COMPUTING A MAP FROM MICHI-ANNAI-BUN OR WRITTEN DIRECTIONS

Teiji Furugori

University of Electro-communications

Chofu, Tokyo, Japan

ABSTRACT

This paper describes processes of transforming michi-annai-bun, literally street-guide-sentence into a map on a display device: we first show how such transformation is performed, and then we discuss what it means in terms of understanding natural language expressions.

INTRODUCTION

In Artificial Intelligence and Cognitive Science there have been a number of studies concerned with maps and directions. Notably, Kuipers£I3 presented a model of representation of large scale environments and used it in constructing routes with street descriptions. Riesbeck[2] observed that much of spatial reasoning was unnecessary when one reads a written set of directions. He claimed that, without detailed information on all the turns, distances, and locales, the set of directions was clear and sensible if it is satisfied certain conditions. He then wrote a program that judged the clarity and crucial ity of the sentence in the text giving directions.

Here we present another program that is concerned with michi-annal-bun, literally street-guide-sentence. QJLT program computes a picture (map) from michi-annai-bun or texts giving directions. The effort is made with a similar ideas in mind that Simmons described when he computed pictures from natural language for the clown's microworld[3].

MICHI-ANNAI-BUN

A michi-annaJ-bun is a sequence of sentences (instructions) that tells us how to get to a place from certain point. For example:

> Get off at Chofu station and take the north exit. Go for a short distance and (you) see a liqueur store on your right. And (you) are at Kyuu-koushuu-kaidou. Turn right. Then turn left in a very short while at Toukai Bank on your left. Go straight for about 200 meters and (you) come to a small intersection. Go a little further and (you) see a needle shop, Toushuu, on your left, and the big Koushuu-kaidou is there. Turn left. Go a little and (you) come to see an elementary school on your left and the big Dentsuu-dai on your right.

Michi-annai-bun's have three types of sentences: move-sentences, exist-sentences, and comment-sentences. A "move-sentence" is a sentence that directs us to move from one point to another. An "exist-sentence" is a sentence that shows us the existence of landmarks along the way to the destination. A "comment-sentence" is a sentence that gives us some other useful information on directions.

Each sentence in michi-annai-bun's is divided into a verb and cases associated with it. In particular, a move-sentence contains at most five cases and an exist-sentences two cases. The cases we came up with for the move-sentence are origin, goal way, direction, and distance. Those for the exist-sentence are position and object. For instance, the sentence

Koushuu-kaidou-o migi-ni magaru.
(Turn right at Koushuu-kaidou.)

is a move-sentence that has a move-verb <u>magaru</u> (turn) and two cases, way (<u>Koushuu-kaidou</u>) and dlrection(<u>migi</u>). The sentence

Koujou-ga aru. (There is a factory.)

is an exist-sentence that has an exist-verb <u>aru</u> (to be) and the case, object(<u>koujou</u>).

The sentence

Minogasu koto-wa arimasen. (You can not miss it.)

is an example of the exist-sentences.

MAP COMPUTATION

Map computation from michi-annai-bun's has three distinct processes: sentence analysis, internal code generation, and map drawing. First, a michi-annai-bun is decomposed into a set of simple sentences each of which, in turn, is divided into a verb and it case relations. Second, the semantic structure of each simple sentence is transformed into a matrix (or matrices) and the michi-annai-bun becomes a sequence of matrices. Finally, with the information supplied by the matrices, a set of Fortran routines that uses GPSL (Graphic Plotting Subprogram Library) is called to compute a map on a display device.

<u>Sentence Analysis</u>. Sentence analysis does two successive decompositions of michi-annai-bun:

1. michi-annai-bun --> simple sentences
2. simple sentence --> standard form (verb

and cases)

The purpose of the decompositions is to enumerate in standard forms a train of conceptual units that corresponds to actions and situations pertinent to the michi-annai-bun.

The sentence analysis in michi-annai-bun is reduced to a pattern matching process, given the sets of move-verbs and exist-verbs in a dictionary and the fact that a simple sentence consists of a sequence of noun and adverb phrases, with case indicating particles at the end of each phrase, followed by a verb. However, the order of phrases in a sentence is quite flexible (except for the rule that the verb comes at the end), and sometimes actual cases used in it differ from those of the surface structure in the pattern matching process.

The patterns for noun phrases may be complicated by a number of nouns, adjectives, particles that do not signify the overt cases for michi-annai-bun's, inflected forms of verbs, and other constituents allowed to appear in a phrase.

Comment-sentences are treated just like comment statements to compilers. When the verb used in a sentence is not for a move-verb or an exist-verb, the sentence is ignored as a comment sentence. This situation also occurs when the decompositions failed for some reasons.

Internal Code Generation. Once the case frame is built for each sentence, information in each phrase is sought to extract the semantic structure of the sentence. That is to say, adjectives and other constituents of a phrase may contain further information about the sentence. In a phrase cokina gakkou (a big school), for instance, the adjective ookina provides information on the size of the building gakkou.

All the information in a sentence is put in a matrix structure that will describe the semantic structure of a sentence. From the verb and the elements that constitute a phrase, we may get the size, type, and name of the landnarks or width, type, and name of the street concerned. From the preceding sentences or following ones, we may get more information about the origin, goal, position, etc. Such information, which is crucial to draw a map, will be put in the matrix. If necessary information is missing, then a default value may be supplied to the appropriate place in the matrix. When the noun signifies an object that may be given a special symbol on a map, then the information is extracted from the dictionary and inserted in the matrix.

The use of the you-are-here pointer is an important intermediary to generate matrices. This is a structure with various variables that keep track of the current location and destination, direction, the side of street you are on, etc. In particular, two variables are kept for the direction since absolute directions, e.g., north, and relative directions, e.g., right, may be used interchangeably in michi-annai-bun's.

MAP DRAWING. A map is computed by a Fortran program that uses GPSL, a set of Fortran subroutines for graphics.

The sequence of matrices generated in the previous section contains the information needed to draw a map. Each matrix should now have sufficient information about a motion or a landmark along the way to the next (intermediate) goal.

The Fortran program contains, for instance, the subroutine WALK which requires several arguments and draws a straight road from the current location; the subroutine CROSS draws an intersection; and the subroutine BUIUD generates a special symbol through one of the arguments.

The verb or noun put in the matrix determines which subroutine is to be called. Then necessary values for the arguments of the subroutine are sought in the matrix. If crucial information is missing and the default value is not in the matrix, the system generates an appropriate question, and the user is required to supply the necessary information.

AN EXAMPLE

Consider the following michi-annai-bun for an illustration:

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EKI-DE ORIRU. KITA-NI MUKATTE MASSUGU SUSUMU.
EKIMAE-DOURI-NI DETA-RA HIDARI-NI MAGARU.
SOSHITE SUKOSHI IKU-TO KOUBAN-GA ARU.

[Get off at the station. Face the north and
go straight. Come to Ekimae-douri and turn left.
Go a little further, and there is the police
stand.]
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When this is analyzed, seven simple sentences, with their case frames below on the right, are identified.

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(1) eki-de oriru.             oriru(eki,-,-,-,-)
(2) kita-ni mukau.            mukau(-,-,-,kita,-)
(3) massugu susumu.           susumu(-,-,-,-,massugu)
(4) ekimae-douri-ni deru.     aru(-,ekimae-douri)
(5) hidari-e magaru.          magaru(-,-,-,hidari,-)
(6) sukoshi iku.              iku(-,-,-,-,sukoshi)
(7) kouban-ga aru.            aru(-,kouban)
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The verb used in each simple sentence is changed to its uninflected form. The case indicating particles and unnecessary conjunctions, if any, are eliminated also.

The order of the cases is origin, goal, way, direction, and distance for the move-sentences. That of the exist-sentences is position and object. Here, except for (4) and (7), all verbs are move-verbs.

Each matrix to be generated represents a semantic primitive. A semantic primitive corresponds to one of the three scenes on the michi-annai-bun: the existence of a street, the existence of a building, and the movement to be initiated by us. Thus, massugu susumu generates a matrix for a movement; kouban-ga aru generates a matrix for an existence of buildings. In this example, the number of matrices is the same as that of the simple sentences as each sentence entails a semantic primitive.

(2), (3), and (6) use the subroutine WALK with various arguments. Eki (train station) as origin in (1) requires a special symbol and determines which subroutine be called. (4) invokes the subroutine TSHAPE to draw a T-shape intersection, (deru in (4) is a move-verb, but is considered to be an exist-verb in the context here.) However, the drawing was the result of a system's interaction with the user since the shape of the corner was not specified in the original sentence and no clue to determine it was obtainable. (5) changes not one's position but his direction.

In (7) the side of kouban was not specified but "on your left" was assumed in the matrix. The reasoning was the result of the assumption that, unless specified otherwise, one remains on the same directional side that prevailed in the previous turn, i.e., hidari (left) in this case, and that, if not specified, a landmark is located on the same side as one is on.

An output from this example is:

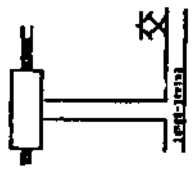

Figure 1 shows an outpu< for the michi-annai-bun exemplified in the section 7iichi-annai-bun. This michi-annai-bun itself is rather dull, but the map created is about right for Dentsuu-dai from the Chofu station. Here, the symbol 12 and *X* are the standard ones for banks and schools, respectively.

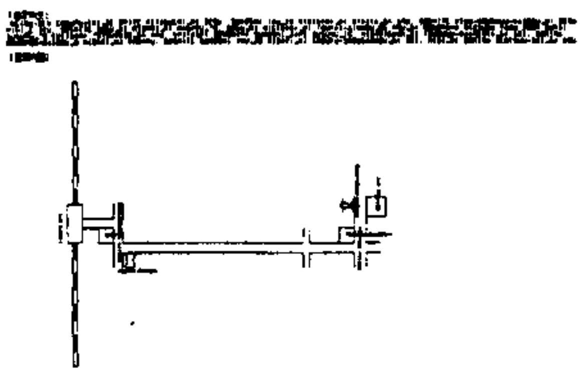

Figure 1

FINAL REMARKS

In the end, the structure of language used in michi-annai-bun's is nothing different from that in exressing any other subjects: one may put it any way he likes. Realistically, however, the main components of a michi-annai-bun are "move-sentences" and "exist-sentences", and most of them are picturable.

The drawing maps from michi-annai-bun's is interesting in two reasons. Pedagogically, it provides with the student a concise example *of* natural language processing. Here t^ understanding of natural language is clear an^H operational, and the student gets a hands-on experiment in this field. Theoretically, we learn much about the properties of natural language processing and the nature of natural language understanding. The map drawing reveals relations between natural language expressions and picture representations. A map represents relative distance and directions among objects well. Michi-annai-bun's are poor at doing this. On the other hand, fuzzy concepts such as "second or third street" are not picturable. The same is true for the expressions like "tall buildinr", "noisy street", "a street with a good smpll of limber", etc.

In many cases, maps drawn from michi-annai-bun's are far from the actual ones. One tends not to express certain local environments in michi-annai-bun; concepts used by him are too fuzzy for the picture drawing. In turn left, for instance, we do not necessarily mean an angle of 90 degrees, which our program assumed. Yet, such a michi-annai-bun is clearly understood when we read it. When we specified all the details in michi-annai-bun's, our program was able to compute fine maps, but then we had hard time to comprehend the michi-annai-bun's.

The map drawing encounters problems common with natural language computation systems like the one presented by Biermann and Ballard[4]. *On* one hand, noun phrases require much the same types of semantic analysis. On the other, our program could be made to draw accurate maps just like they tried to have a matrix calculation program using natural language. However, our intention at the moment was not to have a complete map-drawing program. Instead we are interested more in an understanding of a good michi-annai-bun and its relation to the street map.

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