Japanese Question-Answering System on the Topic of Figure Manipulations

Makoto AMAMIYA*, Akira SHIMAZU*, Tadashi WAKANA*, Tadao WAKAYAMA* and Shiro SAKAI*

Abstract

This paper describes a question-answering system on the topic of figure manipulations, which has been implemented on mini-computers PDP11/20 and GT-40.

The system handles Japanese sentences in declarative, interrogative, and imperative formats, including active, passive, and causative voices. The system manipulates figures as an action, and answers questions about states of figures, properties of figures, past events etc.. Dialogues between a person and the computer are carried out in real time through the Kana (Japanese phonetic symbol) keyboard, and figure manipulations are shown on the display.

1 Introduction

It is considered as very important to develop a man-machine communication technique from the software engineering point of view.

There have been a number of computer question-answering system from the view point of making a computer model of human thought and knowledge.[(1),(2),(3)]

This paper describes a question-answering system, using the Japanese language, about simple figure manipulations. The system manipulates figures on the graphic display and answers questions about states or attributes of the figures. The system interprets and applies the meaning of sentences and takes several actions if possible, or requests more information when there are several possible interpretations. In addition, the system learns logical relations between objects, so the system can handle logics such as modus ponens and syllogism.

Main characteristics of the system are summerized as follows: (1) The question-answering topic includes generations and disappearances of objects. (2) An interpretation of a subjunctive phrase is considerd. (3) Identification of object or location, differentiation between intensional meaning and extensional meaning of object, tense interpretation of relative clause, and default assingment of case elements in a

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* Musashino Electrical Communication Laboratory, Nippon Telegraph and Telephone Public Corporation

sentence are considered. (4) Acquisition of newly defined concepts concerning objects, mental states or relations between objects are considered in a uniform semantic structure model.

2 System implementation

The system software organization is shown in Fig.1. It is written in assembler language, which has macro facilities to manipulate list structured data. The program size of the system is 28Kw in PDP11/20, and 17Kw in GT-40. Lexicon (a 150 word vocaburary) has 7Kw size. 4Kw spaces are reserved for the data-base to store knowledge acquired through dialogue. The programs run under the control of DOS.

The system can interpret normally expressed Japanese sentences, and can answer in 1 to 5 seconds.

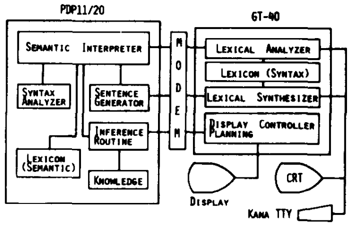


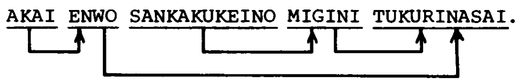
Fig.1 System Construction

A rough sketch of the processing flow for an input sentence is described in the following. (1) The semantic interpreter waits for an input sentence and invokes the lexical analyzer to analyze "Bunsetu", which is a character string delimited by space in the sentence, when it is needed. (2) When the control is returned to the semantic interpreter, with analyzed Bunsetu information from the lexical analyzer, it invokes the syntax analyzer to analyze dependency relation between Bunsetus into dependency tree structure. (3) The semantic interpreter then constructs a semantic structure of the phrase from dependency tree. When the semantic structure is constructed as a command structure for a phrase which conveys a concrete closed meaning, the semantic interpreter invokes the inference routine, which checks the validity of logical meaning of the semantic structure or searches for required items in the database. (4) In the course of the process of interpreting a sentence, many interactions between the semantic interpreter and the lexical analyzer, the syntax analyzer, or the inference routine may occur. Also, the process may backtrack, when a misunderstanding is detected. (5) When a whole sentence has been interpreted, the output sentence is synthesized according to the inference routine result.

3 Lexical analyzer and syntax analyzer

Syntax part of the system consists of the lexical analyzer and the syntax analyzer. The lexical analyzer parses the structure of a Bunsetu, and genarates a data structure which representes the Bunsetu category. The syntax analyzer parses governor-dependents relations between Bunsetus, using dependency rules given to the system in advance, based on the Bunsetu information generated by the lexical analyzer.

A dependency tree structure example is shown in the following. (Arrow heads are governors and tails are dependents.)



(Make a red circle at the right of the triangle.)

4 Semantic interpreter

Semantic interpretation process is basically bottom up. The interpretation proceeds by scanning an input sentence from left to right. At the early stage of interpretation, the semantic structures of words or sub-phrases are considered. These sub-semantic structures are then organized into the semantic structure of a phrase or a whole sentence.

The interpretation process is explained in the following for the above example sentence. The semantic structure of 'AKAI EN' (*a red circle*), 'SANKAKUKEI' (*the triangle*), and 'MIGI' (*right*) are shown in the following.

```
*OB1:  ((IS  #  *OB1  CIRCLE)        | *RL:  ((RIGHT  #  #  *OB2))
        (COLOR  #  *OB1  RED))       | *OBn: object variable, *RL: relation
*OB2:  ((IS  #  *OB2  TRIANGLE))     | variable, #: unspecified element.
```

When the verb 'TUKURINASAI', which is the imperative form of 'TUKURU' (*make*), is recognized, the following command sequence is generated.

```
(FIND  *OB2  ((IS  PRES  *OB2  TRIANGLE)))   *RL:  ((RIGHT  PRES  *OB1  *OB2))
(DO  (MAKE  *OB1  *RL))   *OB1:  ((IS  PRES  *OB1  CIRCLE)(COLOR  PRES  *OB1  RED))
```

On the other hand, if 'TUKURINASAI' in the example is replaced by 'UGOKASINASAI' which is the imperative form of 'UGOKASU' (*move*. Move a red circle...), or 'TUKURIMA SITAKA', which is the interrogative form, in the past tense, of 'TUKURU' (Did you make a red circle...?), the following sequences are generated, respectively.

```
(FIND  *OB1  ((IS  PRES  *OB1  CIRCLE)          | (DO  (MOVE  *OB1  *RL))
              (COLOR  PRES  *OB1  RED)))        | *RL:  ((RIGHT  PRES  *OB1  *OB2))
(FIND  *OB2  ((IS  PRES  *OB2  TRIANGLE)))      |
-------------------------------------------------------------------------------
(FIND  *OB1  ((IS  NIL  *OB1  CIRCLE)           | (TEST  ((MAKE  *EV  *OB1  *RL))
              (COLOR  NIL  *OB1  RED)))         |         (RIGHT  *EV  *OB1  *OB2)))
(FIND  *OB2  ((IS  NIL  *OB2  TRIANGLE)))       |
```

PRES: present tense, NIL: present or past tense, *EV: event variable.

5 Inference routine

Inference process in the system is considered on two levels. The first level of inference is embedded in the semantic interpreter. The second level of inference solves problems, which are represented as command made by the semantic interpreter, from the facts (or knowledge) in the data-base.

In the first level, inference processes are: (a) disambiguation process, (b) differentiation between extensional meaning and intensional meaning, (c) tense extraction, and (d) identification of reference. All of these problems are important, especially in case of Japanese, since the Japanese language has many ambiguous aspects, e.g., the lack of concepts of articles, the relative meaning of tense, the omission of case element.

The second level is a command executor, which operates on the data-base to solve those problems in procedural deduction mechanism based on pattern matching technique including the planning of the figure manipulation on current environment and display control.

6 Sentence Generator

An output sentence is generated by re-constructing from the dependency tree of an input sentence held in the system. This algorithm is very simple and very efficient indeed. Although generated sentences have redundant expression to some extent, they are sufficiently natural for conversation.

7 System facilities and sample dialogue

The approach by the method described so far achieves the following facilities: (a) figure manipulations (e.g., "Make a big yellow triangle at the left of the display and move it to the right of the circle."), (b) searches for objects, locations, events, attributes etc. (e.g., "What did you make on the upper side of the square ?"), (c) pseudo figure manipulations (e.g., "If you erase circles, are there red figures ?"), (d) conditional actions (e.g., "If there is a red circle, erase it."), (e) deductions for special objects or general objects (e.g., "Any circles are round. Make a circle. Is it round ?"), and (f) acquisitions of new concepts, such as name structure of objects, and relations between objects (e.g., "Red circles are named 'Sun'.").

The actual dialogue is shown in Fig.2. The translated English is shown in the second column.

8 Conclusion

A question-answering system, using the Japanese language is introduced through the topic of simple figure manipulations.

This implementation proves the effectiveness of the syntax analysis method by dependency grammar model, of the semantic interpretation model, and of the inference mechanism based on the command notion and procedural deduction through pattern matching. Also, it clarifies a method of solving some problems peculiar to the Japanese language.

Acknowledgment

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Reference

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# ガメンノ ミギニ モットモ オオキナ サンカクケイヲ ツクレ. --- ハイ, ガメンノ ミギニ モットモ オオキイ サンカクケイヲ ツクリマシタ.	# Make the largest triangle in the right of the display. --- Yes, I made the largest triangle in the right of the display.
# ソノ ヒダリニ キイロノ チイサナ シカクケイヲ ツクリ, ソノ シカクケイノ シタニ ソレヨリ チイサイ アカイ エンヲ ツクレ. --- ハイ, ソノ ヒダリニ キイロノ チイサイ シカクケイヲ ツクリ, ソノ シカクケイノ シタニ ソレヨリ チイサイ アカイ エンヲ ツクリマシタ.	# Make a small yellow rectangle on the left of it, and make a red circle which is smaller than it under the side of the rectangle. --- Yes, I made...
# エンヲ アオク ヌリ シカクケイヲ ミギシタニ ウツセ. --- ハイ, エンヲ アオク ヌリマシテ シカクケイヲ ミギシタニ ウツシマシタ.	# Paint the circle blue, and move the rectangle to the right lower part of the display. --- Yes, I painted the circle blue, and...
# アカイ エンハ ウツクシイ. --- ハイ, ワカリマシタ. アカイ エンハ ウツクシイデス.	# Red circles are beautiful. --- I understand. Red circles are beautiful.
# ワタシハ ウツクシイ モノガ スキダ. --- ハイ, ワカリマシタ. アナタハ ウツクシイ モノガ スキデス.	# I like beautiful things. --- I understand. You like beautiful things.
# サンカクケイノ ヒダリニ ナニガ ツクラレタカ. --- サンカクケイノ ヒダリニ シカクケイト アカイ エンガ ツクラレマシタ.	# What was made on the left of the triangle ? --- The rectangle and the red circle were made on the left of the triangle.
# ウツクシイ モノヲ ツクレ. --- ハイ, ウツクシイ モノヲ ツクリマシタ.	# Make a beautiful thing. --- Yes, I made a beautiful thing.
# アカイ エンガ ツクラレタカ. --- ハイ, アカイ エンガ ツクラレマシタ.	# Was a red circle made ? --- Yes, a red circle was made.
# ワタシハ ソレガ スキカ. --- ハイ, アナタハ ソレガ スキデス.	# Do I like it ? --- Yes, you like it.
# シカクケイノ ウエニ アカクテ オオキイ セイサンカクケイガ クッツイタ モノヲ「イエ」ト イウ. --- ハイ, ワカリマシタ. シカクケイノ ウエニ アカクテ オオキイ セイサンカクケイガ クッツキマシタ モノヲ イエト イイマス.	# I call the thing which is made by attaching a large red triangle on a rectangle, "house". --- I understand. You call...
# ワタシノ スハナ モノガ アレバ ソレヲ ウエニ ウゴカセ. --- ワタシハ「スハナ」ト イウ コトバヲ シリマセン.	# If there is a thing which I ljke, move it to the upper. --- I cannot understand the word "ljke".
# ワタシノ スキナ モノガ アレバ ソレヲ ヒダリウエニ ウゴカセ. --- ハイ, アナタノ スキナ モノガ アリマシタカラ ソレヲ ヒダリウエニ ウゴカシマシタ.	# If there is a thing which I like, move it to the left upper. --- Yes, since there was the thing which you liked, I moved it to the left upper.
# イエヲ エンノ ヒダリニ ツクレ. --- エンハ アオイ エント アカイ エンガ アリマス. ノゾミノ モノヲ シメシテクダサイ.	# Make a house on the left of the circle. --- There is the red circle and the blue circle. Please show me the one which you prefer.
# アオイ エンダ. --- ハイ, イエヲ エンノ ヒダリニ ツクリマシタ.	# The blue circle. --- Yes,I made a house to the left part of the circle.
# イエヲ ヒダリシタニ ウツセ. --- ハイ, イエヲ ヒダリシタニ ウツシマシタ.	# Move the house to the left part of the display. --- Yes, I moved the house...
# アカイ エント チイサイ シカクケイヲ ケセ. --- ハイ, アカイ エント チイサイ シカクケイヲ ケシマシタ.	# Erase the red circle and the small rectangle. --- Yes, I erased...

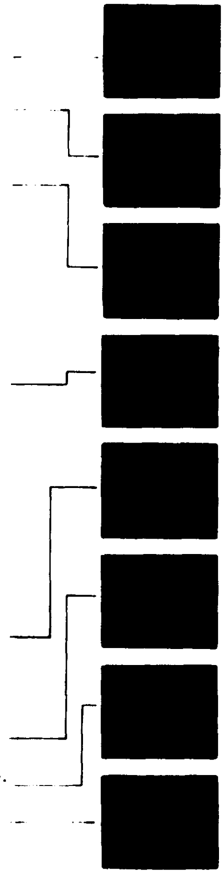

Fig.2 Actual dialogue (#: input sentence by a person, ---: the computer's response)