KNOWLEDGE REPRESENTATION IN THE MONTAGUE FRAMEWORK

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1.Knowledge Representation

1.1 Introduction

Understanding language requires a large amount of knowledge: knowledge about language, knowledge about communication, and knowledge about the world. Representing knowledge in a precise, computer-usable form presents a multitude of difficult problems and knowledge-representation formalisms are of central importance to all natural language understanding systems.

At the present, there is no acknowledged best way to represent knowledge and it is unlikely that a single representation system can be expected to expand all the knowledge domains.

1.2 Declarative VS Procedural Knowledge Representation

There are two kinds of knowledge representation: declarative and procedural. Declarative representations stress the static aspects of knowledge--facts about objects, events and their relations and about the states of the world. Procedural representations stress how knowledge can be used--how to find relevant facts, make inferences, and so on.

1.3 Linguistic VS Non-Linguistic Knowledge

The knowledge that is brought to bear in understanding language is of two kinds: linguistic and non-linguistic. However, there is not a clear division between these two kinds of knowledge. In general, linguistic knowledge consists of the levels of structure that are rather autonomous: phonology, morphology, and syntax. Non-linguistic knowledge comprises the knowledge about the world that the hearer and speaker share: in other words, the world views or the cognitive structure of the speaker and hearer which includes their beliefs about the world and about one another's beliefs, intentions, desires, and so on.

1.4 Montague Semantics as a Knowledge Representation Formalism

Montague semantics has two main attractions for computational linguistics: (i) it is a well-specified semantic theory, and (ii) it is rigorously defined and algorithmic in nature. Montague semantics has been adopted as a linguistic model in many parsing programs and its intensional logic has also been used as an interlingua in machine translation systems. However, the stronger appeal of Montague semantics lies in the model-theoretic semantics of intensional logic which provides a formalism for representing knowledge, linguistic as well as non-linguistic, and an algorithm for interpretation--an algorithm for mapping linguistic entities to real world situation.

2. Montague Semantics

2.1 Introduction

Montague semantics is a truth-conditional semantics, a model-theoretic semantics, as well as a possible world semantics. It is truth conditional because a specification of the conditions under which a given sentence would be true is considered an essential part of the semantic interpretation of any sentence. It is model theoretic because it includes relativized truth--truth under an interpretation or truth relative to a model. It is possible world semantics because the conditions under which a sentence would be true is not limited to conditions in the actual world.

The goal of the Montague system is to define a truth definition. This definition involves constructing two languages: a natural language under analysis referred to as the object language, and an artificial language referred to as the logic. The logic referred to here is tensed intensional logic (IL).

The logic, which is a language with its own syntax and semantics, constitutes the semantics of the object language; the semantics of the object language is done through the semantics of the logic. The object language and the logic are linked together by a set of translation rules.

A central working premise of the Montague theory is that for any language the syntactic rules that determines how a sentence is built out of smaller syntactic parts should correspond one to one with the semantic rules that tell how the meaning of a sentence results from the combination of the meaning of its parts. Since the semantics of the object language is done indirectly through the logic, the premise is reflected in the correspondence between the syntactic rules of the object language and the translation rules and the correspondence between the syntactic categories of the object language and the types of the logic. Types are syntactic categories of the logic.

2.2 The Interpretation

The interpretation involves the construction of an abstract mathematical model. The model specifies things in the world(s) making up the semantic value of expressions in a language and, with respect to this assumed ontology, specifies interpretations of units in the language. In Montague semantics, set-theoretic constructions, such as sets and functions, are employed as the objects in a model that are assigned as semantic values of expressions.

The model under which denotations and semantic rules are also defined is a quintuple <A,W,I,<,F> such that

- A is a set of entities
- W is a set of possible worlds
- I is a set of moment of time
- < is a linear ordering having I as its domain such that i < i' = i is earlier than i'
- F is a function having as its domain the set of all constants.

3. The Thai Fragment

3.1 Introduction

A small fragment of Thai is built in the Montague framework. The portion of Thai included in the fragment is simple sentences and two time expressions /k^{h}əəy/ and /lǽæw/. A universe of discourse is also provided as a basis for interpretation. Presented here are the semantic rules of intensional logic containing the truth conditions of /k^{h}əəy/ and /lǽæw/, a portion of the universe of discourse, and examples to demonstrate how semantic rules access the real-world knowledge and assign truth values to sentences. For the complete fragment, the complete universe of discourse, and more examples, see Chiraporn(1988).

3.2 The Expressions of Time in Thai

Time is expressed lexically in Thai by temporal adverbials, time-location markers, and aspect markers. Thai verbs undergo no morphological change and, when unmarked (occurring by themselves),are considered neutral as far as time is concerned.

3.3 /kʰəəy/ and /lǽæw/

/kʰəəy/ is an experiential aspect marker as well as a past-time-location marker. /lǽæw/ is a perfect aspect marker and also implicates past time. Two examples below illustrate the use of /kʰəəy/ and /lǽæw/.

kʰǎw kʰəəy pay aŋklit

he go England

'He has been to England.'

kʰǎw pay aŋklit lǽæw

he go England

'He has gone to England.'

The meanings of /kʰəəy/ and /lǽæw/ can be distinguished truth conditionally and their truth conditions are as follows:

kʰəəy θ at time p is true if and only if
θ is true at time t such that $t < p$ and
θ is not true at p

lǽæw θ at time p is true if and only if
θ is not true at time t such that $t < p$
and θ is true at p

These truth conditions which are linguistic knowledge are represented in the semantic rules of intensional logic shown below.

(1). If $\alpha \in ME_t$,
then k^həəy $\alpha^{U,w,i} = 1$,
iff $\alpha^{U,w,i'} = 1$ such that
$i' < i$ and $\alpha^{U,w,i} = 0$

(2). If $\alpha \in ME_t$,
then lǽæw $\alpha^{U,w,i} = 1$,
iff $\alpha^{U,w,i'} = 0$ such that
$i' < i$ and
$\alpha^{U,w,i} = 1$

4. The Real-World Knowledge Representation and the Interpretation

4.1 The Real-World Knowledge Representation

The universe of discourse is represented within the same model as the semantic rules in the form of set-theoretic constructions: sets and functions. The following function F(^ron') is a function from the world-time indices to the function from entities to truth values. The function represents the non-linguistic knowledge--the truth values of sentences with unmarked verb /ron/ 'hot' at different world-time indices.

F(^ron')

	CAY	1
‹World 1, Time 1›	NAAM	1
	AA-KAAD	1
	CAY	0
‹World 1, Time 2›	NAAM	0
	AA-KAAD	0
	CAY	0
‹World 2, Time 1›	NAAM	0
	AA-KAAD	0
	CAY	0
‹World 2, Time 2›	NAAM	1
	AA-KAAD	1

4.2 The Interpretation

By specifying an ordered pair <w,i>, an extension of ron' can be extracted from the intension in 4.1. If the ordered pair is <World 2, Time 2>, the following function is derived.

CAY	0
NAAM	1
AA-KAAD	1

By specifying an argument to the above function, a truth value can be derived. If the argument is NAAM 'water', the truth value is 1. If the argument is CAY 'mind', the truth value is 0.

5.Conclusion

A fragment of Thai is built in the Montague framework to demonstrate its potential as a knowledge representation system. The syntactic knowledge of Thai, namely the syntactic categories and syntactic rules, are represented in the syntax of the framework. The semantic knowledge of Thai, namely the truth conditions for sentences with unmarked and sentences containing /k^{h}əəy/ and /lǽæw/, are represented in the semantic rules of intensional logic. The non-linguistic knowledge, namely the truth values of sentences with unmarked verbs at different world-time indices (their intension), are represented as sets and functions in the model under which the semantic rules of intensional logic and the possible denotations are defined.

Since the semantic rules, the possible denotations and the non-linguistic knowledge are defined and represented under the same model, the model-theoretic semantics of intensional logic constitutes a procedural knowledge representation system within which knowledge--linguistic as well as non-linguistic--can be stored and manipulated to provide interpretation.

However, the interpretation derived is by no means complete. The system understands that a certain phenomenon is true or not true for a certain entity at a certain point of time and in a certain world, but it does not know what the entity is and what the phenomenon is. The issue of representation of the meaning of a lexical item needs to be addressed if the goal of the system is to enable the computer to understand language the way a human understands it.

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