁾ is in the opposite direction to afford those rich features of natural language to the system.

To overcome this situation, we introduced a set of defined concepts (SDC) and constructed a hierarchical concepts structure with scenarios.

A hierarchical concepts structure consists of a SDC and scenarios and a scenario is a set of scenario elements.

A scenario element is a partial scenario that correspond to a small part of story, and therefore can easily prepare, delete or correct.

SDC gives general (closer to natural language) definition of each concept by using basic semantic relations (and view-points) with other concepts so that it functions as to widen acceptability of input sentences of natural language understanding system.

An input sentence is analysed syntactically and the conceptual dependency representation with respect to the sentence (CDRS) is generated. CDRS is a directed, labeled graph which represents dependency relations among concepts expressed by words appearing in the sentence.

Figure 1 is a CDRS of a sentence "I go to school." Using this CDRS the system chooses a scenario element from a suitable scenario, say "GO TO SCHOOL" scenario and attaches this CDRS to it as an instance. We call scenario element with an instance attached in this way as semantic graph^{2),3)} (with respect to a sentence ~).

Figure 2 shows a part of "GO TO SCHOOL" scenario element with attached instance

(semantic graph).

However, there may be no scenario element that fits to an input sentence "I go to school to meet my son" in any scenario. In this case, the system tries to find out general definition of "<GO>" in the SDC.

As SDC has definition for every concept, it fits to wide variety of CDRSs. Figure 3 shows "<GO>" element of SDC.



Figure 1. CDRS of "I go to school".

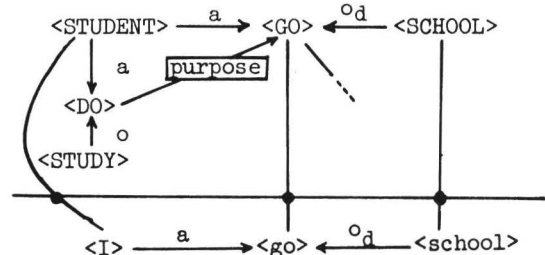


Figure 2. Semantic graph with respect to a sentence "I go to school".

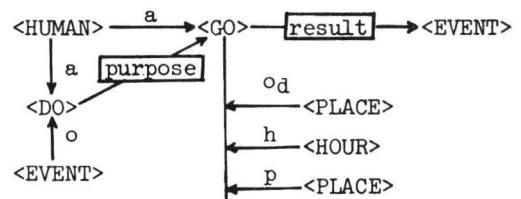


Figure 3. "<GO>" element of SDC.

2. Construction of SDC

2.1. Types of concepts

Concepts are classified into four types that roughly correspond to the concepts expressed by concrete nouns, verbs, adjectives/adverbs and abstract words as follows (see Notations).

- (i) 'concrete object' concepts
- (ii) 'event' concepts
- (iii) 'modality' concepts
- (iv) 'abstract thing' concepts: Abstract concepts that are designated by 'aspects (movements or modalities) of things', 'relations among things' or 'time and place'.

2.2. Semantic relations among concepts

There are following eight basic semantic relations among concepts.

- (i) Super concept-subconcept relation (kind or extension relation)
- (ii) Aspect relation: Relation among a 'concrete object' concept and concepts that give aspects of the concepts. This relation is given by using basic view-points such as "purpose of use", "color", "amount (thickness)". Basic view-points necessary to define <PRODUCT THING> like <PAPER> are given in Table 1.

Aspect relation	Basic view-point
Aspects about use	purpose of use, ways of use (what to use) (how to use)
Aspects about manufacturing	material, how to make
Aspects about structure	parts, arrangement,...
Aspects about property	physical, mental,...
Aspects about quantity	number, weight, length,...
Aspects about aspect	color, shape, value,...
Aspects about time	existing time
Aspects about place	existing place

Table 1. Basic view-points for <PRODUCT>.

- (iii) Case relation
- (iv) Cause-effect relation
- (v) event-event relation other than cause-effect relation

Five relations of "logical", "accompanying", "before and after wrt. time", "condition" and "direct (indirect)" belong to this.

- (vi) Descriptive definition relation

This relation describes an event using with another basic semantic relations and concepts.

- (vii) Modality relation

View-points used in this relation are given by classifying "modality" concepts.

- (viii) Synonym and antonym relation

2.3. Construction of SDC

- i) Definition of concrete objects

Concrete objects are defined by using kind relation and aspect relation. View-points belonging to these relations are called "basic view-points" (Table 1).

- a. Definition of subconcepts

Properties possessed by a super concept is inherited to its subconcepts unless otherwise stated in the definitions of them.

- b. Definition of supreme concepts

It is very important that SDC contains every supreme (most general) concrete object concept that appears as a supreme concept of a given event concept in the case relation. For example, the supreme concept of the given event concept <EAT> in the (object) case relation is <things that can be objects to eat> (Figure 4). This gives judging conditions (or requirements) whether any given type of concept satisfies case relation with a given event concept. For example, if "plastic eraser" satisfies conditions "soft", "not hot", ... then "human being" can "eat" it.

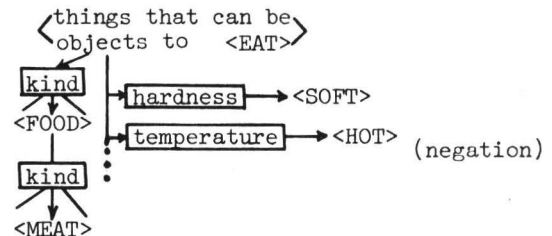


Figure 4. The supreme concept in the object case relation of <EAT>

- ii) Definition of an "event" concept

This concept is defined by using case relation, cause-effect relation, event-event relation, descriptive definition relation, modality relation and synonym-antonym relation.

- iii) Definition of a 'modality' concept

This concept is defined by using case relation, descriptive definition relation, cause-effect relation, modality relation and synonym-antonym relation.

- iv) Definition of an "abstract thing" concept

This concept is defined by using case relation, cause-effect relation, modality relation, descriptive relation, kind relation and synonym-antonym relation.

3. Composition of view-points

There can be many finer view-points other than basic ones.

Is it necessary to define a concept using

all of these finer view-points?

We are getting rid of this problem by composing these finer view-points of basic semantic relations, basic view-points and other concepts.

Let r be an arbitrary m -ary semantic relation and $\alpha_1, \alpha_2, \dots, \alpha_m$ be concepts for which $r(\alpha_1, \alpha_2, \dots, \alpha_m)$ can be asserted.

We obtain a relation,

$$\lambda x r(\alpha_1, \alpha_2, \dots, x, \dots, \alpha_m)$$

from $r(\alpha_1, \alpha_2, \dots, \alpha_m)$,

where x is a concept variable and λ is an abstraction operator.

We express a concept α for which a certain semantic relation $r(\alpha)$ is asserted⁴⁾ as,

$$\alpha \leftarrow - r(\alpha)$$

For example,

$$\alpha \leftarrow - \alpha \text{ --- } \boxed{\text{kind}} \rightarrow \beta$$

means that α is a concept for which $\alpha \text{ --- } \boxed{\text{kind}} \rightarrow \beta$ is asserted.

Let (1) and (2) asserted.

$$r(\alpha_1, \alpha_2, \dots, \alpha_i, \dots, \alpha_m) \dots (1)$$

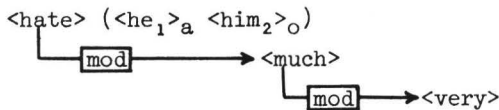
$$\alpha_i \leftarrow - r_1(\alpha_1', \alpha_2', \dots, \alpha_i', \dots, \alpha_n') \dots (2)$$

Where r, r_1 are semantic relations and $\alpha_1, \alpha_2, \dots, \alpha_n'$ are concepts. In this case composition of relation is defined as follows.

$$(\lambda x) r(\alpha_1, \alpha_2, \dots, x, \dots, \alpha_m) (\alpha_i \leftarrow - r_1(\alpha_1', \alpha_2', \dots, \alpha_n'))$$

By repeated application of composition and abstraction to semantic relations, we can obtain any relation from only basic semantic relations and basic view-points.

On the other hand, any sentence is expressed by CDRS briefly explained in chapter 1 by using semantic relations listed in chapter 2. For example, 'He hate him very much.' has the following CDRS.



From this CDRS, we can define a binary hate-relation $(\lambda xy)r_h(x,y)$ as follows.

$$(\lambda x,y)r_h(x,y) = (\lambda x,y)(<hate>(x_a,y_o))$$

Therefore, we can define any semantic relation if we could give definition of the semantic relation by sentences (hence CDRS).

4. Concluding remarks

We discussed about general structure of SDC necessary for constructing natural language understanding system.

We proposed to introduce a hierarchal concept system in which essentially the same semantic relations are used to define concepts in each stage of hierarchy.

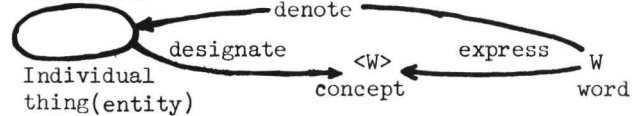
We could not discuss about 'mode' in this paper. For example, CDRS of a sentence, 'I should go there.' is given as follows.

$$<I> \xrightarrow{a} <go> \xleftarrow{op} <there>$$

(necessity)

Here the information given by (necessity) is a 'mode' of an event concept $<go>$. We singled out eighty four such modes which are used in ordinary written sentences⁵⁾. Detailed composition rules of semantic relations including these mode will be discussed in our forth-coming paper.

Notations:



Definition of "denote", "designate" and "express"

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