The Constructive Process Theory and the Multi-Level Translation Method

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Abstract

Computational linguistics has developed as a academic study, but a means of dealing with existing linguistic processing, it is all but useless and there are no examples of its having achieved appreciative results. The basic reason for this is believed to be that computational linguistics has historically segregated its contents from language and has turned it into an abstract form as a problem of formality and theory.

In the ALT-J/E Japanese into English Machine Translation System, a critical posture is assumed toward the position of computational linguitics. The system has suggested and realized a Multi-Level Translation Method grom the view points of handling realistic language. This Method has been devised with the background of the Constructive Process Theory which is one of the traditional Japanese grammar known as the Tokieda Grammar. It features handling of subjective expression which as aware of the speaker and thinks through the meaning of expression structures. Technically, this method is supported by meaning analysis which is based on linguistic knowledge. As linguistic knowledge for meaning analysis, a word meaning dictionary consisting of 400,000 words and a semantic structure dictionary including 15,000 sentence type have been prepared. These have been written under a system of about 100 types (in furtherdetail, these would amount 500 types) of syntactic attributes and about 3,000 types of semantic attributes, If rules were to be written by the same atrribute system, it would consist of such a structure that this knowledge would be mobilized and translation be conducted.

1. Introduction

Computational linguistics underwent development and progress since generative grammar was propounded by Chomsky [Chomsky 1956, 1965]. Examples of this having achieved results in natural language processing [Tomita 1987] were rare and the gapbetween reality remains large. A

great deal of thought has been directed toward identifying the causes for this. In most cases, the impasse confronted by theory and limitations are found in the initial presises of such theories.

Primarily computational linguistics expresses language by a theoretical model that has conformity and has sought to process this by a unified method. Yet, in reality, lamnguage is certainly not anything that abounds in such conformity. Natural language is something like a custom or habit that has spomtaneously grown and developed within its own group of languages. It reflects the anything but an object that is perfectly and beautiflly adusted. It is a means of expression the various distortions and conflicts in society. With the changes in society, language itsself undergoes changes. Thus, to become completely committed to language would make it impossible to pursuue and unchangeable model. In contrast with natural language processing attempts to grasp language as a method of reality, computational linguistics would appear to separate itself from reality and become involved with fictitious argument.

For example, deep structure is suggested as a structural element of linguistic model incomputational linguistics. But this is nothing other than a sel-contradictory argument [Cresswell 1973, Mendeleson 1979 and Bresnan 1982] that ignores the relation between the target objectives and the speaker in the language of reality. There is the strange phenomenon of hypothesizing a meaning to enable explanation of a meaning. Further, by manual translation, as in the saying, "traslation begins with conversion of idioms to idioms" and importance is attached to handling of idiomatic ecpressions. In contrast, in computational linguistics, idioms tend to be rejected as being beyond the scope of principles of compositional semantics. It would be unnecessary to fall back on to the example of idiomatic expression, the number of persons who believe that compositional linguistics is valid in compositional semantics is limmited in number. Yet computational linguistics continued to stand by steadfastly by this assumption.

If languages are a social custom, there should be a method of processing that matches them. Researches of natural language processing require the pursuit of every one of these words.

Accordingly, we have sought a new approach amidst the results of conventinonal linguistics, promoting a new methodology. The background for our research work is the Constructive Process Theory of language [Tokieda 1941] by Motoki Tokieda, who followed up on the work initiated in the 18th century by Norinaga Motoori[Motoori 1779]. Our machine translation research efforts have been based on this theory and has resulted in a Multi-Level Translation method[Ikehara et. al. 1987, 1989, 1989] and a test product Japanese to English experimental machine translation system ALT-J/E.

In this paper, thinking of the conventional computational lingustics will be regarded in a critical manner and in its place, the significance of the multi-level translation method based on the view point of the processinf along this formula will be discussed.

2. Background of Linguistics

2. 1 Genealogy of Formalism

(1) Background of Computational Linguistics

There has been two types of logics, dialectic and formal logic since the era of ancient Greece. Dialectics which was advanced by Hegel [Muramatsu 1959] asserts that actual existence should be thought of as a meaning theory. Hence, it deals with contents. On the other hand, formal logic[Quine 1950] insisted on purity and handling of an ideal world, and cut itself off from the realistic world.

Symbolic logics[Hilbert et. al. 1928], computational logics[Allwood 1971] and computational linguistics are also derived from the latter, formal logics. There appears an effort to apply computational linguistics to natural language processing. But natural language is a language that deals with the realistic world. This would seem to be the cause of various problems. Especially, Frege's principle [Nomoto 1986], which is compositional semantics and constitutes a major assumption in computational linguistic, is not valid in a natural language.

(2) Differences of View-points between Japanese and English

Let us consider the differences between the Japanese and Ind-European languages. The Ind-European languages have sentence patterns such as 5 patterns which are relatively independent from contents. These languages can be classified as a suitcase type lamguage. Structualism was developed from the viewpoint of importance of forms and structures of expressions. Chomsky took notice of the importance of contents to overcome the limitation of structualism. But he still inherited the basic problem of logics.

In contrast, Japanese language is relatively free from forms and does not have a rigid sentence structure. Japanese can be classified as a 「furoshiki」 (wrapping cloth) type language. Forms are dependent on contents. In other words, the shape of contents appears in a form of expression. Thus, contents are important in Japanese processing.

There are 20 different types of grammars in Japanese. And four of them are well known. Hashimoto Grammar and Tokieda Grammar form a contrast. Hashimoto grammar[Hashimoto 1946] which was adopted for use in school by the Ministry of Education of Japan is strongly influenced by European philology. Tokieda grammar[Tokieda 1941] which was derived from Norinaga Motoori[Motoori 1779] is the most traditional one.

As nature is a complexed body of processes that develops with conflicts as the motivating force, so also is language. Tokieda established the Constructive Process Theory of language which placed importance on the contents based on this idea.

2. 2 Outline of Constructive Process Theory of Language

(1) Comparison to Generative Grammar

Fig.1 shows the differences between the Constructive Process Theory and Chomsky's basic concept.

Constructive Process Theory asserts that a language should be

considered as a complex body of processes comprised of objects, speaker recognition and expressions. Objects reflect recognition. This process is explained by the reflection theory. Recognitions are combined into expressions using norms, namely the rule of languages. Linguistic norms are national rules which have been fostered in each community. These norms are referred to as a grammar in the broad meaning of the word.

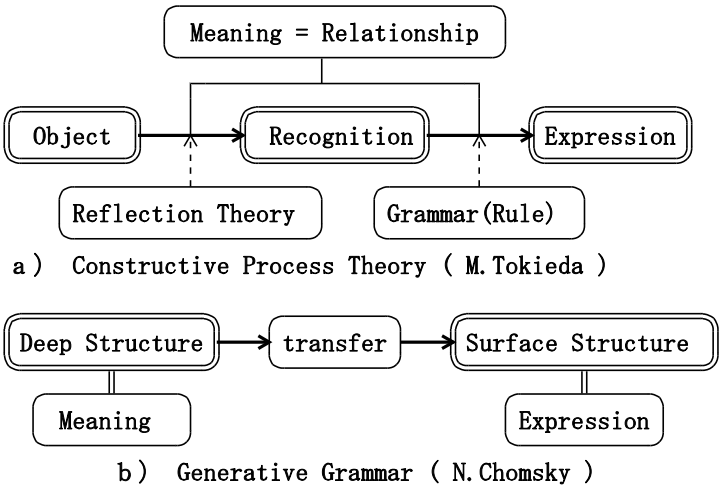
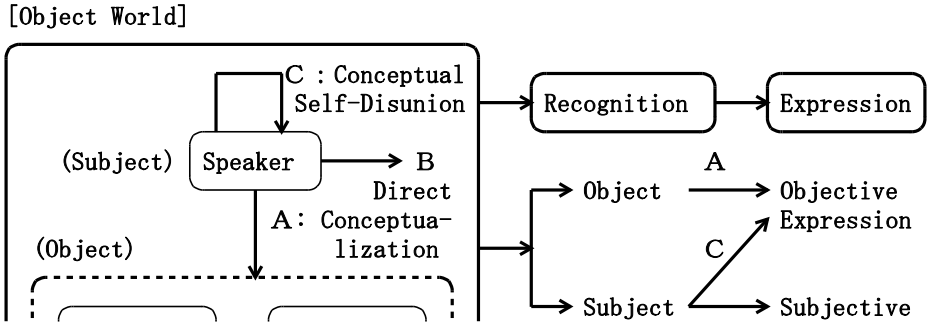


Fig.1 Comparison between Generative Grammar and Constructive Process Theory

In contrast, Chomsky interpreted language in the form of a dual structure, a surface structure and a deep structure. The existence of deep structure has been assumed as the meanings of surface structure. This is certainly a strange theory where because meanings are assumed for the purpose of explaining meanings. More recently, he appears to be attempting explanation based on mystic concepts. He says language cannot be explained without assmuming that humans are born with a basic linguistic ability.

(2) Constructive Process of a Language

Let us now see what happens when we regard language as a causal sequence between object, recognition and expression. The world of objects consists of a speaker and other objects. Objects are composed from substances, attributes and relations. The speaker recognizes the object world and at the same time, recognizes things about himself. In recognition of objects, conceptualization takes place.



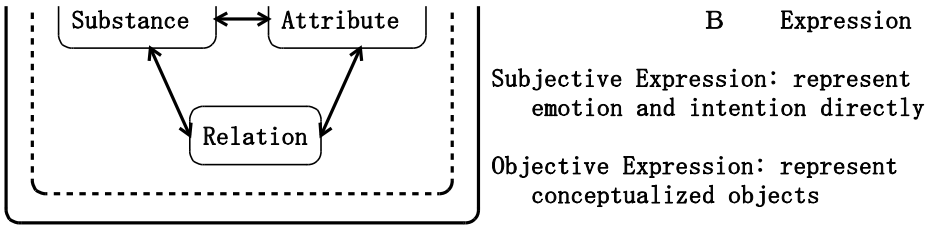


Fig. 2 Relation between Recognition and Expression

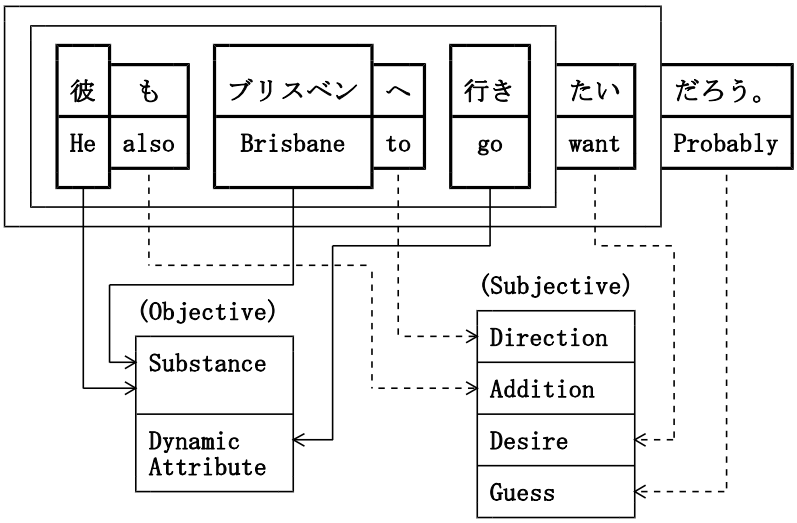


Fig. 3 Processing of Subjective Expressions and Objective Expressions

There are two occasions regarding recognition of self. One is the occasion where speaker represents himself directly in the expression without conceptualizing himself. On other ocassions, he conceptualizes himself and represent it as an object. When he conceptualizes himself, the phenomena of self disunion take place. A separate imaginary self other than the actual self appears. And the self conceputualizes the actual self.

Recognition related to subjects and objects is represented by two types of forms in linguistic expression as shown in Fig. 3. One is a subjective expression and the other is an objective expression. Subjective expressions represent speaker emotions and intentions. These expressions are expressed in the Japanese language by post positionals and adverbs. Objective expressions represent conceptualized objects. And these expressions are generally expressed by nouns and verbs.

This relation is somewhat different in English. Inflections usually express subjective expressions in English.

A similar view is witnessed in the grammar of Port Royal[Lancelot et. al. 1660] in France 300 years ago. The difference is an important factor in the translation method.

3. Meaning and Meaning Processing

3. 1 Relational Meaning Theory

Let us consider the structure of languages. If we assume that meaning is a substance, it is one of either "object", "recognition" or

"expression" and the fourth element of "interpretation".

If we say that meaning is born out of forms, we would arrive at a "formal semantic theory". But this would be ideological. Next, if we say that forms are born out of contents, this would result in a "object semantic theory" or "recognition semantic theory".

If we assume that objects and recognitions are meanings, how should we explain the sentence that has been erroneously written. This would result in a sentence that is incorrect in which something that is opposite is written, yet stating that the meaning is correct. Further, the object and recognition can never remain the same indefinitely and will undergo changes. Then, the meaning of the sentence will change independently from expressions. Motoki Tokieda chose eclecticism and took meanings to be listener's reactions.

Tsutomu Miura[Miura 1967] took after the Tokieda grammar, but improved the theory and advocated the "relation meaning theory". He proposed that structural processes from object to recognition are combined to make an expression. He explained the meanings of linguistic expression as the relationship between object, recogntion and expression. This kind of relationship is concrete and specific. As long as the expression exists, so will the meanings. When expression is cancelled out, so will all relationships, and the meanings are also lost.

The concept of regarding relationships as meaning resembles recent situation semantics[Barwise et al. 1981], but actually, the two are entirely different. In situation semantics, the meanings of expressions and the meanings related to the location in which the expression is placed are completely mixed up. The Miura grammar features a clear distinction between linguistic expression and expression of locations.

3．2 Meaning Analysis and Meaning Understanding

(1) Meaning Processing

Meaning understanding would involve re-tracing such a relationship between object, recognition and expression and to relive and experience the status of object and recognition.

Here, let us consider meaning processing in two step. The first step would be the process which designates the rules or conventions used in linguistic expression. Conventions regarding languages are complex and liable to be construed in many ways. The listener must identify the convention used by the speaker. Let us define this act of identifying the convention as "meaning analysis".

The second step would be the process of identifying the recognition of the speaker and the status of the object that is tied in with the expression. Here, this action is refered as "meaning understanding". Thus meaning processing is comprised of two processes, "meaning analysis" and "meaning understanding".

The knowledge that is required for meaning analysis would be linguistic knowledge, that is, conventions or norms regarding languages. In contrast, meaning understanding would require knowing the status of objects and this would require general knowledge, that

is, worldwide knowledge and knowledge in specialized fields.

(2) Meaning Analysis

Let us consider about the conventions involved in words of the sentence (a). The meaning of the word "高い(takai)" is "expensive", "high", "noble", "loud among others", but here, it is used with the meaning "expensive". "Abura" has various conventions as "fat", "oil", "lard", but here the convention expressing the meaning of "oil" is used. Thus, meaning analysis is identification of the convention which the speaker actually used among numerous conventions that exist in the language.

	sono misewa	takai	aburawo	utte iru
(a)	その店は	高い	油を	売って いる。
	that store	expensive	oil	sell

Meaning analysis cannot be achieved by merely staring at the words one by one. Look at the sentence (b). Literal trnslation of "senotakai" is "back is high". In English, one word "tall" is used to convey this meaning. But looking at "back" and "high" separately will not bring the concept of "tall". The same can be said of the other expression. "Sell" and "oil" jointly means "idle away his time" in this case. Thus, conventions regarding words can never be decisive if they are thought out word by word.

	seno takai	otokoga	sigotochuu	aburawo	utte	iru
(b)	背の 高い	男が	仕事中	油を	売って	いる。
	The tall	man	during work hour	is idling		

Structrures of objects reflect themselves into speaker recognition. These structures are also combined to expressions. This means that the structure of an expressinon is a part of the meaning. Structures cannot be separated from meanings because structures also represent meanings. Thus, in meaning analysis also, there is the need to think the relationship between structure and meanings. More specifically, it is important to grasp the structure of expressions as units of meaning.

(3) Meaning Understanding

Next, let us consider about meaning understanding. As discussed in the foregoing, meaning understanding involves the identification of the speaker's recognition and the status of object as tied in with the expression.

To know the speaker's recognition and the status of object, the listener must be equipped with a certain world in his mind. This world must have certain elements in common with the world which the speaker is depicting. To restructure a world corresponding to the expressions of the speaker, he will be required to link up the elements of the speaker's expressions and the elements of his own world. In other words, meaning understanding can be considered as linking the elements of the linguistic expressions and within the world model of

the listener. This action of linkage will structure a new portion in the listener's world.

3. 3 Meaning processing and Knowledge

In contrast that liguistic knowledge is required for meaning analysis, meaning understanding will require worldwide knowledge. Compared to linguistic knowledge, worldwide knowledge is massive and considerable amount of difficulties will be involved in research.

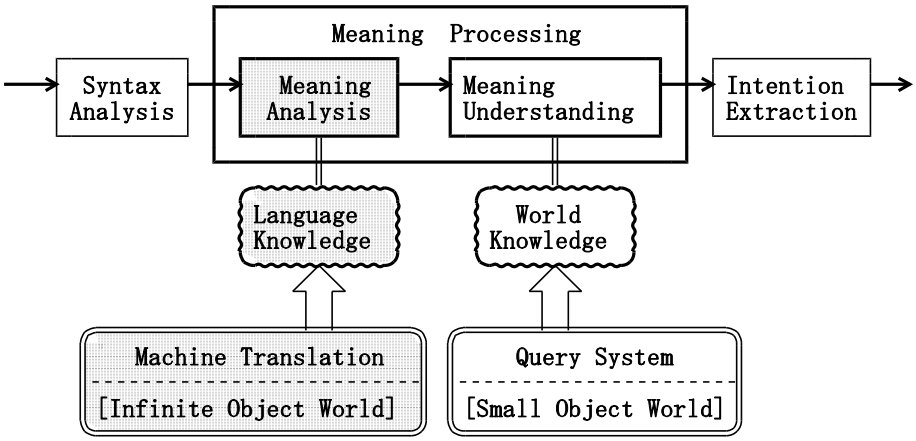


Fig. 4 Meaning Processing and Application

In machine translation, the contents of source text to be translated are diversified and it would be difficult indeed to prepare a worldwide knowledge. Machine translation can be acceptable even if the computer cannot entirely understand the contents of the text as long as the translation results can be finally understood by humans. Replacing the linguistic conventions used in the Japanese language by English conventions and leaving it up to the judgment of the average person. This is the basic stance assumed by our research efforts in machine translation.

First, we want to realize a translation based on meaning analysis. Next, we will extract the expressions and concepts which could not be translated by meaning analysis and attempt a meaning understanding with a limited world model.

It is advisable to deal with meaning processing with areas such as telephone number information and database inquiries, because the target world can be contracted into a comparatively small range.

4. Multi-Level Translation Method

4. 1 Problems of Intermediate Language Method

Conventional translation methods[MT Summit-I, II, Ⅲ 1987, 1989, 1991] can be classified into two types, the pivot method and the transfer method. There are many which seek to achieve the pivot method. However, there have been none that can be stated to have truly realized the pivot method. This is because universal intermediate language that can be commonly applied to many language cannot be designed.

Natural language has primarily originated by reflecting the perspectives and thinking of the group of people using such language.

It would appear unreasonable to consider a intermediate language that would be commonly applicable to every language which differs in thinking and perspective.

When a translation between languages which are very close each other is considered, or if a rough ranslation is to suffice, the pivot method may be satisfactory. But in either case, pivot method seems to have a basic misunderstanding of languages in its background.

The transfer method can be stated as being more realistic compared to the pivot method, because it does not assume that intermediate language is universal. However, if intermediate language can be thought of as a meaning expression such as deep structure, the same difficulties as in the case of the pivot method would arise. The meanings of surface structure cannot necessarily be retained by deep structure.

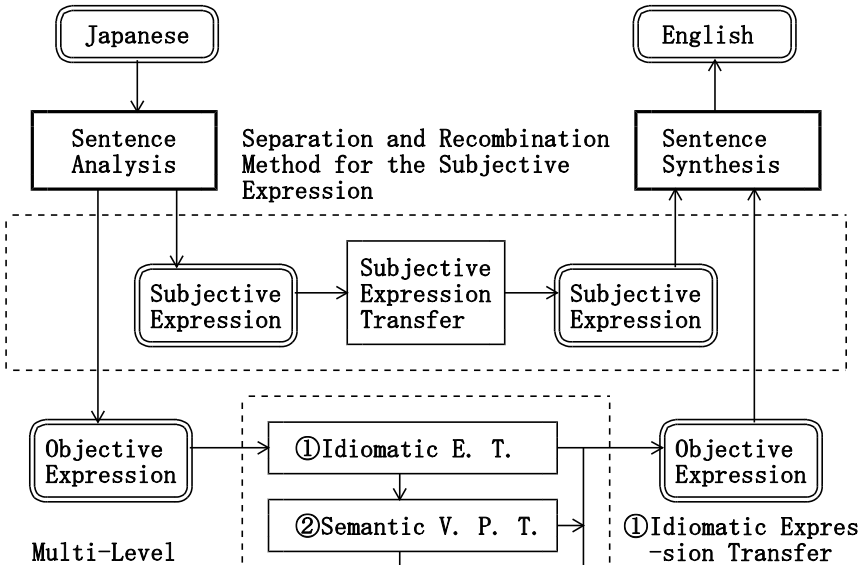
4．2 Basic Concepts of Multi-Level Translarion Method

The method of translation based on the foregoing meaning analysis is the Multi-Level Translation method. The term "Multi-Level" indicates that translation is being conducted at various levels of abstraction.

The need to observe differences between subjective expression and objective expression have previously been mensioned. And, the necessity of consideration about the meaning of structures have also been pointed out. The Multi-Level Translation method has been structured based on these two factors.

The first point is considered as follows. Japanese and English are very different in presenting subjective expressions. Therefore, subjective expressions are segregated from objective expressions and converted into English.

The second point is resolved by abstraction of expression structures. Three levels of abstraction have been proposed. The first is related to a level of idiomatic expressions. The second concerns specific structures such as loosely coupled words. The last concerns most loosely coupled structure that can be represented by general rules.



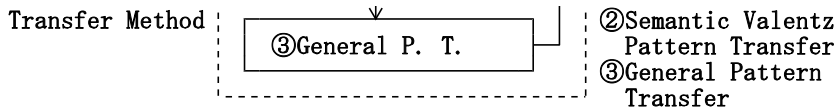


Fig.5 Multi-Level Translation Method

Thus, this system is divided up into 2 major conversion paths. The one is the conversion of the speaker's sense or what is subjective. The other is the path for conversion of the description for the object. And this path splits up into 3 more paths, depending on the abstraction degree in conceptualizing objects. Thus, the Multi-Level Translation method has currently four translation paths.

4．3 Organization of Knowledge

(1) Machine Translation and Knowledge

To realize a machine translation system, a knowledge of language is essential. Natural language processing can be stated as being a battle with ambiguity from the beginning to end. In the translation process, various types of ambiguities arise, but this is regarded as being a lack of knowledge that is required.

To overcome such ambiguity, it is necessary to study what knowledge is lacking and to have such knowledge established as the rule or as a dictionary. It is important to consider the type of ambiguity and relationship with the knowledge corresponding to it. ALT-J/E system placed importance on knowledge for meaning processing for the purpose of solving ambiguity of sentence structure and of the meaning of individual words.

From the viewpoint of linguistic knowledge, linguistic conventions are divided into those which are related to subjective expressions and those related to objective expressions. Of the two, the knowledge related to subjective expressions are smaller in scale compared to objective expressions and have been solved in terms of rules or programming. But the objective expressions being massive, we have decided to compile them in the form of a dictionary.

(2) Semantic Word Dictionary and Semantic Structure Dictionary

When the speaker expresses an object, abstraction is conducted and the objectis conceptualized. In language expressions, the concept of object is expressed separately in terms of a concept of substance and a concept of attribute. Linguistic conventions which combine concepts to expressions have therefore been compiled into 2 separate dictionaries, a semantic word dictionary consisting of 400,000 words and a semantic structure dictionary consising of 15,000 sentence forms.

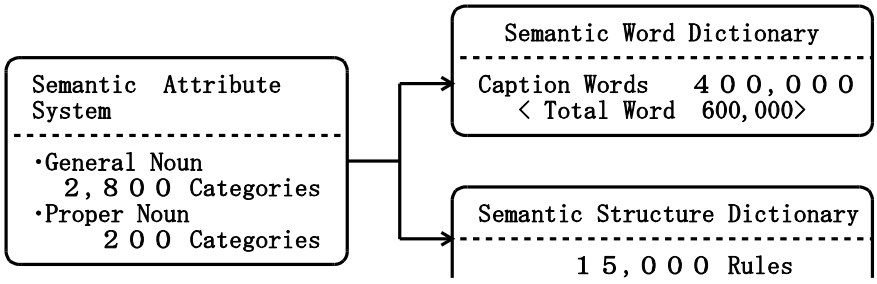


Fig.6 Knowledge for Meaning Analysis

The meanings of words and their translation are listed in ordinary dictionaries. But it does not serve to have the computer know how they are to be used. For example, the word "school" is used as a "place" and also as an "organization". As a means of desscribing these knowledge, we have compiled the use of the meaning of words as a semantic attribute system.

Consider the relation between expression structures and meanings. The meanings of expressions are not necessarily represented by the sum of the meaning of every word in the expression. In fact, it would appear that the meanings of linguistic expressions actually used cannot be explained solely by the meaning of each word used in the expression. Expression structures need to be considered as units of meanings in natural language. Based on such thinking, the abstraction of expression structures centered around declinable words and compiled as units of meanings has resulted in the semantic structure dictionary.

(2) Necessity of Detailed Meaning Attribute System

It is important to consider precision of knowledge description in relation to the degree of ambiguity. For example, an algorithm which was valid in a world of 1,000 words may not necessarily be valid in a world of 100,000 words. Experiences indicate that increase of the number of words causes rapid growth of ambiguities.

Seeking to establish practical method, we have collected words including proper nouns normally used day to day and have compiled a dictionary of about 400,000 words. Thus, it is necessary for semantic attribute system to work with this environment. We began with about 500 categories. But this has resulted in that translation of verbs cannot be precisely described. With the consideration of our aim and environment, we set up 2,800 categories for general noun semantic attributes and 200 categories for proper noun semantic atrributes.

Here, let us look at the differences of description capabilities between of our semantic attribute systems and other similar systems. Case 1 is a typical example of Japanese to English machine translation systems. The number of semantic categories are between 30 to 50. Case 2 is the current plan of EDR [EDR 1990]. Case 3 is an example of our translation system ALT-J/E.

A comparison was made of the three cases. And, the capabilities of describing the translation rules for verbs are evaluated. In the comparison, the case of ALT-J/E has been assumed to be 100%.

Table 1 Comparision of Semantic Attribute System

No	Case	No. of Categories	No. of words	Evaluation (Example*)
1	Current System (J. to E.)	30－50 Categories	50,000 Words	31%
2	EDR Project**	500 Categories	400,000 Words	59%

3	ALT－J／E	3，０００ Categories	400,000 words	１００% (Assumed)

* Relative Amount of Writable Semantic Patterns (Valentz Pattern) for Japanese General Verbs
** Japan Electronic Dictionary Reseach Institute, Ltd.

The results of this comparison are as follows. The capabilities of description was 31% for case 1 and 59% for case 2. Those results indicate that when precision levels of semantic atrributes are low, many essential rules cannot be written. Our experiences also indicates that, in Japanese to English machine translation, precision level for some 3,000 types of semantic attributes are necessary for differentiation of translation for verbs. However, this is not sufficient for translation of nouns.

5. Summary

In machine translation research, some of the main problems include the meaning (convention) in which each word is being used (words that are frequently used have many meanings), the distinction between idiomatic and literal meanings, the sentence form in which sentences with no subjects (or subject matter) and multiple sentences. The achievements of conventional computational linguistics is all but helpless in dealing with realistic problems. When natural language is viewed as having developed as a natural phenomenon and as a social custom, there is a different convention regarding the meaning and method of use for each and every word. The convention needs to be discovered and compiled as a knowledge if we are to realize natural language processing This does not mean collection of knowledge to match the algorithm to match knowledge [Nirenburg 1989].

Based such thinking, this paper points out the @roblems confronted by conventional computational lingfustics, and discusses the significance of a new machine translation system, the multi-level translation method.

As a concept, the multi-level translation method has been devised with the background of the constructive process theory which is one of the traditional Japanese grammar known as the Tokieda Grammar. It feature handling of subjective expression which is aware of the speaker and thinks through the meaning of expression structures. Technically, this method is supported by meaning analysis which is based on lingustic knowledge. As lingustic knowledge for meaning analysis, a word meaning dictionary consisting of 400,000 words and a semantic structure dictionary including 15,000 sentence types have been prepared. These have been written under a system of about 100 types (in further detail, these would amount to 500 types) of syntactic attributes and about 3,000 types of semantic attributes. If rules were to be written by the same attribute system, it would consist of such a structure that this knowledge would be mobilized and translation be conducted.

The ALT-J/E has, by means of this system, accomplished new functions, including,

(1) Differentiation in the translation of the verb and noun
(2) Automatic rewiting function of original Japanese sentences which reduces the number of verbs
(3) Automatic supplementation of subjects and objects

These functions are mandatory in realizing a system of Japanese to English machine translation that requires no pre-editing.

The main issues confronted by machine translation research are:
(1)Meaning Analysis of Complex Noun Phrases and Complex Compound Nouns,
(2)Selection of Determiners and
(3)Global Structure Generation of English for long sentence translations.

Our major research efforts are being concentrated in these areas.

Future research targets will be:
①Multi-Dimension of Semantic Categories,
②Analysis of Speaker's View Point,
③Structure of Recognition,
④Introduction of Common Sense about the World.

Preparations for these studies are now under way.

＝Acknowledgement＝

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Nevertheless the progress of computstional linguistics for these 30 years, they are not useful yet for practical language processing and there are no example where noticeable effects are obtained. The reasons are considered that they historically cut off the actual contents from languages and have focused the attention on the relation between form and rogic of expressions.

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