

A METHOD OF ANALYZING JAPANESE 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 analyzing method 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 in the unification-based lexico-syntactic, syntactico-semantic way. The syntactico-semantic way permits integrated descriptions of information from various sources, and the lexico-syntactic way provides this analysis method with modularity. This 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 (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. The plan recognition inference uses a special kind of plan schemata, 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 it possible to allow supplementation of some ellipsis with expectation of speech acts from higher level plan.

1. INTRODUCTION

In natural language processing, although much effort at understanding or interpreting uni-directional communication has been devoted, only limited research in understanding bi-directional communication between humans via telephone or keyboard has been done. 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 target language meaning. 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. The main characteristic of this method is to translate acts in the speaker's utterances, while previous machine translation methods translate information that the author has written. Therefore, this method extracts speech act types in terms of the source language concepts as the meaning of the input utterance in the source language. This approach allows the 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 target language's strategies to express these types and to maintain dialogue smoothness.

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

etc.

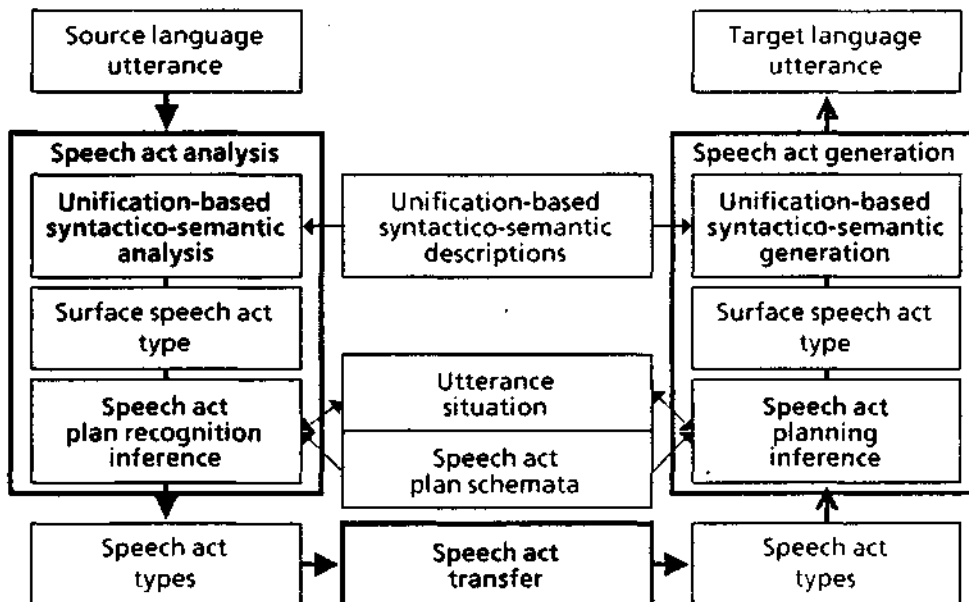


Fig.-1 The overview of the intention translation method.

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 abstract speech acts such as strategies cannot. Analysis of speech acts requires plan recognition inference^[1] 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 information enough to generate translation utterances;
- (2) The representation of surface speech acts and more abstract speech acts must be suitable for plan recognition inference.

Then, 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.

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)^[5]. The principal notions of this approach are derived from Japanese Phrase Structure Grammar (JPSG)^[3].

In this paper's grammar, the most essential grammatical structure is the complement-head structure and it is represented as grammatical rule (1) in the extended version of PATR-II notation^[6,7]:

```
(DEFRULE V -> (P V)
  (<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.

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]]]
[SLASH {}]
[LEX +]
[SEM [[RELN OKURU-1]    ;; RELatioN
      [AGEN ?SUBJSEM]   ;; AGENT
      [RECP ?OBJ2SEM]  ;; RECIPIent
      [OBJE ?OBJSEM]]]] ;; OBJEct

```

(2)

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

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

```
(:PERM A1 ... An :RESTRS R1 ... Rm)
```

form. The form is expanded into the disjunctions of permuted 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 {A₁ ... 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 rule:

```

(DEFRULE V -> (V)
  (<0 HEAD>      == <2 HEAD>)
  (<0 SUBCAT>     == <1 SUBCAT REST>)
  (<0 SLASH IN FIRST> == <1 SUBCAT FIRST>)
  (<0 SLASH IN REST> == <1 SLASH IN>)
  (<0 SLASH OUT>    == <1 SLASH OUT>)
  (<1 LEX>        == +)
  (<0 LEX>        == <1 LEX>)
  (<0 PRAG>       == <1 PRAG>)

```

(3)

The usual complement-head structuring rule like (1) is also applied to the predicate constituent structures. 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. 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 is 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. Especially, pronouns referring to the speaker or the hearer seldom appear. However, many of them 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. For example, the pragmatic conditions on the use of the auxiliary "itadakeru" is described as the <PRAG RESTRS> feature as below^[4]:

```
(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 ?PREDESEM]]
    ?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] ::: SOURce
      [OBJE ?PREDESEM]]]]]]
  [PRAG [[SPEAKER ?SPEAKER]
    [HEARER ?HEARER]
    [RESTRS {[[RELN HONOR-UP][ORIG ?SUBJSEM][GOAL ?OBJSEM]]
      [[RELN EMPATHY-DEGREE][MORE ?SUBJSEM][LESS ?OBJSEM]]}]]]]]
  (4)
```

The HONOR-UP relationship from the speaker to the subject agent of the predicate that "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^[10].

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 relation types such as the relation type called REQUEST, INFORMIF and so on, or their subtypes such as the relation type called ITADAKU-RECEIVE-FAVOR, e.g., the lexical description of the sentence final particle "ka", which expresses a question attitude represented in (5).

```
(DEFLEX か v
  "sentence final particle か KA, traditionally"
  [[HEAD [[POS V][CTYPE NONC]]]
  [SUBCAT (:PERM [[HEAD [[POS V][CFORM SENF][MODL !SFP-1-]]]
    [WH -][SEM ?PRELSEM]])]
  [SEM [[RELN KA-REQUEST]
    [AGEN ?SPEAKER]
    [RECP ?HEARER]
    [OBJE [[RELN KA-INFORMIF]
      [AGEN ?HEARER]
      [RECP ?SPEAKER]
      [OBJE ?PRELSEM]]]]]
  [PRAG [[SPEAKER ?SPEAKER]
    [HEARER ?HEARER]]]) (5)
```

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

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

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 principle in general syntactic rules. For example, the sentence (6), which includes "itadakeru" and "ka" is analyzed in Fig.-2 and the resulting feature structure is as follows:

Ex.: Tourokuyoushi wo kochira ni o-okuri itadake masu ka? (6)

Registration form ACC here DAT HON-send RECEIVE-FAVOR POLITE QUESTION

Can (I) receive a favor of (your) sending me a registration form?

(Lit.) 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]
```


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^[8]. 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 algorithm 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.
- (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 head specified by complements and on complements specified by the head. Thus, the equations are compiled into a looped

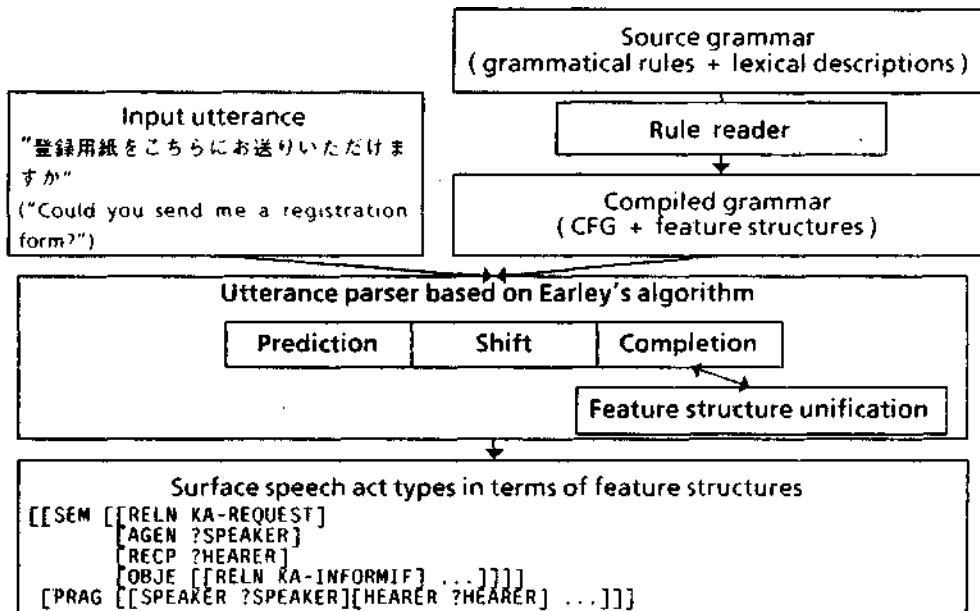


Fig.-3 Unification-based utterance parser configuration.

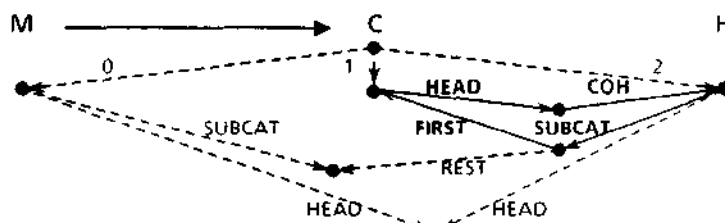


Fig.-4 Cyclic part of the compiled feature structure representing C-H construction.

feature structure (Fig.-4). Therefore, Wroblewski's algorithm[9] is extended to treat looped feature structures.

(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 structure in the 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

The 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-phrase translation of surface speech act types generates inadequate English utterances. For example, the word-to-word/phrase-to-phrase translation of the sentence (6) "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 relation and can then be unified with it.

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 then is used in the speech act type representation. Moreover, the information from the decomposition to the surface type makes it possible to supplement a part of semantic representation corresponding to zero-pronouns.

For example, the surface speech act type (8) is unified with the first decomposition of the speech act plan schema (9):

```
(DEF-SA-SCHEMA ?REQ[ [RELN REQUEST]
                        [AGEN ?SPEAKER]
                        [RECP ?HEARER]
                        [06JE ?OBJ[ [AGEN ?HEARER]]]
                        [MANN [ [PARM ?X01] [RESTR [ [RELN INDIRECTLY] [OBJE ?X01]]]]] ]
:DECOMPOSITIONS
( [ [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]]]]]]]]]] ...))
: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]]) )

```

(9)

In this unification, ?GAPSEM2 and ?GAPSEM1 are unified with ?HEARER and ?SPEAKER, respectively. This conveys the information into the surface speech act type (8). 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 NEARER and SPEAKER, respectively. The zero-pronouns are supplemented. This means that the plan recognition inference can resolve some anaphora by making the expectation that the utterance is a kind of REQUEST.

The application of the speech act plan schema (9) makes one of the speech act types of utterance (6). The speech act type (10) 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]]]]]]]]]]

```

(10)

The transfer process uses the result speech act types. In the transfer process, relation type names for abstract speech act types are transferred to the same names.

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

† The sentence is one of the sentences corresponding to (10). In general, there are many sentences corresponding to a speech act type.

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. (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 (Natural Dialogue Interpretation Expert) system.

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.

ACKNOWLEDGEMENT

The authors are deeply grateful to Dr. Kurematsu, the president of ATR Interpreting Telephony Research Laboratories, Dr. Aizawa, the head of the Natural Language Understanding Department, and all the members of the Natural Language Understanding Department for their constant help and encouragement.

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