MULTI-LEVEL MACHINE TRANSLATION METHOD

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ABSTRUCT

A Multi-Level-Translation Method is developed for machine translation. This method is based on an analysis of the speaker's recognition of both the subject and the object, and a simultaneous analysis of the syntax and meaning. There are two sub-methods: a Separate- Recombine method and a Multi-Level Transfer Method. The Separate-Recombine method analyzes the subjective expression, extracts subjective emotions and intentions, and recombines them into the target language. The Multi-Level Transfer method transfers the remaining objective expressions into the target language by three steps based on how abstract the sentence structure is.

In these three steps, a special recognition structure and an individual recognition structure are extracted and transferred in that order, and the remaining expressions are transferred by general rules.

1. INTRODUCTION

Unlike natural science which deals with nature, research on natural language deals with a mental product, "natural language". Many explanations have been proposed for language depending upon the difference of understanding the mental function. For instance, Saussure's structuralism (Koerner 1973, Fages 1968, Lepschy 1970) assumed that the mental function exists in an "a priori conceptural substance", and explained that the contents of the mental function is a linguistic norm. However, his structuralism or ordinary grammar (Iwanami 1977) cannot explain homographic expressions (why does the same sentence structure often have different meanings). Chomsky (Apel 1971, Kazita 1976) said that a more abtract structure should be

considered as the meaning. He introduced a "deep structure" assuming a common thought pattern for every one. His idea focusses on the content of expression. But, he separated the content from the object so that a reflection theory was ignored and a dualism (Chomsky 1966, 1968) was asserted, where a form was confronted with a content.

Chomsky (1965) first tried to explain a deep structure only by a syntactic structure in his standard theory. The major contradiction in his idea about the explanation of homographic expressions was pointed out by Katz (1970) and Postal. Then, in the revised augumented standard theory (Chomsky 1973), he changed his idea to approve changes of meanings by transformations of expressions. Therefore, meanings that had been explained as existing in a deep structure, also came to exist at a surface structure. Thus, his idea was changed from the dualism of a form and a content to the dualism of contents.

However, the way that the object should be, and the recognition should be, is reflected by the form of an expression, so that the form and the content depend on each other. And the speaker's recognition is connected to an expression. Therefore, a deep structure need not be assumed as a semantic structure separated from a surface structure. On the contrary, the relation between the object, the speaker's recognition and an expression should be considered as the meaning.

A lot of current research (Uchida 1984, Muraki 1984) on machine translation follows a "Transformational Generative grammar", where a common structure of meaning is assumed, which is represented by an intermediate language independent from ordinary languages. However, if the "Process Construction of a language"

(Tokieda 1941, Miura 1967), such as an object, a recognition, and an expression, is taken into consideration, it becomes apparent that only an object is common to languages and the way of recognition differs from person to person also from language to language. Therefore, it is difficult to assume a deep structure as a meaning in common between languages. The difference of recognition structure (Morita 1981, Miura 1981, Anzai 1983) between the original language and the target language should be considered for high quality machine translations.

Based on the "Process Construction Theory" of language (Tokieda 1941, Miura 1967), this paper shows the importance of two points in machine translation: the contents expressed by a subjective expression and

an objective expression, and an undividable relation between a sentence structure and a meaning. This is the basis of the proposed new machine translation method MTLM (Multi-Level Machine Translation Method).

2. PROCESS CONSTRUCTION OF A LANGUAGE

2-1 Introduction to the Process Construction Theory

A language has been metaphysically explained as a complex body of the complete world by formalism and structuralism. An expression was explained by the functions or forms of each part of the expression. Chomsky's explanation satisfactorinly notices the content of expressions. However, the relation between an object and a speaker's recognition was not considered. Before this idea, "the Process Construction Theory", proposed by Tokieda (1941), explained that a language is composed of three processes: an object, a recognition, and an expression.

These processes are combined by a relation of the causality. The way that object should be reflects a speaker's recognition, and the way that a recognition should be, is connected to an expression through the language norm. The differences between Chomsky and Tokieda are shown in Fig. 1

2-2 Speaker's Recognition and Representation

(1) Recognition of the Subject and the Object

The world that a speaker recognized is composed of a subject, namely the speaker him-self, and other objects as shown in Fig.2. A speaker recognizes both his own state and the state of other objects, and connects them to expressions. From this point of view, Tokieda explained that a Japanese sentence is composed of two kinds of expressions:

##"Subjective Expressions" directly represent subjective emotions and intentions. Japanese adverbs and "joshi" (a post positional word functioning as an auxiliary to a main word) are used for these expressions.

##"Objective Expressions" represent conceptualized objects. Nouns, verbs and adjectives are used for these expressions. When a speaker conceptualizes a subject (the speaker him-self), the subject can be represented by these objective expressions.

The relationship of these expressions has been pointed out by Port-Royal (Lancelet and Arnauld 1966) for Indo-European languages.

(2) Connection between a Recognition and an Expression

The object can be subdivided into the substance, the attribute and the relation, all of which have many structures. These structures are reflected in expressions through a speaker's recognition. The substance has a hierarchical relation between a part and the whole and so on. The attribute is related to the substance. And, the relation is mainly constructed by the three kinds of relation: the relation between substances, attributes and relations.

These components and partial structures are combined to construct a total structure in many ways in a speaker's mind. The way of recognition depends on the view point of a speaker. Every language has

it's own framework that represents such a recognition.

Thus, the original structure of the object was not directly reflected in the expression but through a speaker's recognition. The difference between languages is the difference between the frameworks of a speaker's recognition. Then, the relationship between a subjective expression and an objective expression in the original language should be reconstructed and expressed in the target language.

2-3 Definition of Meaning

(1) Ordinary Explanations and the New Definition

Many explanations of the meaning of an expression have been proposed in ordinary linguistics. Katz(1970) explained that a meaning exists in a

dictionary. Grice (Miura 1981) said it was a listener's behavior. Searle (Miyashita 1981) defined it as a speaker's intention. Saussure (Koerner 1973) explained it by an "a priori conceptual substance". Moreover, and Wiseman (1965) said that we should not think about meaning.

Saussure separated a "lang" to be social and a "parol" to be individual. Conversely, Chomsky separated a content (a "deep structure") from a syntactic structure. In this respect, their ideas are different. However, they agree that: contents are independent from the object, and a "lang" and a "deep structure" are common to humans or human groups. A lot of current research on machine translation is based on their ideas and assumes a

deep structure to be the meaning. There are also cases where a deep structure is explained as the way that a object should be, differing from a speaker's recognition.

In opposition to these ideas, we define the meaning of an expression to be the relations between the object, the recognition and the expression. This definition is based on the fact that the way that a subject and a object should be, are connected to an expression through a speaker's recognition. Accordingly, the meaning (i.e. relation) does not exist without an expression. The ordinary meaning of a word defined in a dictionary is not exactly a meaning, but a language norm. Only when a word is used in an expression, does the relation to a recognition

and an object arise. Then, the word acquires a meaning.

(2) Meaning of a Syntactic Structure

A speaker consolidates his recognition and represents it by an expression, using rules for words, phrases and clauses. This comsolidation is based upon language norms supported by a meaning. That is, the way that the object should be, reflects a speaker's recognition, and a speaker's recognition reflects an expression. This means that the syntactic structure is combined with the object and the recognition, and it means that the syntactic struc ture is part of the meaning. Unlike a "Transformational Generative grammar" where a structure (a surface structure) is opposed to a meaning (a deep struc-

ture), a surface structure can be thought as part of a meaning. Therefore, transforming an expression, strictly speaking, changes the meaning. A transformation can not leave the meaning unchanged. Transformations in ordinary language processing are transformations to other approximated expressions.

Accordingly, an Element Composition method, which tries to compose the whole meaning a part of the meaning, neglects the meaning of a syntactic structure, and it can not prevent the meaning of a syntactic structure being missed. The meaning of the part of an expression can be interpretated only in the context of whole sentences. Accordingly, the rules of the meaning of a word used in the expression, can be determined only for the context as shown in

Fig. 3.

3. PROPOSAL OF MULTI-LEVEL MACHINE TRANSLATION METHOD

A "competent sentence" can be defined as a sentence that can be translated in isolation with only a knowledge of language, namely grammer and a dictionary. The Multi-Level Machine Translation Method (MLMT method) is proposed for competent sentences as shown in Fig. 4. The MLMT method has two sub-methods described in this section.

General knowledge of a world and context analysis among several sentences have often been pointed out to be necessary in a machine translation. However, this knowledge and analysis are not always necessary. About 90% of Japanese written sentences in practical use are "competent" sentences. Therefore, we first focus on the translation of these sentences.

3-1 Separate and Recombine Method for the Subjective Expressions

Japanese is classified as an agglutinative language, so that "joshi" and adverbs are used for subjective expressions. Conversely, English is an inflectional language, with subjective expressions usually represented by inflections. Thus, Japanese subjective expressions do not directly correspond to English ones and it is difficult to translate word for word. First, the speaker's emotions and intentions are classified into categories. An analysis determines what kind of categories the subjective part of a given Japanese sentence represents. Thus the original Japanese sentences are transformed into basic Japanese sentences. The Japanese sentences remain-

ing after the subjective expressions are extracted, are objective expressions. These expressions are translated into basic English sentences by the Multi-Level Transfer method described in the next section. Finally, the speaker's previously extracted emotions and intentions are recombined with the basic English sentences. Adverbs and prepositions are added and nouns and verbs are inflected. Thus, information about the subjective expressions separated from the original Japanese sentences are recombined in creating English sentences.

It will be sufficient for information of subjective expressions to be classifid by the amount of the break-down required for a translation from Japanese to English. Therefore, strictly speaking, the objective expressions, remaining after extracting this subjective information, also have a few subjective expressions. These subjective expressions are used to understand the relations of

sentence elements in the analysis process of subjective expressions.

3-2 Abstraction of Structures of Objective Expressions and the Multi-Level Transfer Method

The way that the object should be, is represented in a basic Japanese sentence (an objective expression) through a speaker's view point. A speaker's recognition about an object has several structures and these structures reflect the structure of the objective expressions. If we strictly consider that changing an expression changes the meaning and that a united process of syntactic structure and meaning are needed for accurate translation, then matching English expressions are needed for all Japanese expressions. Clearly, this is not practical because of the infinite number of expressions. Thus, sentence structures are classified into three levels,

noting the strength of the link between the sentence structures and the meanings. Sentence structures are transformed through a suitable method to one of the levels.

(1) Specific Recognition Structures (An Idiomatic Expression Transfer Method)

Expressions, such as idioms, have meanings which can not be determined from their individual words. Moreover, there are many Japanese phrases that correspond to single English words. These expressions are not idiomatic in Japanese but are idiomatic in English.

These kinds of expressions are especially difficult for an Element Composition method to translate. Therefore, these expressions are completely trans-

ferred by Idiomatic Expression Transfer rules prepared as a matched a pair of Japanese and English expressions from pair pattern dictionary. An idiomatic expression is made up of soveral words. If these word combinations appear, an Idiomatic Expression Transfer method is preferentially applied.

(2) Individual Recognition Structure (a Semantic Valentz Pattern Transfer Method)

More general structures are classified into these categories. The appearance of written words is completely fixed in the specific recognition structure. Conversely, an individual recognition sturcture represents the structure where the appearance of a single word is fixed and the other words are not fixed but restricted by the semantic attributes of

the words. When the appearance of a declinable word is fixed, the contents of other "bunsetsu" (Japansese clauses) connected to the declinable word are restricted in the use of "joshi" and the semantic attributes of nouns. A case grammar (Fillmore 1975) can be applied for these individual recognition structures. However, a Valentz Pattern (Ishiwata 1983) Transfer method is suitable because it does not need a deep structure, which is difficult to define exactly. In a case grammar, some of the meaning of a syntactic structure is missed in the decision process of deep cases, wheras the meaning of a syntactic structure can be transferred in a Valentz Pattern Transfer method.

This paper uses a Valentz Pattern Transfer

method augmented by restrictions of the attributes of a word. This method is supported by a system of pecise and mutually exclusive semantic attributes of words. This method can transfer meanings which can not be categorized by case grammar.

Individual recognition structures are paired for Japanese to English expressions registered in a pattern dictionary. An English recognition structure also has a related key word used in a translation and other restrictions such as prepositions and semantic attributes of nouns. So the ambiguity in selecting a translation word will decrease. This method requires many patterns, up to about ten thousand, and a precise system of semantic attributes. However, pattern groups, which have the same key word, are independent

of each other. Therefore, the consistency of each rule does not need to be checked in principle, and the system of transfer rules can easily expand.

(3) General Recognition Structure (A General Pattern Transfer method)

In the previous two structures, a special word and its combination was considered as a pattern. Here, more general patterns are considered. The appearance of a word is not fixed. For instance, patterns are calssified by verb types as a instanteneous verbs or verbs of state and so on. General patterns corresponding to groups of verbs are prepared. Rough translation cannot be avoided with this method because of the generality.

For these three methods, the more special the structure that a pattern has, the higher the quality of the translation that can be expected. These methods are applied to basic Japanese sentences (a subjective expressions) in the order described above. If any patterns relevant to a given Japanese sentence can not be found in an Idiomatic Expression Pattern dictionary or a Semantic Valentz Pattern dictionary, then a General Pattern is used, and the quality of translation decreases. However, as the pair pattern dictionary grows, the translation quality should improve.

3-3 Construction of the MLMT (Multi-Level Machine Translation) Method

The MLMT method consists of two sub-method, a Se-

parate and Recombine method for subjective expressions, and a Multi-Level Transfer method for objective expressions, as shown in Fig. 5.

This translation process is similar to translation by a human shown in Fig. 6. That is, in human translations, a translator first experiences for himself the speaker's experience described by a given sentence. This process is supported by the Japanses norm that connect a speaker's recognition to Japanese expressions. Thus, a translator understands the way the objects should be and the speaker's emotions and intentions towards them. In the MLMT method, an original Japanse sentence is separated into descriptions of the way the objects should be and the speaker's emotions. The way objects should be are represented by a

basic Japanse sentence (an objective expression) and speaker's emotions are rearranged in a reference table.

In human translation, the way objects should be are next reorganized in the framework of English, and the speaker's emotions are recombined with it. Similary, in the MLMT method, the meanings of objects are transferred into English by the three levels of transfer method. The speaker's emotions, rearranged in a reference table, are recombined to give the final English expressions.

This method has the following characteristics. Idiomatic patterns or Valentz patterns, by which syntactic structure and meanings are represented, can be used, not only for Japanese to English translation but also, for Japanese sentence analysis. Therefore, there

should be fewer ambiguities in the analysis than with the ordinary method. Moreover, transfer rules are highly independent of each other, so the consistency check is limited to a small range. The translation system should expand easily.

4. Implementation of a Japanese to English Translation System

The MLMT method has been implemented in the "Automatic Language Translation System for Japanese to English" (ALT-J/E). This system first analyzes the morphemes of a given sentence. A morpheme is a meaningful linguistic unit that does not contain any smaller meaningful units. In this analysis, the boundaries of words are determined, and the synactic features of every word are determined. Dependencies between components of a sentence are subsequently determined. A "nuit sentence" is extracted by a declinable word and it's related parts. A unit has only one declinable word. A "simple sentence" has a single dedinable word as the top of a tree structure for a sen-

tence. It sometimes has several declinable words as the lower node of the tree structure.

When a simple sentence is separated into several unit sentences, the relations between declinable words of a simple sentence are preserved. After a unit sentence is extracted, it is dealt with as a unit of analysis. A unit sentence is transformed to a basic Japanese sentence after extracting subjective information such as aspects, modes, tense and so on represented by the predicate. Patterns are used to analyze a Japanese sentence. When a simple sentence has several choices for a unit sentence, every choice is analyzed with patterns. Only the unit sentences which fit some of the patterns are used. This process decreases the ambiguity of analysis.

After this analysis with patterns, the pattern to be applied to every unit sentence has been determined, so the corresponding English pattern has also been simultaneously determined. Then, basic English expressions can be easily obtained. The final English sentence is generated by adding subjective information kept in a related talbe.

5. Conclusion

A machine translation method called the MLMT (Multi-Level Machine Translation) method was developed based on the Constructive Process theory of a natural language.

Problems of ordinary methods based on generative and transformation grammar were discussed. The importance was shown for machine translations that recognitions about a subject and a object should be separated, and meanings connected to a syntactic structure should not be missed. The MLMT method consists of two sub-method which correspond to these two ideas: a Separate and Recombine method for subjective expressions, and a Multi-Level Transfer method for objective expressions.

Ideally, to handle a syntactic syructure and its meaning as one unit, to produce high quality translation, all expression should be registered. The characteristics of a natural language make this technically inpractical. A technical compromise can be summarized as follows: ① sentence structures are classified as patterns corresponding to abstraction levels of a speaker's recognition. ② subjective expressions are separated from original sentences to improve the ration of fitting patterns.

The MLMT method was proposed for translating "competent Japanese sentences" into English. But this mithod can be applied to other translations such as English to Japanese or Japanese to chinese.

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