Knowledge Acquisition from Dialogue

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1. Introduction

In one's life, a person acquires a lot of information and knowledge via natural language. For example, reading is knowledge acquisition via written language, and both hearing and discussion are knowledge acquisition from spoken language. From the viewpoint of knowledge acquisition, dialogue is knowledge transfer process, in which speaker's knowledge (information) is transferred to a hearer. I regard this as an important function of dialogue, however, neither its model nor its implementation has been treated as a main problem in dialogue research.

In this research, I focused on the knowledge transfer function of dialogue. For a hearer, knowledge transfer is understanding of utterances, i.e., extraction of information on utterances. Our final goal is to make a computer program that acquires information and knowledge through dialogue with other agents.

2. A Prototype System

Firstly, I studied a model of understanding of utterances. I believe that hearer's knowledge plays an important role in the process of understanding of utterances. From this point of view, I developed a new model that has the following features.

1. Understanding an utterance is the process of matching between the utterance and hearer's knowledge. Every content word in the utterance has to be connected to an entity in the hearer's knowledge. If every content word is connected to an entity, the utterance is understood and the new information on the utterance is integrated into the hearer's knowledge.

2. The response to the utterance is determined by the result of the matching.

According to this model, we developed a small prototype system, which can converse with users. The following is an example of conversation.

Dialogue 1

	(The current topic is a room$_1$.)
User$_1$	*heya niha ookina tsukue ga aru.* (U_{11})
	There is a big desk in the room.
User$_1$	*sono tsukue ha koukada.* (U_{12})
	The desk is expensive.

Dialogue 2

	(The current topic is the $room_1$.)
$User_2$	*heya niha koukana tsukue ga aru ka.* (U_{21})
	Is there an expensive desk in the room?
System	*hai.* (U_{22})
	Yes.
$User_2$	*sore ha chiisai ka.* (U_{23})
	Is it small?
System	*iie.* (U_{24})
	No.

In this system, I have concentrated on the implementation of the connecting process of content words to entities in the hearer's knowledge. Two triggers invoke this connecting process. The first trigger is surface *key* forms. The following three forms require that the referents (entities to which the content words are connected) exist already: pronouns, noun phrases marked by *shijisi* (ex. *sono*), and noun phrases marked by *ha*. If the system encounters one of these forms, it searches the current topic and the previous context for the entity to which the form ought to be connected. For example, in U_{11} the phrase *heya niha* (in ϕ room) invokes the connecting process because of *ha*-marked form, and is connected to the current topic "$room_1$".

Another trigger is an end of an utterance. When the end of the utterance is recognized, the system tries to integrate the information on the utterance into its knowledge. For the integration, the system tries to connect unconnected content words in the utterance. If the system fails to connect a word to a entity, it creates a new entity and connects the word to it. For example, in U_{11} the phrase *ookina tsukue* (big desk) is connected into a new entity "$desk_2$". In U_{21} the phrase *koukana tsukue* (expensive desk) is connected into the entity "$desk_2$", because the system already knows that "the $desk_2$ is expensive" from U_{12}.

In this system, interrogative sentences are processed in the almost same manner as declarative sentences. For example, in U_{21} the part except *ka*, i.e. *heya niha koukana tsukue ga aru*, is a declarative sentence, which means "there is an expensive desk in the room." This part is processed the same as the declarative sentence. The only difference is the existence of *ka*. *Ka* is regarded as a request of a response, which informs the result of matching between the information on the declarative part and the system's knowledge. If the information is already existed in the system's knowledge, the system answers *hai* (yes): If the information contradicts the system's knowledge, the system answers *iie* (no): If the information is new, the system answers *wakarimasen* (I don't know).

3. A System for DiaLeague

Hasida et al. (1995) proposed DiaLeague as a new contest for natural language dialogue system. It aims at evaluating the performance of natural language systems from the viewpoint of "language as a communication tool". This contest is executed as follows.

1. A task is given to a participant. It necessarily involves the conversation with a partner.

2. Each system is scored according to how successfully and quickly the task is achieved.

3. The final score of a system is caluculated by summation of all matches.

The task given to a participant in DiaLeague '95 is the shortest path search with an incomplete map, in which some virtual routes are made up and some of stations' names are omitted. This lack is expected to be filled by conversation with a partner. The partner's map is also incomplete and integration of two maps leads the complete map. Execution of tasks by systems can be viewed as knowledge transfer via dialogue so that the DiaLeague is a good example for my dialogue model.

I designed two protocols that enable efficient knowledge transfer. The basic protocol is SDNS-NS protocol.

Q: *TENNOJI kara KITA he 6TUME no MINAMIMORICHO made ikemasu ka.*
Can we go from TENNOJI to the 6TH station, MINAMIMORICHO, by the NORTH line?

A1: *hai 6TUME no eki made ikemasu.*
Yes, we can go to the 6TH station.

A2: *1TUME no SHITENNOJIMAE made ikemasu.*
We can go only to the 1ST station, SHITENNOJIMAE.

A3: *kita heno rosen ha arimasen.*
There is no line to the north.

The first one is a question that asks existence of a line. This question pattern consists of four important elements: starting station's name (*TENNOJI*), direction (*KITA*), distance (*6TUME*), and end station's name (*MINAMIMORICHO*). When asked the question, a system (hearer) examines the existence of the line that is determined by these four elements.

In case there is a north line from TENNOJI to MINAMIMORICHO in the hearer's knowledge, the hearer answers A1. From Q-A1 pair, both the questioner and the answerer acquire that "there is a north line from TENNOJI to MINAMIMORICHO in the complete map", because integration of two systems' maps leads the complete map.

In case the hearer cannot find a connection from the first station to the second station on the line, the hearer answers A2. From Q-A2 pair, both the questioner and the answerer acquire that " the north line from TENNOJI ends at the first station, SHITENNOJIMAE".

It is very important that some unknown stations' names are transferred implicitly by question-answer pairs. Suppose the questioner does not know the first station's name on the north line from TENNOJI. From Q-A2 pair, the questioner can acquire the name, SHITENNOJIMAE, because A2 contains the distance information (*1TUME*). However the station name in A2 is redundant in case the questioner knows the name, the answerer should say this name in case the answerer does not know whether the questioner knows the name or not.

Five tricks that shorten dialogue are implemented in my system for DiaLeague. The following three out of five are essential.

1. The system does not ask existence of a line when it can prove the existence by itself.
2. The system omits a starting station's name if the starting point is obvious in the context.
3. The system omits redundant stations' names in SDNS-NS protocol if the system infers that the partner knows the names.

The second trick is achieved by tracing a default starting station, DSS, which is updated per a question–answer pair. For example,

(currently DSS = TENNOJI)

Q: *[TENNOJI kara] KITA he 6TUME no MINAMIMORICHO made ikemasu ka.*
Can we go [from TENNOJI] to the 6TH station, MINAMIMORICHO, by the NORTH line?

A1: *hai.* (DSS := MINAMIMORICHO)
Yes.

A2: *1TUME no SHITENNOJIMAE made ikemasu.* (DSS := SHITENNOJIMAE)
We can go only to the 1ST station, SHITENNOJIMAE.

A3: *kita heno rosen ha arimasen.* (DSS := TENNOJI)
There is no line to the north.

In this example, the part surrounded by square brackets is omitted.

The last trick is achieved by inferring stations' names that the partner knows: The partner will know all stations' names presented in the dialogue. By using this inference rule, presence of stations' names in utterances carries the information that "the speaker knows the stations' names." For example, the hearer acquires "the questioner knows the name MINAMIMORICHO" from the following utterance.

Q: *KITA he 6TUME no MINAMIMORICHO made ikemasu ka.*
Can we go to the 6TH station, MINAMIMORICHO, by the NORTH line?

DiaLeague '95 was held on July 28, 1995 at Tokyo. ATR, Sony, NTT, and JAIST joined DiaLeague '95 and my system (JAIST) showed the best performance at the contest. The detail can be obtained via http://www.csl.sony.co.jp/dialeage/.

4. Conclusion

This research focused on the knowledge transfer function of dialogue. An utterance carries various type of information; the primary and explicit information that is called *meaning* and other implicit information. Knowledge acquisition from dialogue is unification of hearer's knowledge and these carried information.

Keywords: Dialogue, Knowledge Acquisition, Knowledge Transfer, Understanding, DiaLeague