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A Method of Analyzing Japanese Speech Act Types (I)

– Combining Unification-Based Syntactico-Semantic Analysis and Plan Recognition Inference –

日本語発話行為タイプの解析 (I)

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Abstract

A method of analyzing Japanese utterances is developed for a new dialogue translation method, which is called the intention translation method. The analysis consists of two stages, (i) extraction of surface speech act types from input utterance, and (ii) extraction of less language-dependent speech act types from surface types. In the first stage, input utterances are analyzed according to the unification-based lexico-syntactic, syntactico-semantic principles. In the second stage, surface speech act types are analyzed by using plan recognition inference in order to obtain less language-dependent speech act types.

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ABSTRACT

A method of analyzing Japanese utterances is developed for a new dialogue translation method, which is called the Intention Translation method. The analysis consists of two stages, (i) extraction of surface speech act types from input utterances, and (ii) extraction of less language-dependent speech act types from surface types.

In the first stage, input utterances are analyzed according to the unification-based lexico-syntactic, syntactico-semantic principles. Syntactico-semantic analysis permits integrated descriptions of information from various sources, and lexico-syntactic analysis provides modularity. This allows descriptions of complex constraints on the uses of predicate constituents. These constraints, especially on the uses of honorific predicate constituents, make it possible to analyze ellipsis related to discourse participants. This first stage is used as the analysis part of NADINE (Natural Dialogue Interpretation Expert) system.

In the second stage, surface speech act types are analyzed by using plan recognition inference to obtain less language-dependent speech act types. Plan recognition inference uses a special kind of plan schemata, so-called speech act schemata. The inference is extended to use the unification of surface speech act types with decompositions of schemata instead of simple pattern-matching. This allows bi-directional information flow between decompositions and surface speech act types, and then makes possible supplementation of some ellipsis with expectation of speech acts from a higher level plan.

1. INTRODUCTION

In natural language processing, although much effort has been devoted to understanding or interpreting uni-directional communication , only limited research in understanding bi-directional communication between humans via telephone or keyboard has been carried out. In such bi-directional natural language communication, rich expressions for a wide variety of speech acts are used. Therefore, a system to interpret them is required to extract the meanings from these expressions and correctly transfer them into the same meaning in the target language. Moreover, the translation must both express intent and maintain smoothness of communication.

This paper presents the analysis section of a new dialogue interpretation method, which is called the Intention Translation method[8,9]. The main characteristic of this method is to translate acts in the speaker's utterances, while previous machine translation methods translate the author's written information. Therefore, this method extracts speech act types in terms of source language concepts as the meaning of the input utterance in the source language[16,17]. This approach allows uniform treatment of surface speech act and indirect speech acts as acts. The method then transfers these types into speech act types in terms of the target language concepts. Finally, the method generates surface utterances from the speech act types by using the target language's strategies to express these types and to maintain dialogue smoothness.

In the next section, the overview of the speech act analysis is described. In Section 3, unification-based syntactico-semantic analysis of Japanese utterances is described. The section assumes that the readers understand the basic concepts of recent unification-based natural language analysis†. At first, this paper's grammatical framework is introduced. Then, the semantic represetations obtained in the grammar framework, so-called surface speech act types, are described. Finally, the analysis mechanism is illustrated. In Section 4, combining unification-based utterance analysis and plan recognition inference is described. This approach allows bi-directional information flow.

2. OVERVIEW OF SPEECH ACT TYPE ANALYSIS

The primary characteristic of the intention translation method analysis process is that the process consists of two stages, (i) extraction of surface speech acts from input utterances, and (ii) extraction of less language-dependent speech acts from surface acts.

Surface speech acts include information both on the speech acts that the speaker mainly intends to carry out, and on the speech acts related to maintaining dialogue smoothness, e.g., acts to express politeness. There are strategies to express politeness. These are performed by using linguistic devices. The adequacy of applying a certain strategy depends on the languages and the society. Moreover, to perform the same strategy, linguistic devices that don't word-to-word/phrase-to-phrase correspond to each other are used in different languages. For example, Japanese has special prefixes and predicates to express politeness. Thus, a strategy that works in a certain situation in one language isn't always applicable to the same situation in another language. Even when the same strategy is applicable in different languages, corresponding devices aren't always applicable. Therefore, recognition of strategies, at least, is required. However, surface speech acts are needed to generate response utterances. Moreover, surface speech acts can be directly analyzed in a syntactico-semantic compositional way, but more

† If the reader is unfamiliar with this field, the authors strongly recommend to read [22] before reading the followingsection.

abstract speech acts such as strategies cannot. Analysis of speech acts requires plan recognition inference[2] using dialogue circumstance information. Therefore, two stage-analysis is adopted.

In order to represent both surface speech acts and more abstract speech acts, the following representations are required:

(1) The representation of surface speech acts must have suficient information to generate translation utterances;

(2) The representation of surface speech acts and more abstract speech acts must be suitable for plan recognition inference.

Thus, this analysis adopts representation by using partial descriptions of relationships included in acts. In this paper, representations of surface speech acts and more abstract speech acts are called surface speech act types and speech act types, respectively.

3. UNIFICATION-BASED UTTERANCE ANALYSIS

The first stage of this analysis method extracts from input utterances their surface speech act types and constraints on their uses. To analyze these, a unification-based, lexico-syntactic approach is adopted. This is because:

(a) a unification-based approach permits integrated descriptions of information from various sources such as syntax, semantics and pragmatics. That is, constraints between them can be described in terms of feature structures. Therefore, this approach can create complex speech act types in the compositional framework and, moreover, allows their simultaneous analysis.

(b) A lexico-syntactic approach is modular. In this approach, a grammar has only a small number of general syntactic rule schemata, and most of the grammatical information is to be specified in descriptions of lexical items. Linguistic generalizations can be captured by partial specifications in terms of feature structures. Therefore, it is easy to extend a grammar simply by adding new lexical items to the lexicon or adding new information to lexical items.

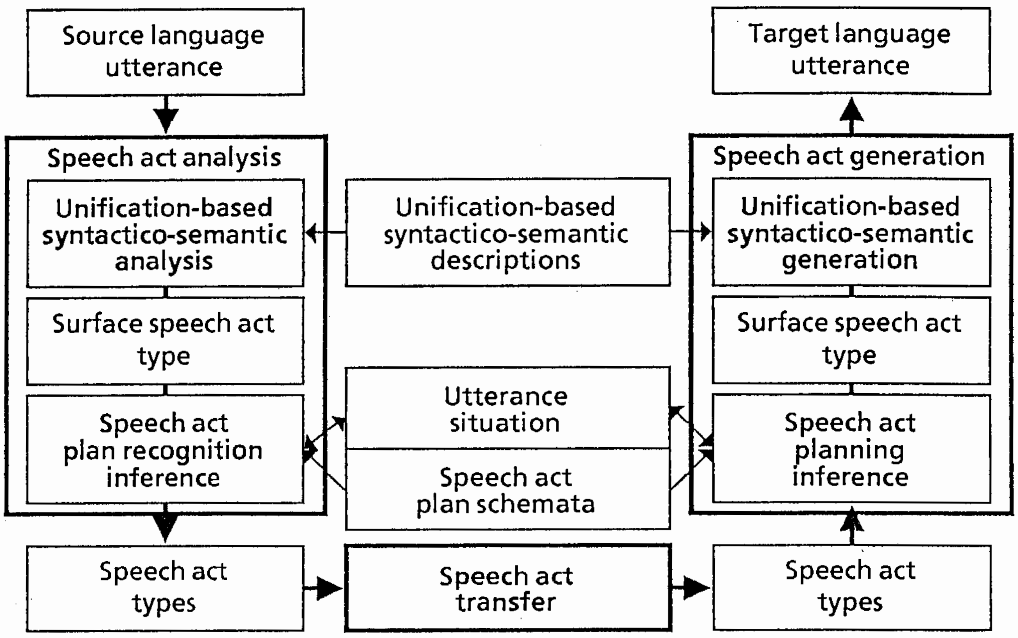

Fig.-1 The overview of the intention translation method.

3.1. Head-driven Phrase Structure Framework for Japanese Utterance in Dialogue

This paper's approach is essentially based on a version of Head-driven Phrase Structure Grammar (HPSG)[21]. The principal notions of this approach are derived from Japanese Phrase Structure Grammar (JPSG)[7].

In this paper's grammar, the most essential grammatical structure is the complement-head structure. It is represented as grammatical rule (1) in the extended version of PATR-II notation[22,23]:

```
(DEFRULE V -> (P V)
  "Complement-Head construction rule"
  (<0 HEAD>            == <2 HEAD>)
  (<1>                 == <2 SUBCAT FIRST>)
  (<0 SUBCAT>          == <2 SUBCAT REST>)
  (<1 HEAD COH>        == <2>)                ;;; Category Of Head
  (<0 SLASH IN>        == <1 SLASH IN>)
  (<1 SLASH OUT>       == <2 SLASH IN>)
  (<2 SLASH OUT>       == <0 SLASH OUT>)
  (<0 SEM>             == <2 SEM>)
  (<0 PRAG SPEAKER>    == <1 PRAG SPEAKER>)   ;;; PRAGmatics
  (<0 PRAG HEARER>     == <1 PRAG HEARER>)
  (<0 PRAG SPEAKER>    == <2 PRAG SPEAKER>)
  (<0 PRAG HEARER>     == <2 PRAG HEARER>)
  (<0 PRAG RESTRS IN>  == <1 PRAG RESTRS IN>) ;;; RESTRictionS
  (<1 PRAG RESTRS OUT> == <2 PRAG RESTRS IN>)
  (<2 PRAG RESTRS OUT> == <0 PRAG RESTRS OUT>) )                        (1)
```

The statement consists of two parts: CFG and equations. CFG is used only to propose a top-down expectation in the parser described below. The notation uses angle braces to denote a feature structure path, and " = = " to denote a token identity relationship between two feature structures.

The above rule specifies the way of constructing a mother phrase with the POS feature V (i.e., a verb or verb phrase, the righthand side V in CFG) from a complement daughter phrase with the POS value P (i.e., a postpositional phrase, which typically consists of a noun phrase and a postposition; the first element of the righthand side) and a head daughter phrase with the POS value V (i.e., the second element of the righthand side). In the equations, feature structure paths <0>, <1>, <2> denote the feature structure of the mother V, the feature structure of the complement daughter P, and the feature structure of the head daughter V, respectively. The first equation in the rule

```
(<0 HEAD>            == <2 HEAD>)
```

specifies the so-called HEAD feature principle (HFP) that the HEAD feature of the mother V <0 HEAD> should be token indentical with the HEAD feature of the head daughter V <2 HEAD>.

The second and the third equations specify the SUBCAT feature principle;

```
(<1>                 == <2 SUBCAT FIRST>)
(<0 SUBCAT>          == <2 SUBCAT REST>).
```

The SUBCAT feature specifies valency patterns of lexical items and phrases. These two equations specifies that the feature structure of the complement daughter <1> should be token identical with the feature structure of the head's first SUBCAT feature element <2 SUBCAT FIRST> and the feature structure of the mother's SUBCAT <0 SUBCAT> should be token identical with the rest of the head daughter's <2 SUBCAT REST>.

One of the major characteristics of this grammar is the way it treats predicate constituents and zero-pronouns which cause difficult and unavoidable problems in analyzing Japanese spoken utterances.

3.1.1. Treatment of predicate constituents

In Japanese, sentence final position predicate constituent structures are very important in expressing illocutionary forces. A combination of predicate constituents is used for expressing major surface speech act types. The appearance and conjugation properties of predicate constituents are generally restricted by heads immediately following them. Thus, these restriction conditions are dealt with by specifying the morphological and modality feature by means of the SUBCAT feature. In this grammar, the SUBCAT feature has as its value a list and the value is as specified in (2):

```
(DEFLEX 送 V  "the stem of the verb 送る OKURU (sending)"
  [[HEAD [[POS V][CTYPE CONS][CFORM STEM][CLINE R]]]
   ;;; Part-Of-Speech = Verb, Conjugation-TYPE = CONSonant-stem-type,
   ;;; Conjugation-FORM = STEM, Conjugation-LINE = R.
   [SUBCAT (:PERM [[HEAD [[POS P][FORM WO][GRF OBJ]]][SEM ?OBJSEM]]
                  [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?OBJ2SEM]]
                  [[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?SUBJSEM]])]
   ;;; GRF: GRammatical-Function
   [SLASH {}]
   [LEX +]
   [SEM [[RELN OKURU-1]      ;;; RELatioN
         [AGEN ?SUBJSEM]     ;;; AGENt
         [RECP ?OBJ2SEM]     ;;; RECiPient
         [OBJE ?OBJSEM]]]    ;;; OBJEct
  [PARG [[RESTRS {}]]]]])                                              (2)
```

where "?" is the prefix for tag. The feature values that have the same tag are token identical.

The above rule specifies the way of making the semantic representation of verb phrases including the verb "okuru" from the semantic representations of its complements. For example, the SEM feature value of the first SUBCAT element (i.e., the postpositional phrase with the surface case marker "wo") is specified by the tag ?OBJSEM and the OBJE feature value of the SEM feature value is specified by the same tag ?OBJSEM. This means that it is possible that the OBJE role of the verb phrase including this verb is the semantics of the postpositional phrase.

In order to allow word order variation among elements in the SUBCAT value, a SUBCAT value is in general described in a

(:PERM A_1 ... A_n :RESTRS R1 ... Rm)

form. The form is expanded into the disjunctions of permutated list descriptions by a rule reader described below. For example,

```
(:PERM ?A ?B ?C :RESTRS (:PRECEDE ?A ?B) (:PRECEDE ?A ?C))
```

is expanded into

```
(:OR (:LIST ?A ?B ?C) (:LIST ?A ?C ?B)).
```

Furthermore,

```
(:LIST ?A ?B ?C),
```

for example, is expanded into a feature structure such as

```
[[FIRST ?A][REST [[FIRST ?B][REST [[FIRST ?C][REST END]]]]]].
```

Similarly, the SLASH feature value is generally described by using the form $\{A_1 \ \ldots \ A_n\}$. A typical lexical item has its SLASH feature value {}. This form is expanded into the other list expression:

[[IN ?α][OUT ?α]]

where ?α is a newly created tag. The lexical item that has non-empty SLASH feature value (namely, a gapped lexical item) is created by using the following rules:

```
(DEFRULE V -> (V)
  "Slash Introduction for a verb"
  (<0 HEAD>              == <1 HEAD>)
  (<0 SUBCAT>            == <1 SUBCAT REST>)
  (<0 SLASH IN FIRST>    == <1 SUBCAT FIRST>)
  (<0 SLASH IN FIRST>    == [[HEAD [[POS P]]]])
  (<0 SLASH IN REST>     == <1 SLASH IN>)
  (<0 SLASH OUT>         == <1 SLASH OUT>)
  (<1 LEX>               == +)
  (<0 LEX>               == <1 LEX>)
  (<0 PRAG>              == <1 PRAG>) )                              (3)

(DEFRULE V -> (V)
  "Slash Introduction for an auxliary verb"
  (<0 HEAD>              == <1 HEAD>)
  (<0 SUBCAT FIRST>      == <1 SUBCAT FIRST>)
  (<0 SUBCAT FIRST>      == [[HEAD [[POS P]]]])
  (<0 SUBCAT REST>       == <1 SUBCAT REST REST>)
  (<0 SLASH IN FIRST>    == <1 SUBCAT REST FIRST>)
  (<0 SLASH IN FIRST>    == [[HEAD [[POS P]]]])
  (<0 SLASH IN REST>     == <1 SLASH IN>)
  (<0 SLASH OUT>         == <1 SLASH OUT>)
  (<1 LEX>               == +)
  (<0 LEX>               == <1 LEX>)
  (<0 PRAG>              == <1 PRAG>) )                              (4)
```

For example, the rule (3) can take as its input one of the feature structure specified by the lexical description (2)[†];

```
[[HEAD [[POS V][CTYPE CONS][CFORM STEM][CLINE R]]]
 [SUBCAT [[FIRST [[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?SUBJSEM]]]
          [REST [[FIRST [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?OBJ2SEM]]]
                 [REST [[FIRST [[HEAD [[POS P][FORM WO][GRF OBJ]]][SEM ?OBJSEM]]]
                               [REST END]]]]]]]
 [SLASH [[IN ?SLASH-OUT]
         [OUT ?SLASH-OUT]]]
 [LEX +]
 [SEM [[RELN OKURU-1]
       [AGEN ?SUBJSEM]
       [RECP ?OBJ2SEM]
       [OBJE ?OBJSEM]]]
 [PRAG [[RESTRS [[IN ?PRAG-RESTRS-OUT]
                 [OUT ?PRAG-RESTRS-OUT]]]]]]                         (5)
```

and convert it into the following feature structure;

† Tag names appearing in feature structures convey information only that feature structures with the same tag name are token identical. In order to make it easy to understand meanings of feature structures, in this paper, meaningful names are used instead of systematically created names such as ?X001, ?X002, and so on.

```
[[HEAD [[POS V][CTYPE CONS][CFORM STEM][CLINE R]]]
 [SUBCAT [[FIRST [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?OBJ2SEM]]]
         [REST [[FIRST [[HEAD [[POS P][FORM WO][GRF OBJ]]][SEM ?OBJSEM]]]
                [REST END]]]]]
 [SLASH [[IN [[FIRST [[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?SUBJSEM]]]
             [REST ?SLASH-OUT]]]
        [OUT ?SLASH-OUT]]]
 [LEX +]
 [SEM [[RELN OKURU-1]
       [AGEN ?SUBJSEM]
       [RECP ?OBJ2SEM]
       [OBJE ?OBJSEM]]]
 [PRAG [[RESTRS [[IN ?PRAG-RESTRS-OUT]
                 [OUT ?PRAG-RESTRS-OUT]]]]]]                          (6)
```

Moreover, the rule (3) takes (6) as its input and converts it into (7);

```
[[HEAD [[POS V][CTYPE CONS][CFORM STEM][CLINE R]]]
 [SUBCAT [[FIRST [[HEAD [[POS P][FORM WO][GRF OBJ]]][SEM ?OBJSEM]]]
         [REST END]]]
 [SLASH [[IN [[FIRST [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?OBJ2SEM]]]
             [REST [[FIRST [[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?SUBJSEM]]]
                    [REST ?SLASH-OUT]]]]]
        [OUT ?SLASH-OUT]]]
 [LEX +]
 [SEM [[RELN OKURU-1]
       [AGEN ?SUBJSEM]
       [RECP ?OBJ2SEM]
       [OBJE ?OBJSEM]]]
 [PRAG [[RESTRS [[IN ?PRAG-RESTRS-OUT]
                 [OUT ?PRAG-RESTRS-OUT]]]]]]                          (7)
```

The feature structure of the phrase consisting of the honorific prefix "o", the verb stem "oku" with feature structure (7) and the verb inflection "ri" has the following feature structure;

```
[[HEAD [[POS V][CTYPE CONS][CFORM INFN][CLINE R]]]
 [SUBCAT [[FIRST [[HEAD [[POS P][FORM WO][GRF OBJ]]][SEM ?OBJSEM]]]
         [REST END]]]
 [SLASH [[IN [[FIRST [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?OBJ2SEM]]]
             [REST [[FIRST [[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?SUBJSEM]]]
                    [REST ?SLASH-OUT]]]]]
        [OUT ?SLASH-OUT]]]
 [LEX -]
 [SEM [[RELN OKURU-1]
       [AGEN ?SUBJSEM]
       [RECP ?OBJ2SEM]
       [OBJE ?OBJSEM]]]
 [PRAG [[RESTRS [[IN ?PRAG-RESTRS-OUT]
                 [OUT ?PRAG-RESTRS-OUT]]]]]]                          (8)
```

This phrase can combine with a postpositional phrase with the postposition "wo" according to the rule (1). For example, the postpositional phrase "tourokuyoushi wo" (registration form ACC) with the following feature structure:

```
[[HEAD [[POS P][FORM WO][GRF OBJ]]]
 [SUBCAT END]
 [SLASH [[IN ?SLASH-OUT]
         [OUT ?SLASH-OUT]]]
 [SEM [[PARM ?X01]
       [RESTR [[RELN TOUROKUYOUSHI-1]
               [OBJE ?X01]]]]]
 [PRAG [[RESTRS [[IN ?PRAG-RESTRS-OUT]
                 [OUT ?PRAG-RESTRS-OUT]]]]]]                              (9)
```

can combine with the phrase "o oku ri" with feature structure (8). The combined phrase has the following feature structure;

```
[[HEAD [[POS V][CTYPE CONS][CFORM INFN][CLINE R]]]
 [SUBCAT END]
 [SLASH [[IN [[FIRST [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?OBJ2SEM]]]
              [REST [[FIRST [[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?SUBJSEM]]]
                     [REST ?SLASH-OUT]]]]]
         [OUT ?SLASH-OUT]]]
 [LEX -]
 [SEM [[RELN OKURU-1]
       [AGEN ?SUBJSEM]
       [RECP ?OBJ2SEM]
       [OBJE [[PARM ?X01]
              [RESTR [[RELN TOUROKUYOUSHI-1]
                      [OBJE ?X01]]]]]]]
 [PRAG [[RESTRS [[IN ?PRAG-RESTRS-OUT]
                 [OUT ?PRAG-RESTRS-OUT]]]]]]                              (10)
```

The usual complement-head structuring rule in (11) is also applied to the predicate constituent structures:

```
(DEFRULE V -> (V V)
  "Complement-Head construction rule combining a predicate with an auxiliary"
  (<0 HEAD>             == <2 HEAD>)
  (<1>                  == <2 SUBCAT FIRST>)
  (<0 SUBCAT>           == <2 SUBCAT REST>)
  (<1 HEAD COH>         == <2>)
  (<0 SLASH IN>         == <1 SLASH IN>)
  (<1 SLASH OUT>        == <2 SLASH IN>)
  (<2 SLASH OUT>        == <0 SLASH OUT>)
  (<0 SEM>              == <2 SEM>)
  (<0 PRAG SPEAKER>     == <1 PRAG SPEAKER>)
  (<0 PRAG HEARER>      == <1 PRAG HEARER>)
  (<0 PRAG SPEAKER>     == <2 PRAG SPEAKER>)
  (<0 PRAG HEARER>      == <2 PRAG HEARER>)
  (<0 PRAG RESTRS IN>   == <1 PRAG RESTRS IN>)
  (<1 PRAG RESTRS OUT>  == <2 PRAG RESTRS IN>)
  (<2 PRAG RESTRS OUT>  == <0 PRAG RESTRS OUT>) )                         (11)
```

All the predicate constituents are classified as having the same POS (part of speech) value, V, irrespective of whether they are traditional grammar subsidiary verbs, auxiliaries, or sentence final particles. The POS feature is a HEAD feature (i.e., the feature specified in the HEAD feature value.) Therefore, every utterance has the same POS value, V.

3.1.2. Treatment of zero-pronouns

In a Japanese sentence, "obligatory" components can always be omitted. A sentence can be missing its subject and a transitive verb can be missing its object. Particularly in spoken discourses, instead of using anaphoric expressions, information recoverable from context is very often not explicitly expressed. This makes machine translation into English difficult. The following types of unexpressed information are analyzed by this method.

(a) Information related to discourse participants:

In Japanese spoken discourses, instead of using overt expressions referring to discourse participants, zero-pronouns are used very frequently. In particular, pronouns referring to the speaker or the hearer seldom appear. However, many of these can be resolved by using pragmatic felicity conditions on uses of speech act expressions, especially honorific expressions. To represent the pragmatic conditions, the PRAG feature is introduced[16,19,20]. For example, the pragmatic conditions on the uses of the auxiliaries "moraeru" and "itadakeru" are described as the <PRAG RESTRS> features as in [12] and (13) below:

```
(DEFLEX もらえ V
  "the stem of the auxiliary もらえる MORAERU (receiving favor of)"
  [[HEAD [[POS V][CTYPE VOW][CFORM INFN]]]   ;;;  VOWEL-stem-type INFiNitive
   [SUBCAT (:PERM ?PRED[[HEAD [[POS V][CFORM TE]]]
                        [SUBCAT (:PERM [[HEAD [[POS P][form GA][GRF SUBJ]]]
                                        [SUBCAT END]
                                        [SEM ?OBJSEM]])]
                        [SEM ?PREDSEM]]
                  ?OBJ[[HEAD [[POS P][GRF OBJ][FORM NI]]][SEM ?OBJSEM]]
                  ?SUBJ[[HEAD [[POS P][GRF SUBJ][FORM GA]]][SEM ?SUBJSEM]]
            :RESTRS (:PRECEDE ?PRED ?OBJ) (:PRECEDE ?PRED ?SUBJ))]
   [SLASH {}]
   [SEM [[MORAERU-CAN]
         [AGEN ?SUBJSEM]
         [OBJE [[RELN MORAERU-RECEIVE-FAVOR]
                [AGEN ?SUBJSEM]
                [SOUR ?OBJSEM]                   ;;; SOURce
                [OBJE ?PREDSEM]]]]]
   [PRAG [[SPEAKER ?SPEAKER]
          [HEARER  ?HEARER]
          [RESTRS {[[RELN EMPATHY-DEGREE][MORE ?SUBJSEM][LESS ?OBJSEM]]}]]]])         (12)
```

```
(DEFLEX いただけ V
  "the stem of the auxiliary いただける ITADAKERU (receiving favor of)"
  [[HEAD [[POS V][CTYPE VOW][CFORM INFN]]]   ;;;  VOWEL-stem-type INFiNitive
   [SUBCAT (:PERM ?PRED[[HEAD [[POS V][CFORM INFN]]]
                        [SUBCAT (:PERM [[HEAD [[POS P][form GA][GRF SUBJ]]]
                                        [SUBCAT END]
                                        [SEM ?OBJSEM]])]
                        [SEM ?PREDSEM]]
                 ?OBJ[[HEAD [[POS P][GRF OBJ][FORM NI]]][SEM ?OBJSEM]]
                 ?SUBJ[[HEAD [[POS P][GRF SUBJ][FORM GA]]][SEM ?SUBJSEM]]
            :RESTRS (:PRECEDE ?PRED ?OBJ) (:PRECEDE ?PRED ?SUBJ))]
   [SLASH {}]
   [SEM [[ITADAKERU-CAN]
         [AGEN ?SUBJSEM]
         [OBJE [[RELN ITADAKERU-RECEIVE-FAVOR]
                [AGEN ?SUBJSEM]
                [SOUR ?OBJSEM]
                [OBJE ?PREDSEM]]]]]
   [PRAG [[SPEAKER ?SPEAKER]
          [HEARER  ?HEARER]
          [RESTRS {[[RELN HONOR-UP][ORIG ?SUBJSEM][GOAL ?OBJSEM]]
                   [[RELN EMPATHY-DEGREE][MORE ?SUBJSEM][LESS ?OBJSEM]]}]]]])        (13)
```

Related lexical items referring to the speaker and the hearer are described as follows:

```
(DEFLEX わたし N
  [[HEAD [[POS N]]]
   [SEM ?SPEAKER]
   [PRAG [[SPEAKER ?SPEAKER]]]]])                                               (14)
```

```
(DEFLEX あなた N
  [[HEAD [[POS N]]]
   [SEM ?HEARER]
   [PRAG [[HEARER ?HEARER]]]]])                                                 (15)
```

One of the major differences between the "itadakeru" (12) and "moraeru" (13) lexical descriptions is that (13) has

`[[RELN HONOR-UP][ORIG ?SUBJSEM][GOAL ?OBJSEM]]`

as one of its <PRAG RESTRS> conjuncts but (12) doesn't. The HONOR-UP relationship from the speaker to the subject agent of the predicate that "moraeru" or "itadakeru" is subcategorized for, and the EMPATHY-DEGREE relationship between the subject and the object (namely, the speaker empathizes with the subject more than the object) are required. Each SLASH element in the analysis results is examined to determine whether or not the set of constraints in <PRAG RESTRS> attached to it is compatible with previously introduced discourse objects.

(b) Topic information:

Once a topic has been established by using a topic marker such as the particle "wa" it need no longer be expressed in the following sentences. To supplement such information, this analysis uses the TOPIC feature to represent the sentence topic and inter-sentential rules to represent topic continuity[14,15,27]. To obtain a sentence topic, the particle "wa", which marks a topic expression is described as follows:

```
(DEFLEX は P
  [[HEAD [[POS P]
          [COH [[HEAD [[POS V][CFORM SENF][TOPIC ?TOPIC]]]]]]
   [SUBCAT (:PERM [[HEAD [[POS N]]][SEM ?TOPIC]])]
   [SEM ?TOPIC]])                                                    (16)
```

This lexical description and the ADJUNCT-HEAD construction rule (17) makes the semantics of the noun phrase marked by "wa" the TOPIC value feature of the sentence including the expression:

```
(DEFRULE V -> (P V)
  "Adjunct-Head construction rule.
   An application of this rule consumes a SLASH element in the head."
  (<0 HEAD>             == <2 HEAD>)
  (<0 SUBCAT>           == <2 SUBCAT>)
  (<1 HEAD COH>         == <2>)                ;;; Category Of Head
  (<1>                  == <2 SLASH IN FIRST>)
  (<0 SLASH IN>         == <1 SLASH IN>)
  (<1 SLASH OUT>        == <2 SLASH IN REST>)
  (<2 SLASH OUT>        == <0 SLASH OUT>)
  (<0 SEM>              == <2 SEM>)
  (<0 PRAG SPEAKER>     == <1 PRAG SPEAKER>)   ;;; PRAGmatics
  (<0 PRAG HEARER>      == <1 PRAG HEARER>)
  (<0 PRAG SPEAKER>     == <2 PRAG SPEAKER>)
  (<0 PRAG HEARER>      == <2 PRAG HEARER>)
  (<0 PRAG RESTRS IN>  == <1 PRAG RESTRS IN>)  ;;; RESTRictionS
  (<1 PRAG RESTRS OUT> == <2 PRAG RESTRS IN>)
  (<2 PRAG RESTRS OUT> == <0 PRAG RESTRS OUT>) )                     (17)
```

3.2. Representation of Surface Speech Act Types

In parallel with syntactically classifying predicate constituents into the same major category (i.e., with POS value V), they are semantically classified into relationship types. Words related to surface speech act types are partially represented in complex relationships consisting of speech act primitive relationship types such as the relationship type called REQUEST, INFORMIF and so on, or their subtypes such as the relationship type called ITADAKU-RECEIVE-FAVOR, e.g., the lexical description of the sentence final particle "ka", which expresses a question attitude represented in (9).

```
(DEFLEX か V
  "sentence final particle か KA, traditionally.
   This lexical item is subcategorized only for a sentence with no WH-elements."
  [[HEAD [[POS V][CTYPE NONC]]]
   [SUBCAT (:PERM [[HEAD [[POS V][CFORM SENF][MODL !SFP-1-]]]
                   [WH -][SEM ?PREDSEM]])]
   [SEM [[RELN KA-REQUEST]
         [AGEN ?SPEAKER]
         [RECP ?HEARER]
         [OBJE [[RELN KA-INFORMIF]
                [AGEN ?HEARER]
                [RECP ?SPEAKER]
                [OBJE ?PREDSEM]]]]]
   [PRAG [[SPEAKER ?SPEAKER]
          [HEARER  ?HEARER]]]])                                      (18)
```

where "!" is the prefix for template and !SFP-1- is expanded to

```
    [[SFP-1 -][SFP-2 -][SFP-3 -]].
```

This expansion is specified by the following template definition:

```
(DEFTEMP SFP-1- ()
  [[SFP-1 -][SFP-2 -][SFP-3 -]])                                      (19)
```

The surface speech act types of the sentences, including these words are derived from the SEM value of the word's lexical descriptions by using semantic principles in general syntactic rules. For example, sentence (20), which includes "itadakeru" and "ka" is analyzed in Fig.-2. The resulting feature structure is as follows:

```
Ex.1 Tourokuyoushi     wo  watashi ni  o-okuri  itadake        masu   ka?      (20)
     Registration form ACC me       DAT HON-send RECEIVE-FAVOR POLITE QUESTION
     Can (I) receive a favor of (your) sending me a registration form?
     → Could you send me a registration form?
```

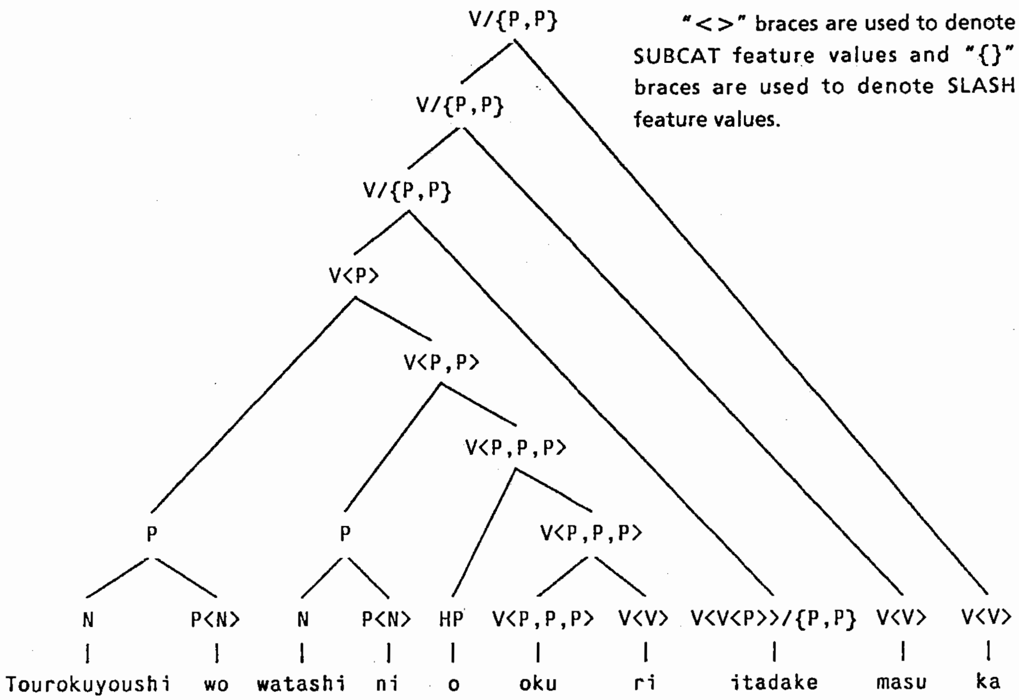

Fig.-2 The derivation tree of the sentence:
"tourokuyoushi wo watashi ni o-okuri itadake masu ka"
("Could you send me a registration form?")

```
[[HEAD [[POS V][CTYPE NCONC]]]
 [SUBCAT END]
 [SLASH  {[[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?GAPSEM2]]
          [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?GAPSEM1]]}]
 [SEM [[RELN KA-REQUEST]
       [AGEN ?SPEAKER]
       [RECP ?HEARER]
       [OBJE [[RELN KA-INFORMIF]
              [AGEN ?HEARER]
              [RECP ?SPEAKER]
              [OBJE [[RELN ITADAKERU-CAN]
                     [AGEN ?SPEAKER]
                     [OBJE [[RELN ITADAKERU-RECEIVE-FAVOR]
                     [AGEN ?GAPSEM2]
                     [SOUR ?GAPSEM1]
                     [OBJE [[RELN OKURU-1]
                            [AGEN ?GAPSEM1]
                            [RECP ?SPEAKER]
                            [OBJE [[PARM ?X01] ;;; PARaMeter
                                   [RESTR [[RELN TOUROKUYOUSHI-1]
                                           [OBJE ?X01]]]]]]]]]]]]]]]]]]
   [PRAG [[SPEAKER ?SPEAKER]
          [HEARER  ?HEARER]
          [RESTRS  {[[RELN HONOR-UP][ORIG ?SPEAKER][GOAL ?HEARER]]
                    [[RELN HONOR-UP][ORIG ?GAPSEM2][GOAL ?GAPSEM1]]
                    [[RELN EMPATHY-DEGREE][MORE ?GAPSEM2][LESS ?GAPSEM1]]}]]]]
```

(21)

Pragmatic constraints on uses of predicates can eliminate ambiguities on COMPLEMENT-HEAD structures. For example, the following sentence, which is the same as sentence (20) except that the order of postpositional phrases is different, seems to have the derivations shown in Fig.-3 and Fig.-4:

Ex.2 Watashi	ni	tourokuyoushi	wo	o-okuri	itadake	masu	ka?	(22)
me	DAT	Registration form	ACC	HON-send	RECEIVE-FAVOR	POLITE	QUESTION	

The derivations as in the figures 3 and 4 have analyzed feature structures (23) and (24), respectively.

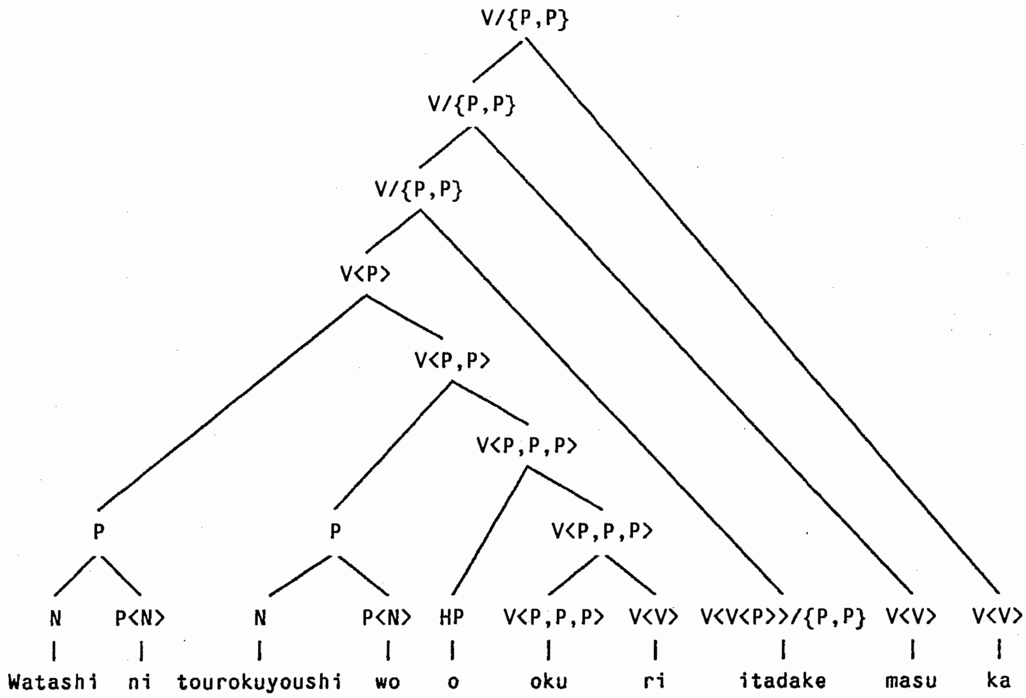

Fig.-3 A well-formed derivation tree of the sentence:
"watashi ni tourokuyoushi wo o-okuri itadake masu ka"
("Could you send me a registration form?")

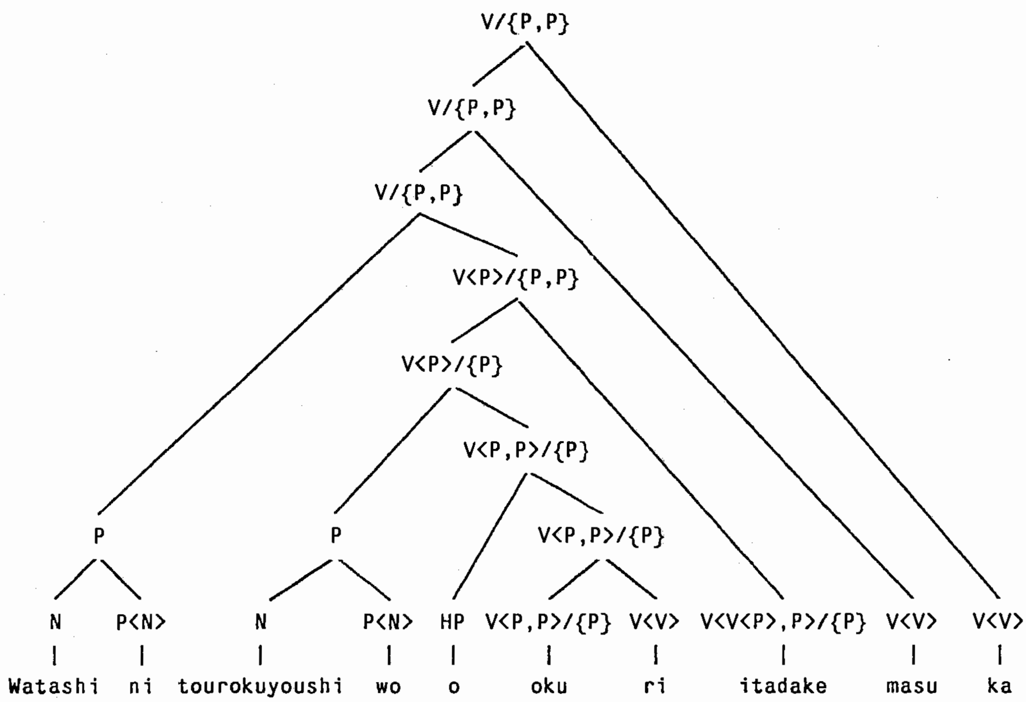

Fig.-4 An ill-formed derivation tree of the sentence:
"watashi ni tourokuyoushi wo o-okuri itadake masu ka"
(*"Could I send me a registration form?")

```
[[HEAD [[POS V][CTYPE NCONC]]]
 [SUBCAT END]
 [SLASH  {[[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?GAPSEM2]]
          [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?GAPSEM1]]}]
 [SEM [[RELN KA-REQUEST]
       [AGEN ?SPEAKER]
       [RECP ?HEARER]
       [OBJE [[RELN KA-INFORMIF]
              [AGEN ?HEARER]
              [RECP ?SPEAKER]
              [OBJE [[RELN ITADAKERU-CAN]
                     [AGEN ?SPEAKER]
                     [OBJE [[RELN ITADAKERU-RECEIVE-FAVOR]
                     [AGEN ?GAPSEM2]
                     [SOUR ?GAPSEM1]
                     [OBJE [[RELN OKURU-1]
                            [AGEN ?GAPSEM1]
                            [RECP ?SPEAKER]
                            [OBJE [[PARM ?X01] ;;; PARaMeter
                                   [RESTR [[RELN TOUROKUYOUSHI-1]
                                           [OBJE ?X01]]]]]]]]]]]]]]]]]]]
   [PRAG [[SPEAKER ?SPEAKER]
          [HEARER  ?HEARER]
          [RESTRS  {[[RELN HONOR-UP][ORIG ?SPEAKER][GOAL ?HEARER]]
                    [[RELN HONOR-UP][ORIG ?GAPSEM2][GOAL ?GAPSEM1]]
                    [[RELN EMPATHY-DEGREE][MORE ?GAPSEM2][LESS ?GAPSEM1]]}]]]]          (23)
```

```
[[HEAD [[POS V][CTYPE NCONC]]]
 [SUBCAT END]
 [SLASH  {[[HEAD [[POS P][FORM GA][GRF SUBJ]]][SEM ?GAPSEM2]]
          [[HEAD [[POS P][FORM NI][GRF OBJ2]]][SEM ?GAPSEM1]]}]
 [SEM [[RELN KA-REQUEST]
       [AGEN ?SPEAKER]
       [RECP ?HEARER]
       [OBJE [[RELN KA-INFORMIF]
              [AGEN ?HEARER]
              [RECP ?SPEAKER]
              [OBJE [[RELN ITADAKERU-CAN]
                     [AGEN ?SPEAKER]
                     [OBJE [[RELN ITADAKERU-RECEIVE-FAVOR]
                     [AGEN ?GAPSEM2]
                     [SOUR ?SPEAKER]
                     [OBJE [[RELN OKURU-1]
                            [AGEN ?SPEAKER]
                            [RECP ?GAPSEM1]
                            [OBJE [[PARM ?X01] ;;; PARaMeter
                                   [RESTR [[RELN TOUROKUYOUSHI-1]
                                           [OBJE ?X01]]]]]]]]]]]]]]]]]]]
   [PRAG [[SPEAKER ?SPEAKER]
          [HEARER  ?HEARER]
          [RESTRS  {[[RELN HONOR-UP][ORIG ?SPEAKER][GOAL ?HEARER]]
                    [[RELN HONOR-UP][ORIG ?GAPSEM2][GOAL ?SPEAKER]]
                    [[RELN EMPATHY-DEGREE][MORE ?GAPSEM2][LESS ?SPEAKER]]}]]]]          (24)
```

However, the feature structure (24) has inconsistent pragmatic constraints on the HONOR-UP and EMPATHY-DEGREE relationships:

[[RELN HONOR-UP][ORIG ?SPEAKER][GOAL ?HEARER]] (25)
[[RELN HONOR-UP][ORIG ?GAPSEM2][GOAL ?SPEAKER]] (26)

Constraint (26) restricts the use of the utterance (20) so that the utterance is adequate only when the speaker respects to himself. However, this is an unusual case. Thus, analysis result candidate represented by (24) is removed from the correct analysis results.

The surface speech act type for sentence (20) has the following form:

[[RELN S-INFORM]
 [AGEN ?SPEAKER]
 [RECP ?HEARER]
 [OBJE <*the result SEM feature value (21)*>]] (27)

In the surface speech act type, there are two semantic elements related to zero-pronouns, ?GAPSEM1 and ?GAPSEM2. They are attached to HONOR-UP and EMPATHY-DEGREE constraints and will be determined by using pragmatic constraints on the uses of the expressions or by using higher level plans.

3.3. A Unification-based Utterance Parser

The analysis system for obtaining surface speech act types consists of source grammatical descriptions such as general syntactic rules and lexical item descriptions, a rule reader and a unification-based parser (Fig.-3). The rule reader compiles source descriptions into CFG rules with feature structures representing equations.

The parser takes a sequence of characters and a grammar object as its inputs. The input character sequence is simultaneously analyzed both morphologically and syntactico-semantically[16]. The grammar object consists of its start symbol and a hash table to retrieve a set of production rules with nonterminal symbols as keys. The parser is based on Earley's

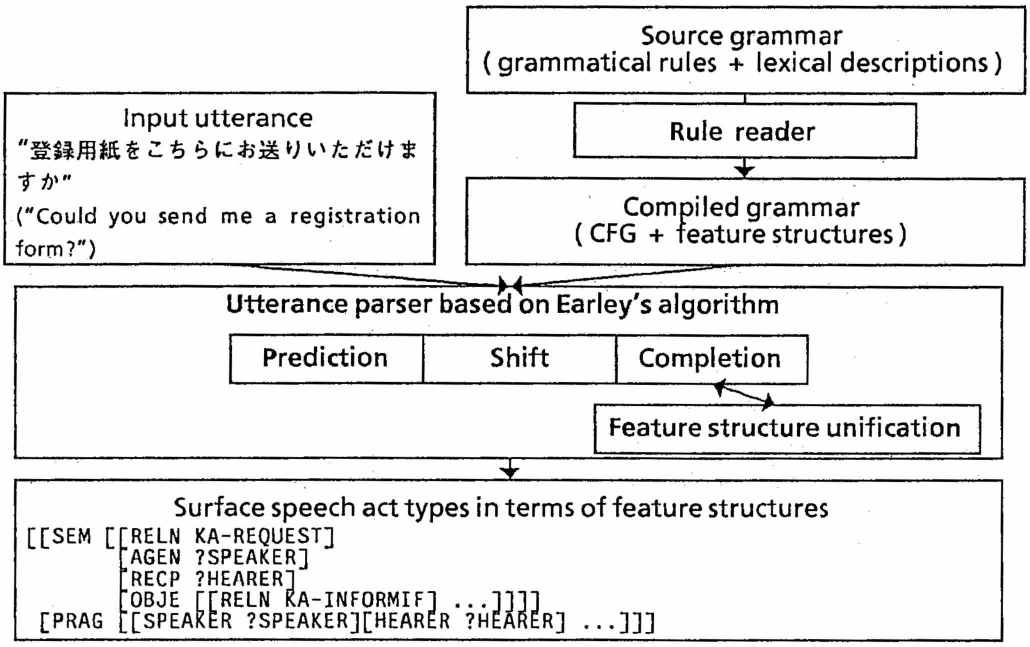

Fig.-3 Unification-based utterance parser configuration.

algorithm[5]† and applies feature structure unification in its completion stage (i.e., when combining two well-structured substrings).

The feature structure unification algorithm has the following characteristics:

(a) In order to unify typed feature structures, each type is attached to its own unification method. First, the unification algorithm examines the unification between types of input feature structures. If there is a unified type, the method attached to the type is invoked; otherwise, the unification fails. By defining a new feature structure type, for example, the unification by using thesauri is allowed. Suppose that the RELATION-NAME feature structure type is defined and is attached the unification method which uses the RELATION-NAME thesaurus. This makes it possible for feature structures of this type denoted by

$_{\text{RELATION-NAME}}$|ITADAKERU-RECEIVE-FAVOR and $_{\text{RELATION-NAME}}$|ITADAKERU-RECEIVE-FAVOR, which is described as a subrelation of the RECEIVE-FAVOR relation in the relation thesaurus, can be unified and the unification result is $_{\text{RELATION-NAME}}$|ITADAKERU-RECEIVE-FAVOR.

(b) The unification algorithm for complex type feature structures allows unification of looped feature structures. The set of equations for a typical complement-head structuring includes constraints both on the head specified by complements and on complements specified by the head. Thus, the equations are compiled into a looped feature structure (Fig.-4). Therefore, Wroblewski's algorithm[26] is extended to treat looped feature structures[12,13]. This can be done simply by adding the steps which examine whether there is already an edge which has the same label as the edge to be added to the node, and to unify the destination node of the new edge with the destination node of the existing edge instead of simply adding the new edge. This procedure is so simple that it requires only a small computation.

(c) To represent negation of a token identity relationship, a different node list is added to the data structure which represents feature structures. When a feature structure is about to be unified with one of the structures in a different node list, the unification fails.

The utterance parser outputs feature structures for accepted syntactico-semantic constraints. From the feature structures, surface speech act types are created. The next stage uses mainly these surface speech act types.

4. SPEECH ACT TYPE ANALYSIS BY SIMPLE PLAN RECOGNITION INFERENCE

Surface speech act types are analyzed by using plan recognition inference to obtain less language-dependent, more strategy-free types. This is because the word-to-word/phrase-to-

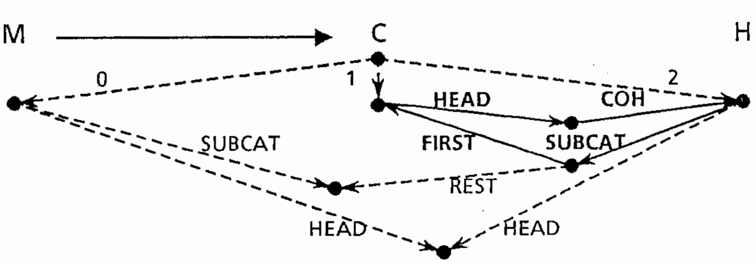

Fig.-4 Cyclic part of the compiled feature structure representing C-H construction.

† Recently, a new parser which is based on Active Chart Parsing algorithm[25] has been implemented and the new parser takes as its input not a string but a lattice. The parser also applies feature structure unification when combining two well-formed substrings.

phrase translation of surface speech act types generates inadequate English utterances. For example, the word-to-word/phrase-to-phrase translation of the sentence (8) "Can I receive a favor of your sending me a registration form?" is not an adequate expression.

In order to extract speech act types, the plan recognition inference uses a special kind of plan schema, speech act schema. A speech act plan schema consists of a goal whose value is a partial description of a speech act type, decompositions whose value is a disjunction of partial descriptions of surface speech act types, effects and constraints. A surface speech act type attempts to unify with decompositions.

The plan recognition inference is extended to use unification instead of simple pattern matching. Moreover, a subrelationship type name can be unified with its superrelationship type names in order to absorb differences in surface expressions. For example, ITADAKERU-RECEIVE-FAVOR is a subrelationship type name of RECEIVE-FAVOR relationship type name and can then be unified with RECEIVE-FAVOR. This can be done by using the relationship name thesaurus. In the thesaurus, the relationships between RECEIVE-FAVOR and relationship names such as ITADAKERU-RECEIVE-FAVOR are represented like follows:

```
(RELATION-IS-A ITADAKERU-RECEIVE-FAVOR RECEIVE-FAVOR)
(RELATION-IS-A ITADAKU-RECEIVE-FAVOR   RECEIVE-FAVOR)
(RELATION-IS-A MORAERU-RECEIVE-FAVOR   RECEIVE-FAVOR)
(RELATION-IS-A MORAU-RECEIVE-FAVOR     RECEIVE-FAVOR)
```

This unification of a surface speech act type with a decomposition allows bi-directional information flow (i.e., from the surface speech act type to decomposition and vice versa). The information from the surface speech act type to the decomposition is conveyed to the goal and is then used in the speech act type representation. Moreover, the information from the decomposition to the surface type makes it possible to supplement part of semantic representation corresponding to zero-pronouns.

For example, surface speech act type (21) is unified with the first decomposition of the speech act plan schema (28):

```
(DEF-SA-SCHEMA ?REQ[[RELN REQUEST]
                    [AGEN ?SPEAKER]
                    [RECP ?HEARER]
                    [OBJE ?OBJ[[AGEN ?HEARER]]]
                    [MANN [[PARM ?X01][RESTR [[RELN INDIRECTLY][OBJE ?X01]]]]]]
  :DECOMPOSITIONS
    (;MORAE MASU KA, ITADAKE MASU KA
     [[RELN S-INFORM]
      [AGEN ?SPEAKER]
      [RECP ?HEARER]
      [OBJE [[RELN REQUEST]
             [AGEN ?SPEAKER]
             [RECP ?HEARER]
             [OBJE [[RELN INFORMIF]
                    [AGEN ?HEARER]
                    [RECP ?SPEAKER]
                    [OBJE [[RELN CAN]
                           [AGEN ?SPEAKER]
                           [OBJE [[RELN RECEIVE-FAVOR]
                                  [AGEN ?SPEAKER]
                                  [SOUR ?HEARER]
                                  [OBJE ?OBJ]]]]]]]]]]
    ;NEGAE MASU KA
    [[RELN S-INFORM]
      [AGEN ?SPEAKER]
      [RECP ?HEARER]
      [OBJE [[RELN REQUEST]
             [AGEN ?SPEAKER]
             [RECP ?HEARER]
             [OBJE [[RELN INFORMIF]
                    [AGEN ?HEARER]
                    [RECP ?SPEAKER]
                    [OBJE [[RELN CAN]
                           [AGEN ?SPEAKER]
                           [OBJE [[RELN REQUEST]
                                  [AGEN ?SPEAKER]
                                  [RECP ?HEARER]
                                  [OBJE ?OBJ]]]]]]]]]]
 ...)
  :PREREQUISITE
     ([[RELN BELIEVE]
       [EXPR ?SPEAKER]
       [OBJE [[RELN CAN][AGEN ?HEARER][OBJE ?OBJ]]]]
      [[RELN WANT]
       [EXPR ?SPEAKER]
       [OBJE ?OBJ]])
  :EFFECTS
     ([[RELN BELIEVE][EXPR ?HEARER][OBJE ?REQ]]) )                                (28)
```

In this unification, ?GAPSEM2 and ?GAPSEM1 are unified with ?HEARER and ?SPEAKER, respectively. This conveys the information into the surface speech act type (21). The information identifies the AGEN(t) of the ITADAKERU-RECEIVE-FAVOR with ?SPEAKER and the REC(i)P(ient) with ?HEARER. Then, the AGEN and RECP of the OKURU-1 (sending) are identified with ?HEARER and ?SPEAKER, respectively. The zero-pronouns are supplemented. This means that the plan recognition inference can resolve some anaphora by assuming that the utterance is a kind of REQUEST.

The application of speech act plan schema (28) makes one of the speech act types of utterance (8). Speech act type (29) corresponds to the English sentence "could you send me a registration form?"†.

```
[[RELN REQUEST]
 [AGEN ?SPEAKER]
 [RECP ?HEARER]
 [OBJE [[RELN OKURU-1]
        [AGEN ?HEARER]
        [RECP ?SPEAKER]
        [OBJE [[RARM ?X01]
               [RESTR [[RELN TOUROKUYOUSHI-1]
                       [OBJE ?X01]]]]]]]
 [MANN [[PARM ?X02]
        [RESTR [[RELN INDIRECTLY]
                [OBJE ?X02]]]]]                                          (29)
```

The transfer process uses this speech act types. In the transfer process, relationship type names for abstract speech act types are transfered to the same names. Like the analysis process, the generation process consists of two stages, (i) obtaining surface speech act types by using the target language's strategies in terms of the target language's speech act plan schema, and (ii) generating surface utterances in a unification-based lexico-syntactico way.

5. CONCLUSION

In this paper, the analysis method of the intention translation method was proposed. What this method translates are acts in terms of speech act types. In the analysis part, surface speech act types are first extracted in a unification-based syntactico-semantic way, and then, less language-dependent speech act types are analyzed by using plan recognition inference.

In the first stage,

(i) the unification-based syntactico-semantic approach permits integrated descriptions of information from various sources, and

(ii) the lexico-syntactic approach allows very modular descriptions.

Property (i) allows descriptions of complex constraints on the uses of predicate constituents, and these constraints, especially on the uses of honorific predicate constituents, make it possible to analyze ellipsis related to discourse participants. This first stage is used as the analysis part of NADINE (<u>Na</u>tural <u>D</u>ialogue <u>In</u>terpretation <u>E</u>xpert) system. In order to speed up analysis, an efficient disjunctive feature structure unification algorithm is required because there are general disjunctions related to order variation of the SUBCAT and SLASH feature values in lexical descriptions[10,11]‡.

In the second stage, the surface speech act types are analyzed to extract abstract speech act types. In this stage, unification of the surface speech act types with decompositions is used instead of simple pattern-matching. This paper showed that the bi-directional information flow capability in the unification allowed the supplementation of some ellipsis with expectation of speech acts. Current plan recognition inference is simple and makes only inferences related to strategies. Additional higher level plan recognition inference should be implemented to treat more complex phenomena such as action subsumption.

† The sentence is one of the sentences corresponding to (27). In general, there may be many sentences corresponding to a speech act type.

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