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Research Activities
of the
Natural Language Understanding Department
and the
Knowledge and Data Base Department
for **Feb. 1989~Oct. 1989**

ATR Interpreting Telephony Research Laboratories

November 8, 1989

ATR Interpreting Telephony Research Laboratories

Abstract

This report summarizes the research activities of the language-related departments in the ATR Interpreting Telephony Research Laboratories: the *Natural Language Understanding Department* and the *Knowledge and Data Base Department.* Also contained are reprints of the related technical publications during Feb. 1989.~ Oct. 1989.

The current research areas of the Natural Language Understanding Department include:

(1) Dialogue Modeling
- Functional Analysis of Intention
- Japanese Grammar for Dialogue Translation

(2) Mechanisms for Dialogue Comprehension
- Plan Recognition Model for Dialogue Understanding
- Interpreting Japanese Utterances Based on Context Information
- Noun Phrase Identification in Dialogue
- Inference Mechanisms for Dialogue Understanding
- Case-Based Dialogue Understanding and Translation

(3) Dialogue Translation Method
- Analysis of Japanese Dialogue
- Transfer of Japanese Dialogue into English
- Generation of English Dialogue
- Typed Feature Structures and Rewriting Systems
- Translation of Spoken Language / Translation Based on Examples
- Parallel Parsing Algorithms

The research areas of the Knowledge and Data Base Department are

(4) Integration of Speech and Language Processing
- Continuous Speech Recognition Using HMM and LR-Parsing
- Statistical Evaluation of Outputs from HMM-LR
- Reducing the Number of Candidates Using Kakariuke Semantic Relationship
- Development an Experimental Spoken Language Translation System from Japanese to English

(5) Knowledge Base
- Defining Word Associative Knowledge Base
- Inference on the Knowledge Base
- Application to Speech and Language Processing Integration

- Defining Translation Knowledge Base

(6) Linguistic Database

- Construction of Linguistic Database
- Linguistic Database Management System :

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1. Research Organizations

1.1 ATR Interpreting Telephony Research Laboratories

An Automatic Telephone Interpretation system is a facility which enables a person speaking in one language to communicate readily by telephone with someone speaking another language. At least three constituent technologies are necessary for such a system: *speech recognition*, *machine translation*, and *speech synthesis*. Integrated research into these technologies is also very important. A feasibility study, published by the Japanese Ministry of Posts and Telecommunications, says that realizing such a system will require at least fifteen years.

Basic research on each of the above technologies has already started at the ATR Interpreting Telephony Research Laboratories of which Dr. Akira Kurematsu is the president. These laboratories were founded in April, 1986 with the support of the Japan Key Technology Center, ATR International, NTT, KDD, NHK and other Japanese enterprises.

The ATR Interpreting Telephony Research Laboratories have three departments: the Speech Processing Department, the Natural Language Understanding Department and the Knowledge and Data Base Department. These three departments cover the respective research areas to demonstrate the feasibility of an automatic telephone interpretation system shown in **Figure 1.** In this figure, the speech processing department is concerned with speech recognition, speech synthesis, speaker normalization, and voice conversion. The main research area of the natural language understanding department is language translation, and that of the knowledge and data base department is integrated process of speech and language.

1.2 Natural Language Understanding Department

The Natural Language Understanding Department is headed by Teruaki Aizawa. Its primary goal is to establish a machine translation technology for spoken dialogues as a result of speech recognition. Systems presently available for translating written texts are not applicable here as spoken dialogues contain many peculiar linguistic phenomena not found in written texts, such as: frequent omission of the subject or part of the predicate; frequent use of polite or honorific expressions; and frequent ambiguities. Robust parsing for incompletely recognized utterances is also an important research theme.

In order to qualitatively improve language processings for machine translation, the Natural Language Understanding Department now has three

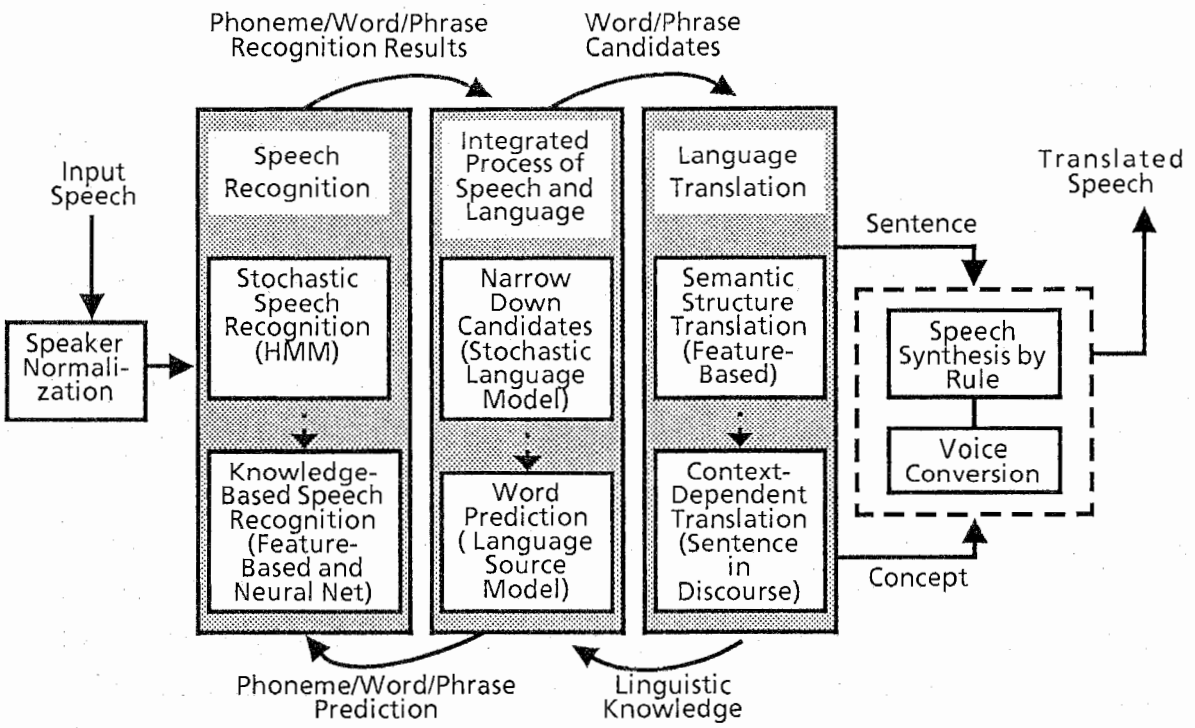

Figure 1. Proposed Automatic Telephone Interpretation System.

research groups: *dialogue modeling*, *mechanisms for dialogue comprehension*, and *dialogue translation method.*

The *dialogue modeling* research group, directed by Kei Yoshimoto, is working from a linguistic viewpoint to construct a discourse-dialogue model that can be implemented on a computer. A dialogue model as well as a broad explanation of the dialogue process will be effective for machine translation. Major linguistic phenomena peculiar to Japanese spoken dialogues have been investigated. Among others, research topics concerning zero pronouns, honorifics, negation, and intention are being studied, and the results obtained have been integrated step by step as a grammar for Japanese dialogue analysis, which is based on HPSG intiated by Pollard and Sag (1987) and its Japanese version Japanese Phrase Structure Grammar (JPSG) by Gunji (1987).

The *mechanisms for dialogue comprehension* research group is directed by Hitoshi Iida. It is our belief that the telephone interpretation system should be able to comprehend meaning in context. Considerable research has been focused on a plan recognition model for understanding and translating dialogue. Also a computational model for context processing using constraints on dialogue participants' mental states is being studied. A way to identify differently expressed noun phrases on the basis of domain knowledge is the first step toward dialogue meaning inference. Inference mechanisms using an ATMS

(Assumption-based Truth Maintenance System) have been implemented in order to cope with sophisticated dialogues containing negative answers or fallible actions.

The *dialogue translation method* research group, primary directed by Kiyoshi Kogure, is now carrying on an intermediate step in a study of translation of dialogue between computer terminals. This type of dialogue is fundamentally similar to spoken dialogue and important for practical applications. The proposed translation method is essentially based on the semantic transfer approach, and can be characterized by two translating processes: one which extracts intentions in utterance such as Request, Promise, Greetings etc., and another which transfers propositional parts of utterances. [Iida 88-3] A feature structure is adopted as an integrated description of information for the whole process of analysis, transfer and generation. A method to efficiently handle the feature structures is also being studied.

1.3 Knowledge and Data Base Department

The Knowledge and Data Base Department is headed by Tsuyoshi Morimoto. Three areas are being investigated: Integration of Speech and Language Processing, Knowledge Base, and Linguistic Database. The main area is the first one, but the other two areas, as described below, are substantially related to the former.

In speech recognition, some language information must be used to attain a high recognition rate. Moreover, if the speech recognition rate were low, many candidates would still remain and the language processing would explode because it would then have to analyze all combinations of all candidates.

Thus, problems that must be studied are: 1) developing an efficient continuous speech recognition mechanism using a language model, 2) finding and formalizing an effective language model, and 3) gathering conversational text and constructing a linguistic database as basic information for these studies.

The *Integration of Speech and Language Processing* research group is working on studies of integration of speech recognition and language processing. The proposed method is composed of three stages, Bunsetsu speech recognition, Bunsetsu candidate filtering and language analysis. At these stage, linguistic information is used in stepwise fashion ; the Bunsetsu speech recognition module which is called as HMM-LR recognizes input speech by using Bunsetsu syntax and phonetic hidden Markov models (HMM), the Bunsetsu filtering module filters out unplausible candidates by using Bunsetsu Kakariuke relationship and

language analysis module selects the unique sentence by using strict sentential syntactico-semantics or heuristics on sentential structure. An evaluation method of outputs from HMM-LR using their statistical characteristics was also studied. These methods have been integrated in our experimental spoken language translation system which is called as SL-TRANS and proved their effectiveness.

The *Knowledge Base* reserch group is trying to define the semantic relationship between words, and to apply it to reduce the number of candidates, moreover to predict the next word to be uttered. This knowledge is constructed from the linguistic database semi-automatically, then it can be seen as a kind of language model.

The *Linguistic Database* reserch group is engaged in constructing a Japanese spoken language text database. To enhance the usefulness of this database, various information is being added to these texts and stored in the database. The data structure then becomes fairly complicated. For easy handling of these complex data, a special linguistic database management system is also being developed.

2. Research Activities

Research activities and the related technical publications for 1989 are summarized in Sections 2.1 through 2.3 for the Natural Language Understanding Department, and in Sections 2.4 through 2.6 for the Knowledge and Data Base Department.

2.1 Dialogue Modeling

A dialogue model as well as a broad explanation of the dialogue process will be effective for machine translation. Major linguistic phenomena peculiar to Japanese spoken dialogues have been investigated from a linguistic viewpoint to construct a discourse-dialogue model that can be implemented on a computer. Among others, research topics concerning zero pronouns, honorifics, negation, and intention are being studied, and the results obtained have been integrated step by step as a grammar for Japanese dialogue analysis, which is based on HPSG intiated by Pollard and Sag (1987) and its Japanese version Japanese Phrase Structure Grammar (JPSG) by Gunji (1987).

2.1.1 Functional Analysis of Intention [Kume]

In devising a machine translation system of telephone dialogues, one of the problems is how to adequately translate the underlying meaning of the source utterance, or the speaker's intention, into the target language. In dialogue, smoothness of communication depends on understanding the speaker's

underlying meaning.

A framework for translating the speaker's underlying meaning in MT system was proposed on the basis of two concepts, Illocutionary Force Types (IFTs) and Decision Parameters (DPs). IFTs are a type of classification of utterances concerning speaker's meaning. DPs present background information of language use in order to desire an appropriate expression from speaker's meaning.

As for the IFTs in Japanese, the extracting mechanism is studied and also demonstrated using RETIF system (see 2.3.4, R. Zajac & M. Emele).

Technical Publications: [Kume 88-3][Kume 88-9]

2.1.2 Japanese Grammar for Dialogue Translation [Hattori]

Japanese, like most languages, shows ambiguities in the scope of adverbs and context depending meanings of idiomatic expressions. The following topics are mainly studying.

Adverbial elements in Japanese are diverse in their semantic/discourse properties as well s syntactic constraints imposed on them.

This research aims at (A) a classification of adverbial elements in Japanese in terms of their syntactic/semantic properties ((i) cooccurence restrictions with predicate phrases, (ii) preference on surface positions, and (iii) restriction/preference on possible interpretations) and (B) formalization of these elements within a grammatical framework.

A classification of Japanese idiomatic expressions is propsed. Formal properties of each class of idiomatic expressions and their implications for machine translation is shown.

Technical Publications: [Hattori89-5][Hattori 89-6]

2.2 Mechanisms for Dialogue Comprehension

It is our belief that the telephone interpretation system should be able to comprehend meaning in context. Considerable research has been focused on a plan recognition model for understanding and translating a dialogue. Also a computational model for context processing using constraints on dialogue particitants' mental states is being studied. A way to identify differently expressed noun phrases on the basis of domain knowledge is the first step toward dialogue meaning inference. Inference mechanisms using an ATMS (Assumption-based Truth Maintenance System) have been implemented in order to cope with sophisticated dialogues containing negative answers or fallible actions.

2.2.1 Plan Recognition Model for Dialogue Understanding [Yamaoka, Iida]

A plan recognition model for resolving ellipses of phrases or choosing an appropriate translated word was proposed. A kind of prediction of the next utterance necessary for the integrated process of speech and language will be also

performed in this framework.

The model consists of plans, objects, and inference rules. Four kinds of plans are used in the current model : *domain plans*, which represent the structure of domain-dependent action hyerarchies; *dialogue plans*, which manage the global change of topics in the domain; *communication plans*, which represent a sequence of communicative acts for information exchange; and *interaction plans*, which manage the local structure of the dialogue, that is a demand-response pair in a goal-oriented dialogue. An analyzed utterance in a demand matches the decomposition of an interaction plan. Then the interaction plan matches the decomposition of a discourse plan which introduces an object and a domain plan. A response utterance matches the decomposition of an interaction plan which has already been instantiated. Plan chaining is done via Decomposition, Effects and Constraints described in the slots of a plan scheme. A prototype system of plan recognition based on this model has been implemented for the demand-response sample dialogues about the conference.

Technical Publications: [Iida 89-3][Iida 89-10-1]

2.2.2 Interpreting Japanese utterances based on context information

[Dohsaka]

Shared goals and mutual beliefs between dialogue participants are mainly taken as the context in task-oriented Japanese dialogue. Communicative actions performed by dialogue participants can be interpreted based on such context information. Honorific relations between dialogue participants, speaker's point of view and speaker's territory of information are also regarded as the context in Japanese dialogue.

An utterance interpretation model based on Situation Theory has been developed. In the model, the state of dialogue is composed of communicative act situation, mutual belief situation and shared goal situation. Speaker's communicative actions convey information on communicative action situation. Context information is included in mutual belief situation and shared goal situation. Constraints are defined between those situations. Communicative actions are interpreted under the context information through the constraints. The interpretation process is made on the basis of Constraint Application Method and Information Merging Method. Through Information Merging Method, elliptical information in utterances can be filled based on the known context information.

A model to identify zero-pronouns referring to persons in Japanese dialogue has been developed. In this model, pragmatic constraints on honorific relations between persons in a dialogue, speaker's point of view and speaker's territory of

information are fetched from utterances. The constraints represented as State of Affairs (SOAs) in Situation Theory. Zero pronouns in utterances are depicted as parameters(indeterminate) in the SOAs. The context is a set of satisfactory conditions, which the constraints from utterances have to satisfy.

The constraints fetched from utterances are interpreted under the current context. The interpretation of constraints under the context is a process of rewriting the constraints with the satisfactory conditions and unified parameters for zero-pronouns with appropriate constants for persons in the context. This rewriting process can be regarded as a kind of refutation procedure applied to a set of the satisfactory conditions and the constraints, except that the new constraints compatible with the current context can be introduced to the context, and used in the interpretation process of the following utterances.

Technical Publications: [Dohsaka 89-3-1][Dohsaka 89-3-2][Dohsaka 89-10-1] [Dohsaka 89-10-2]

2.2.3 Noun Phrase Identification in Dialogue [Nogaito]

Noun phrase identifications are considered as a kind of anaphora. Noun-noun relationships are ambiguous, as are noun-pronoun relations. Generally, nouns must match more 'antecedent' information than pronouns. But a noun's antecedent can be more remote, so that the analysis scope of a noun-noun relationship will be larger than that of a noun-pronoun relationship. Based upon these considerations, a noun phrase identification model for understanding and translating dialogue was proposed through use of domain knowledge and a plan recognition model. The domain knowledge consists of two types of information: an *element* which has some relationship to another element, and a *predicate* which corresponds to a verb in an utterance. The identification process first checks nouns in a dialogue by using a noun hierarchy system from an element at the domain knowledge, and then proceeds to check conditions in detail by using a predicate. The model has been implemented on an expert system in a Symbolics machine.

Technical Publications: [Nogaito 89-5]

2.2.4 Inference Mechanisms for Dialogue Understanding [Kudo, Myers]

An inference mechanism using an ATMS (Assumption-based Truth Maintenance System) has been implemented in order to cope with sophisticated dialogues. One type of dialogue we want to treat is an indirect answer such as in the example: *"I would like to attend the conference."* / *"It is suspended."* A model to deal with those dialogues is being studied using "assumption-based proposition management".

A method used to perform plan recognition using an ATMS is also examined.

Since an ATMS only stores and maintains the truth of data that is given to it (but cannot originate data), an ATMS cannot effectively be used by itself, but must be coupled with a problem-solver. This takes the form of an inference engine. The conceptual design of the resulting system was proposed; both the ATMS and the inference engine have been implemented, and preliminary results obtained. Current efforts include research on "fallible execution" resulting in pragmatic constraints on recovery actions. For instance, (Q1) "I would like to attend the conference. How much is the registration fee ?", and (A1) "I'm sorry, it's closed." or (A2) "It's 200$.", "it" in (A1) points to the different word which "it" in (A2) points to.

In order to resolve such a anaphora relation, we defined linguistic knowledge as to whether the answer sentence is connected with the question sentence, This is called "cohesive knowledge". We extracted 100 verbs and 200 nouns from the ATR corpus and constructed the linguistic knowledge. We are currently implementing and testing it as a context process of Dialogue Machine Translation system.

Technical Publications: [Nogaito 89-6]

2.2.5 Case-Based Dialogue Understanding and Translation [Iida]

Construction and operation of understood meaning of utterance are being studied as a memory model on which context processing, inference and dialogue comprehension mechanisms are to work.

A new paradigm of machine translation based on dialogue comprehension has been studying. It consits of both a logical translation method using various kinds of transfer rules and a case-based translation method based on the cases in which some phrases (or clauses) has been previously transferred. It is considered as an extended approach including an example-based translation method (see 2.3.5).

2.3 Dialogue Translation Method

The development of an experimental Japanese-into-English translation system which deals with inter-keyboard dialogue as a first step toward spoken dialogue translation has been started. This type of dialogue is fundamentally similar to spoken dialogue and important for practical applications. The proposed translation method is essentially based on the semantic transfer approach, and can be characterized by two translating processes: one which extracts intentions in utterance such as Request, Promise, Greetings etc., and another which transfers propositional parts of utterances. [Iida 89-9] [Iida 89-10-2] A feature structure is adopted as an integrated description of information for the whole process of analysis, transfer and generation. A method to efficiently handle the feature structures is also being studied.

2.3.1 Analysis of Japanese Dialogues [Kogure, Dohsaka, Nagata]

In order to obtain communicative act types, which are of the basic object to be translated in our framework, two-stage analysis has been adopted. The first stage obtains surface communicative act types and the second stage obtains more abstract communicative act types.

Spoken-style Japanese sentences are very different from written-style sentences in several ways, especially in distribution of zero-pronouns and in construction of predicate phrases. This difference makes spoken-style sentences ambiguous in the ways inherent to spoken-style sentences. In order to disambiguate them, it is required to extract pragmatic constraints on uses of expressions and to select the most plausible analysis candidate by using these constraints.

One of our major goals of Japanese dialogue analysis is to establish an analysis method for extracting both surface communicative act types and pragmatic constraints.

To achieve the above goal, an analysis method has been developed which consists of a lexico-syntactic grammar framework in terms of typed feature structures and an analysis order controllable parser.

Unification-based lexico-syntactic Japanese Grammar This grammar emphasizes the treatment of complex sentence final predicate constituents and of zero-pronouns referring to dialogue participants. In May, the grammar has been able to treat various kinds of complex predicate phrases and 2 sample dialogues. From June to September, this grammar has been continuously exntended, especially in complex nominal phrase treatments and tense/aspect analysis. This grammar can be treated 7 sample dialogues.

Parser The parser is called (Typed) Feature Structure Propagation Parser (T)FSP Parser. The parser has the parsing order control mechanism by using the edge score and the feature structure selection mechanism by using the TFS score. The parser can accept sentence lattices, which are speech recognition results.

Sentence lattice analysis experiments Application of this method to speech recognition sentence lattices obtains 92% correct recognition.

Technical Publications: [Kogure 89-3][Kogure 89-8][Kogure 89-9]
[Kogure 89-10]

2.3.2 Transfer of Japanese Dialogue into English [Hasegawa]

The transfer process converts communicative act representations in terms of the source language's concepts into the corresponding act representations in terms of the target language's. This process works with structures consisting of illocutionary force structures and proposition structures. Illocutionary force structures are converted into the same type of structure because these structures represent language independent concepts. Internal proposition structures are

converted in a mannar similar to usual semantic transfer process. An experimental transfer system whih is based on a feature structure rewriting system has been implemented. It can control transfer processes flexibly using both rewriting rules and constraints on rule application conditions.

Technical Publications: [Hasegawa 89-3][Iida 89-10-3]

2.3.3 Generation of English Dialogue [Ueda]

A generation system must handle the illocutionary forces which play an important role in a cooperate smooth dialogue. Bi-directional use of grammar / lexicon is favorable not only because it can increase the maintainability of grammar but also because it helps to describe the relationship between the illocutionary forces and the surface utterances explicitly. Bi-directionality is set to be the main feature of our generation system. The grammar is based on HPSG and is consisted from CFG rules with constraints on the feature structure. The mechanism of the generation is based on the typed feature structure unification system. Generation is achieved by reversing the application of the grammar rules for analysis. Some controls are still necessary in order to avoid the application of grammar rules which will finally fail and to increase efficiency. Nevertheless, they must be described in a static way to keep the advantages of bi-directional grammar. We have classified the features into several types and can control the application of rules by checking the constraints (called assertions) attached to the grammar rules.

Experimental generation system is developed. It uses the typed feature to controlling the rule application, and it uses disjunction capability for the structure sharing in order to reduce the over-copy of feature structures.

The base of the bi-directional grammar is developed. The relationship between illocutionary forces and the surface utterances is analyzed and the feature structure representation of the English sentences is designed. The grammar is based on HPSG and the analysis of Robert Borsley (by Sondra Ahlén).
Further works

Technical Publications: [Kurematu 89-8]

2.3.4 Typed Feature Structures and Rewriting Systems [Zajac, Emele, Nicolas]

The first version of the rewriting system for typed feature structures (RETIF) based on the formal semantics of Aït-Kaci, which handles disjunction and single type inheritance, was implemented in Common Lisp.

For the transfer model, the type rewriting system is used to describe 1) the

relation between a surface structure produced by a unification-based parser and the abstract structure used for transfer, and 2) the relation between Japanese and English structures.

Our generation model can be characterized as multilevel but homogeneous. The individual levels of linguistic representations (i.e. abstract communicative acts, surface communicative acts, constituent structure, and surface utterance), as well as the mappings between these levels (e.g. constituent structure templates, grammar rules, lexical entries, etc.) are uniformly represented using typed feature structures and the type rewriting system to relate the individual levels of linguistic representations.

A new prototype of a rewriting system for typed feature structures has been implemented. The main purpose of this new version is to enhance the expressive power of the semantic formalism by introducing multiple inheritance. The semantics has been extended to multiple inheritance and the interpreter has been reimplemented for treating multiple inheritance.

Technical Publications: [Zajac 89-3][Emele 89-3][Zajac 89-6]

2.3.5 Translation of Spoken Language / Translation Based on Examples [Sumita]

In order to establish robust translation technology which resolves rule-based concrete translation problems example-based paradigm has been adopted. Example based processing consists of finding similar preceding examples to the current object and adapting the examples to solve new problems. This new paradigm has three major advantages: (1) it enables the improvement of system performance only by improvement of example database; (2)it outputs the result with reliability factor; (3) it enables quick reasoning by indexing and parallel computing. The method is now applying to two kinds of translation pocessing. One is disambiguation of speech recognizer output. The other is Translation of noun groups connected by particle "NO".

Preparing a correct bunsetu database as examples and the bunsetu-lattices of HMM-LR as input and the system calculates the similarity using LEX and POS. The results of experiment is encouraging but it also shows that semantic and contextual information must be incorporated[Sumita 89-10].

Translation subsystem for noun groups connected by particle "NO" has been implemented. First about 1000 examples (noun groups and their English examples) have been extracted from ATR's Linguistic database. Secondly a lexicon with English equivalents and thesaurus code as semantic information has been built for about 2500 Japanese nouns. The current translation mechanism is based on a simple similarity calculation and sort function and it will be modified

in order to improve the accuracy and speed.

Retrieval mechanism based on the importance determined by rules is developed. And the first implementation is applied to translation aid and the second implementation is aimed at a tool for teachers of Japanese[Sumita 89-2].

Technical Publications: [Sumita 89-2][Sumita 89-10]

2.3.6 Parallel Parsing Algorithms [Kato]

Interpreting telephone system requires a real-time or a quasi real-time processing, especially a Japanese dialogue analyzer which handles a lattice input. The performance of ATR's unification based parser is now being improved by using parallel processing technique.

A suitable parallel algorithm for a unification based parser has been designed, and its validity and performance on a parallel computer iPSC2 is being verified. An experimental parallel parser has been developed on iPSC2 (INTEL). A main characteristic of this parser is to decompose the unification processees on distributed PE(Processing Element) with few communication overhead.

2.4 Integration of Speech and Language Processing

The Integration of Speech and Language Processing research group is working on studies of integration of speech recognition and language processing. The proposed method is composed of three stages, Bunsetsu speech recognition, Bunsetsu candidate filtering and language analysis. At these stages, linguistic information is used in stepwise fashion ; the Bunsetsu speech recognition module which is called as HMM-LR recognizes input speech by using Bunsetsu syntax and phonetic hidden Markov models (HMM), the Bunsetsu filtering module filters out unplausible candidates by using Bunsetsu Kakariuke relationship and language analysis module selects the unique sentence by using strict sentential syntactico-semantics or heuristics on sentential structure. An evaluation method of outputs from HMM-LR using their statistical characteristics was also studied. These methods have been integrated in our experimental spoken language translation system which is called as SL-TRANS and proved their effectiveness.

2.4.1 Continuous Speech Recognition Using HMM and LR-Parsing [KITA, HOSAKA]

HMM-LR is a continuous speech recognition mechanism which combines the HMM and Generalized LR-parsing method. In HMM-LR, each phoneme is defined as Hidden Markov Model and the grammar which describes the syntactical constraints on phoneme sequence is also defined. According to the grammar, HMM-LR predicts the next phonemes and verifies the existence of them by using corresponding HMM. Reduce actions are performed at appropriate points. These

actions proceed in parallel for multiple candidates, and only those sequences with high probabilities are kept(that is "beam search").

Some experiments for phrase (Japanese Bunsetsu) recognition were performed. For the task including about 1,000 words, phrase recognition rate was 85% for the top candidate and 95% for the best five candidates. This result indicates the effectiveness of this method.

Generalized LR-parsing method is used in this mechanism as described above, then it can handle not only a grammar for Bunsetsu but any context free grammar such as for sentences. It is expected also that recognition rate could be raised by introducing stochastic grammar based on the idea of language source modeling. At present, studies and experiments over these topics are being carried on.

Technical Publications: [Kita 89-3] [Kita 89-5] [Kita 89-8] [Kita 89-8] [Hosaka 89-10]

2.4.2 Statistical Evaluation of Outputs from HMM-LR [SAKANO]

Scores of the outputs from HMM-LR are those calculated from probability defined on each HMM, but they include some degree of error. To evaluate the reliability of them, relation between these scores and probability of correctness of outputs were investigated, and a proper statistical distribution function which takes score as a statistical valuable was proposed. This reliability evaluating method can be applied to for two purpose; to reduce the number of candidates, or to evaluate the reliability of speech recognition itself for a certain phrase.

Technical Publications: [Sakano 89-3] [Sakano 89-10]

2.4.3 Reducing the Number of Candidates Using the Kakariuke Semantic Relationship [KAKIGAHARA]

The method which reduces the number of the candidates from the HMM-LR is being studied. In this method, the Japanese Kakariuke relationship is used. This relationship is a kind of semantic relationship between two Bunsetsu. About 60 kinds of semantic relationships were defined, and have been attached to each Bunsetsu in the text database. From this database, a possible Kakariuke relationship and its frequency for two Bunsetsu were extracted and compiled as a Kakariuke dictionary. Using this dictionary, only probable Bunsetsu candidates are selected from the HMM-LR outputs. Experiment result indicated the

usefulness of this method; the number of candidates was reduced to less than one-third the number of raw candidates.

Technical Publications: [Kakigahara 89-10-1]

2.4.4 Development an Experimental Spoken Language Translation System from Japanese to English [MORIMOTO, OGURA, SAKANO, KITA, KAKIGAHARA, HOSAKA]

An experimental spoken language translation system (SL-TRANS) has been developed. This system recognizes spoken Japanese conversational sentences, translates them into English and outputs synthesized English speech. This system composed of four main modules (shown in Fig.2); HMM-LR for Bunsetsu recognition, Bunsetsu candidate selecting module, dialogue translation module, DECtalk and the total system controller. It also has a function for evaluating the reliability of HMM-LR results in two ways. One is by using the distribution function for HMM-LR scores as described above. Another is by checking the existence of Kakariuke relationship; if none of candidates for a certain phrase has any Kakariuke relationship to other candidates for rest phrases at all, the phrase is regarded as recognized incorrectly.

Japanese input sentence analyzer in the dialogue translation module was functionally extended so that it could accept lattice inputs and, if there still remain several sentential candidates, select the most probable sentence by checking exact syntactico-semantic validity or evaluating complexity of structure of each candidates (see 2.3.1).

From the language source modeling point of view, this system is composed of three stages which apply language model of different degree ; HMM-LR with Bunsetsu syntax, filtering candidates with Kakariuke relationship and language analyzer with sentential syntactico-semanticc constraints or heuristics on sentense structure.

Preliminary experiment results showed the effectiveness of this method. The results for the conversations that contain about 300 words were as follows:

(1) average number of output candidates per Bunsetsu form HMM-LR was 4.6 and Bunsetsu recognition rate was 96%.

(2) this number was reduced to 1.5 by Bunsetsu filtering module.

(3) final percentage of sentences that were selected correctly after the sentence analyzer was 92%.

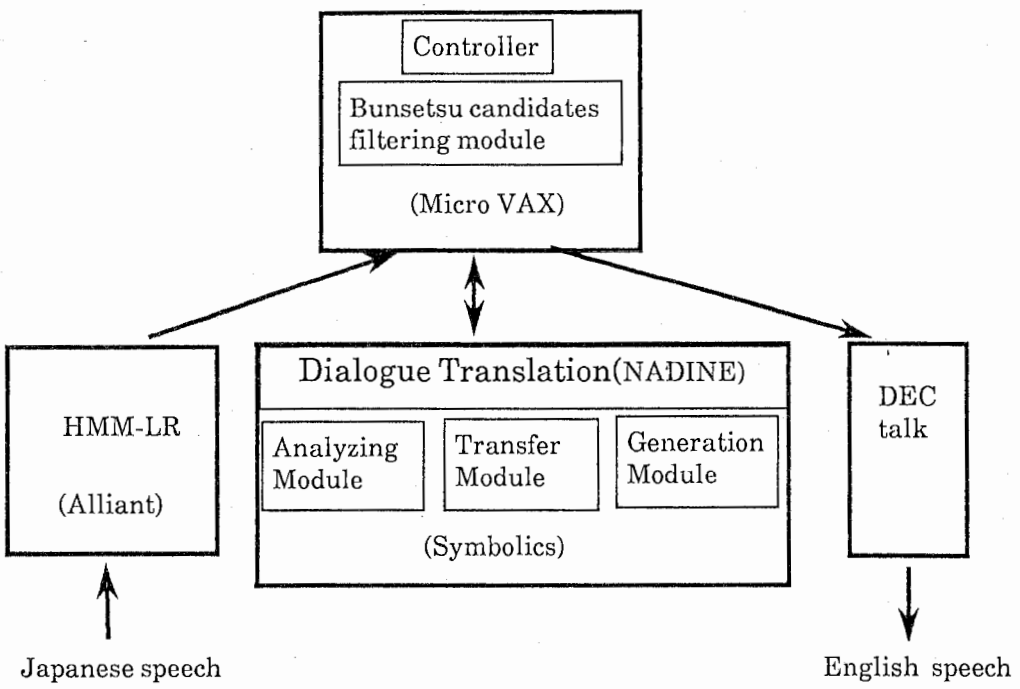

Fig.2 Configuration of SL-TRANS

Technical Publications: [Morimoto 89-10][Kita 89-10][Kakigahara 89-10-2]

2.5 Knowledge Base

The Knowledge Base research group is trying to define the semantic relationship between words, and to apply it to reduce the number of candidates, moreover to predict the next word to be uttered. This knowledge is constructed from the linguistic database semi-automatically, then it can be seen as a kind of language model.

2.5.1 Defining Word Associative Knowledge Base [INOUE]

The Kakariuke relationship mentioned above is basically a 2 term(2 words) relationship. But it would be very useful if these 2 term relationships were combined to form n term relationship. For example, even if only n−i terms appeared in the input sentence, the remaining i terms could be inferred from the corresponding n term relationship. This is just what is called as supplementing ellipsis.

These relationships express the associative relations between words, and in this sense, it is called as a ' word associative knowledge base'. In this knowledge base, one word is defined as a node. The semantic relationship is defined as a link between nodes. Moreover, association intensity (weight) between words is also

defined on a link in proportion to the frequency of appearance in the text data base.

2.5.2 Inference on the Knowledge Base [INOUE]

The inference mechanism developed is based on maker passing and activation spreading. When one word appears in the input data, the corresponding node becomes active and then it spreads the activation markers through the links to the upper nodes. Activation strength of the upper node is calculated according to the weight on the link. Upper nodes which received activation maker then spread prediction markers to other lower nodes. Prediction score is also calculated according to the weight on the link. Passing prediction marker means predicting next words that would possibly appear. If the word appears actually in the next step, the activation strength of the node which is calculated in normal way would be strengthen by adding prediction score to it.

Technical Publications: [Inoue 89-10]

2.5.3 Application to Speech and Language Processing Integration [INOUE]

Applying this knowledge base to reduce the number of candidates from speech recognition has been studied. Initially, nodes corresponding to all candidates are activated. But through the inference, only those which have a mutual relationship remain active. Some experiments showed the effectiveness of this method. Now, refinement of the inference algorithm or knowledge base itself is being carried on. In next step, we are planing to combine this knowledge base to a parser to enhance inference ability

Technical Publications: [Inoue 89-9]

2.5.4 Defining Translation Knowledge Base [KOHYAMA]

Studies about defining translation knowledge from Japanese to English is started. As the first step, translation examples about noun phrases connected with Japanese "の" are gathered from the linguistic database. This database will be used in studies on new translation method based on examples (see 2.3.5).

2.6 Linguistic Database

The Linguistic Database research group is engaged in constructing a Japanese spoken language text database. To enhance the usefulness of this database, various information is being added to these texts and stored in the database. The data structure then becomes fairly complicated. For

easy handling of these complex data, a special linguistic database management system is also being developed.

2.6.1 Construction of Linguistic Database [EHARA, OGURA, INOUE, HASHIMOTO, KOHYAMA]

As basic information for the above research, and at the same time for machine translation research, a large number of texts are being gathered and built into a "linguistic database". Several domains, such as inquiry for an international conference registration, inquiry to a travel agency, were selected and conversational texts over them have been gathered through simulation with keyboard or telephone. Gathered texts are analyzed and various information is added. This information is "word information" such as part of speech, "Kakariuke semantic relationship", or "corresponding translated English" etc..

Technical Publications: [Ogura 89-3]

2.6.2 Linguistic Database Management System [OGURA, HASHIMOTO]

All data is stored in the Relational Database (RDB) of a central processor. However its schema is very complicated; each word is defined as a tuple in a word table, some sequence of which forms a Bunsetsu, which is defined as another tuple in a Bunsetsu table. The Kakariuke relationship between these Bunsetsu is defined in yet another table, ad infinitum. RDB very efficiently stores considerable data, but it is hard for a user to access the data without knowing the physical structure of the table. To allow the user to access more logically and easily, a special linguistic database management system was developed. In this system, object-oriented data structure was adopted for a user interface. Object oriented data structure is suitable for defining logical relationship between data, and for accessing them based on these logical relationships. When a user wants to retrieve certain data, the corresponding portion of the relational database is read and converted into object oriented data structure automatically. In the first version of the system, a Symbolics workstation was used for a user site machine connected with a central processor through Ether network, and data structure conversion was performed on it. To enhance the usability of the system, user interface using a inexpensive dumb terminal such as VT100 is now under development.

Technical Publications: [Ogura 89-10]

3. Research Staff

The research staff is mainly composed of members from the research institutes and laboratories which support ATR. Also, visiting foreign scientists are included. The following members have participated in language-related research for the period of 1989.

Natural Language Understanding Department

Name	*Position*	*Home company*	*Period*
Teruaki Aizawa	Department Head	NHK	Apr., 1986 ~ Jun., 1989
Hitoshi Iida	Senior Researcher	NTT	Apr., 1986 ~
Kei Yoshimoto	Senior Researcher	NTT	Sep., 1986 ~ Feb., 1989
Kiyoshi Kogure	Senior Researcher	NTT	Sep., 1986 ~
Masako Kume	Researcher	Proper	Jan., 1987 ~
Hidekazu Arita	Researcher	Mitsubishi	Sep., 1986 ~ Feb., 1989
Izuru Nogaito	Researcher	KDD	Apr., 1986 ~ Aug., 1989
Yoshihiro Ueda	Researcher	Fuji Xerox	Mar., 1988 ~
Eiichiro Sumita	Researcher	IBM (TRL)	Jan., 1989 ~
Susumu Kato	Engineer	Nihon Symbolics	Apr., 1987 ~
Ikuo Kudo	Researcher	CSK	Apr.,1987 ~
Hiroyuki Maeda	Researcher	Sharp	Sep., 1986 ~ Aug., 1988
Koji Dohsaka	Researcher	NTT	Mar., 1988 ~
Toshiro Hasegawa	Researcher	CSK	Nov., 1987 ~
Masaaki Nagata	Researcher	NTT	Mar., 1989 ~
Takayuki Yamaoka	Researcher	Mitsubishi	May, 1989 ~
Ken-ichi Itsumi	Researcher	CSK	Sep., 1986 ~ Aug., 1988
Rémi Zajac	Invited Researcher	GETA, France	Mar., 1988 ~ Sep., 1989
Christian Boitet	Invited Researcher	GETA, France	Apr.~July.,1988
Gayle K. Sato	Invited Researcher	Hawaii-Manoa Univ.	Apr.,1988~Mar., 1989
Tadasu Hattori	Invited Researcher	Kyoto Univ.	May, 1988 ~
John K. Myers	Invited Researcher		Sep., 1988 ~
David Carter	Invited Researcher	SRI Cambridge	Sep., 1989 ~
Martin C. Emele	Invited Researcher	Stuttgart Univ.	Sep., 1988 ~ Sep., 1989
Yves Nicolas	Intern student	ENST, France	Apr.~Nov.,1988

Knowledge and Data Base Department

Name	*Position*	*Home company*	*Period*
Tsuyoshi Morimoto	Department Head	NTT	March,1987 ~
Terumasa Ehara	Supervisor	NHK	July, 1989 ~
Kentaro Ogura	Senior Researcher	NTT	Sep., 1986 ~
Masami Suzuki	Senior Researcher	KDD	Aug., 1989 ~
Koji Kakigahara	Researcher	Matsushita	Oct., 1986 ~Sept., 1989
Kenzi Kita	Researcher	Oki	Sep., 1987 ~
Naomi Inoue	Researcher	KDD	Aug.,1987 ~
Kazuo Hashimoto	Researcher	Osaka Gas	Sep., 1987 ~
Toshiyuki Takezawa	Researcher	Proper	Oct., 1989 ~
Toshiya Sakano	Researcher	Sharp	Sep., 1988 ~
Hideo Kohyama	Researcher	TIS	April., 1989 ~
Naoko Shinozaki	Engineer	TIS	Sept.,1986~Mar.,1989
Zyunko Hosaka	Invited Researcher	Stuttgart Univ.	Sep., 1988 ~

4. Research Facilities in the language-Related Departments

The two language-related departments have common computer systems which consists of VAX 8600/8800 with ULTRIX systems, an iPSC parallel computer by INTEL Corp. and various types of workstatons such as Symbolics 3675 / 3650 / 3620, Xerox 1121, Explorer II, SUN 3/4 and ELIS. They are connected through the Ethernet network. Common Lisp and C are the major programming languages used in our departments.

List of Technical Publications
of the
Natural Language Understanding Department
and the
Knowledge and Data Base Department
for **Feb. 1989 ~ Oct. 1989**

General Form

[*Reference ID*] *Authors* (*Affiliation other than ATR*) :
「*Japanese Title*」 (Only for a paper written in Japanese.)
"*English Title*",
Conference or Journal (*Date*) - - - (page).

[Tsutumi 89-2] Yutaka Tsutsumi and Ei-ichirou Sumita:
「用例検索による日本語教師支援システム」
"An Assistant System for Teachers of Japanese by a text retrieval",
WGCE Meeting of IPSJ 4-3 (1989-2) - - - (1).

[Dohsaka 89-3-1] Kohji Dohsaka:
「対話参加者の心的状態に関する制約を用いた文脈処理方法」
"Context Processing Using Constraints on Dialogue Participants' Mental States",
(1989-3) - - - (9).

[Dohsaka 89-3-2] Kohji Dohsaka, Kiyoshi Kogure and Hitoshi Iida :
「対話参加者の心的状態に関する制約を用いた文脈処理手法」
"Context Processing Using Constraints on Dialogue Participants' Mental States ",
IPSJ Spring Meeting, 4D-5(1989-3) - - - (19).

[Hasegawa 89-3] Toshiro Hasegawa and Kiyoshi Kogure:
「日英対話翻訳における意味構造変換手法」
"The Semantic Transfer Method in Japanese-English Dialogue Translation System",
IPSJ Spring Meeting, 3E-9(1989-3) - - - (21).

[Iida 89-3] Hitoshi Iida:
「対話およびテキスト理解」
"Dialogue and Text Understanding",
IEICE Spring Meeting, GD (1989-3) - - - (23).

[Kogure 89-3] Kiyoshi Kogure:
「タイプ付き素性構造単一化の一手法」
"An Implementation of Typed Feature Structure Unification",
IPSJ Spring Meeting, 2D-1(1989-3) - - - (25).

[Kume 89-3] Masako Kume and Kei Yoshimoto:
「意図を表す言語形式の語用論的制約について」
"Pragmatic Constraints on Illocutionary Force Indicators ",
IPSJ Spring Meeting, 4D-4 (1989-3) - - - (27).

[Nogaito 89-3] Izuru Nogaito and Hitoshi Iida:
「名詞句の同一性の理解と応用」
"A Method of Semantic Identification for Noun Phrases in Dialogues & Its Application",
IPSJ Spring Meeting, 6D-5(1989-3) - - - (29).

[Ueda 89-3] Yoshihiro Ueda and Kiyoshi Kogure:
「素性構造を入力とする英文生成」
"Generating English Sentences from Feature Structures",
IPSJ Spring Meeting, 2D-4(1989-3) - - - (31).

[Ogura 89-3] Kentaro Ogura, Naoko Shinozaki and Tsuyoshi Morimoto:
「形態素情報収集支援システム」
"Tools for Word Information Collection",
IPSJ Spring Meeting, 4E-1 (1989-3) - - - (33).

[Inoue 89-3] Naomi Inoue, Tsuyoshi Morimoto and Kentaro Ogura:
「単語の共起関係を定義した知識ベースの構成」
"The Structure of the Knowledge Base in which the Cooccurrence Between Words in Defined",
IPSJ Spring Meeting (1989-3) - - - (35).

[Sakano 89-3] Toshiya Sakano, Kenji Kita and Tsuyoshi Morimoto:
「音声認識候補の統計処理による絞り込み」
"Reduction of Speech Recognition Candidates by Statistical Method",
IEICE Spring Meeting, A-21 (1989-3) - - - (37).

[Morimoto 89-3] Tsuyoshi Morimoto:
「音声言語の意味理解」
"Speech Understanding"
IEICE Spring Meeting, GD-1(1989-3) - - - (38).

[Kita 89-3] Kenji Kita, Takeshi Kawabata and Tsuyoshi Morimoto:
「HMM-LR連続音声認識システムにおける計算量削減のための一検討」
"Computing Amount Reduction in HMM-LR Continuous Speech Recognition System",
ASJ Spring Meeting (1989-3) - - - (40).

[Zajac 89-3] Rémi Zajac:
"A Typed Feature Structure Unification-based Appoach to Transfer",
WGNLC Meeting of IEICE 88-31 (1989-3) - - - (42).

[Emele 89-3] Martin C.Emele:
"A Typed Feature Structure Unification-based Appoach to Generation",
WGNLC Meeting of IEICE 88-32(1989-3) - - - (48).

[Kume 89-4] Masako Kume, Gayle K. Sato and Kei Yoshimoto:
"A Descriptive Framework for Translating Speaker's Meaning - Towards a Dialogue Translation System between Japanese and English-",
European Chapter of ACL89 (1989-4) - - - (54).

[Kita 89-5] Kenji Kita, Takeshi Kawabata and Hiroaki Saito:
"HMM Continuous Speech Recognition Using Predictive LR Parsing",
ICASSP'89 (1989-5) - - - (62).

[Hattori 89-5] Tadasu Hattori:
「反復を含む構文の性質について」–日本語は文脈自由文法で記述可能か?–
"On the Nature of Reduplicative Constructions in Japanese: Is Japanese a Context-free Language?",
Linguistic Research Vol. 7, Linguistic Institute of Kyoto Univ.
(1989-5) - - - (66).

[Nogaito 89-5] Izuru Nogaito and Hitoshi Iida:
「キーボード会話における名詞句の同一性の理解」
"A Method of Semantic Identification for Noun Phrases in Inter-Keyboard Dialogues",
(1989-5) - - - (82).

[Zajac 89-6] Rémi Zajac:
"A Transfer Model Using A Typed Feature Structure Rewriting System with Inheritance",
ACL Annual Meeting 89 (1989-6) - - - (90).

[Hattori 89-6] Tadasu Hattori:
「ない」による否定の作用について
"On the Scope of Negation in Japanese",
The 98th Meeting of the Linguistic Society of Japan (1989-6) - - - (96).

[Myers 89-6] Jone K.Myers:
"An Assumption-Based Plan Inference System for Conversation Understanding",
WGNL Meeting of IPSJ 73-18 (1989-6) - - - (102).

[Kita 89-8] Kenji Kita, Takeshi Kawabata and Hiroaki Saito:
"Parsing Continuous Speech by HMM-LR Method",
International Workshop on Parsing 89 (1989-8) - - - (110).

[Kogure 89-8] Kiyoshi Kogure:
"Parsing Japanese Spoken Sentences Based on HPSG",
International Workshop on Parsing 89(1989-8) - - - (116)

[Kurematsu 89-8] Akira Kurematsu and Yoshihiro Ueda:
"Generation in Dialogue Translation",
Machine Translation Workshop at Univ. of Manchester (1988-8) - - - (126).

[Inoue 89-9] Naomi Inoue, Tsuyoshi Morimoto and Kentaro Ogura:
"A Linguistic Knowledge Base for Applying Semantic Information to a Speech Understanding System",
European Conference on Speech Technology and Communication 89(1989-8) - - - (130).

[Iida 89-9] Hitoshi Iida, Kiyoshi Kogure, Kei Yoshimoto and Teruaki Aizawa:
"An Experimental Spoken Natural Dialogue Translation System Using a Lexicon-Driven Grammar",
European Conference on Speech Technology and Communication 89(1989-9) - - - (134).

[Kogure 89-9] Kiyoshi Kogure, Hitoshi Iida, Kei Yoshimoto and Teruaki Aizawa:
「対話の自動翻訳手法」
"A New Paradigm of Dialogue Translation",
Computer World 89 in Osaka (1989-9) - - - (138).

[Ogura 89-10] Kentaro Ogura, Kazuo Hashimoto and Tsuyoshi Morimoto:
"Object-Oriented User Interface for a Linguistic Database",
A Working Conference on Data and Knowledge Base Integration (1989-10) - - - (146).

[Dosaka 89-10-1] Koji Dosaka:
「対話参加者の心的状態に関する制約に基づく発話解釈モデル」
"Utterance Interpretation Based on Constraints on Dialogue Participants' Mental States."
Journal of Computer Software, Vol.6, No.4, Japanese Society of Software Science (1989-10) - - - (161).

[Ehara 89-10] Terumasa Ehara:
「商用機械翻訳システムの現状」
"Present State of Commercial Machine Translation System in Japan",
Seminer of IEICE (1989-10) - - - (174).

[Iida 89-10-1] Hitoshi Iida and Teruaki Aizawa:
「意図の理解」
"Understanding Intentions", IPSJ Jornal of Information Processing,Vol.30, No.10 (1989-10) - - - (182).

[Iida 89-10-2]Hitoshi Iida:
「通訳電話のための機械翻訳技術」
"The Art of Machine Translation for an Interpreting Telephone"
Seminer of IEICE(1989-10) - - - (190).

[Kakigahara 89-10-1] Koji Kakigahara and Tsuyoshi Morimoto:
「文節間の係り受け関係を用いた文節候補選択手法」
"A Method of Bunsetsu Candidates Selection Using Kakari-uke Semantic Relationship",
ASJ Fall Meeting (1989-10) - - - (198).

[Morimoto 89-10] Tsuyoshi Morimoto, Kentaro Ogura, Teruaki Aizawa and Akira Kurematsu:
「音声言語日英翻訳実験システム(SL-TRANS)の概要」
"Outline of an Experimental Spoken Language Translation System from Japanese to English",
IPSJ Fall Meeting, 4G-4 (1989-10) - - - (200).

[Kita 89-10] Kenji Kita, Toshiya Sakano, Junko Hosaka and Takeshi Kawabata:
「SL-TRANSにおける文節音声認識–HMM音韻認識とLR構文解析法による文節音声認識」
"Speech Recognition Method in SL-TRANS",
IPSJ Fall Meeting, 4G-5(1989-10) - - - (202).

[Kakigahara 89-10-2] Koji Kakigahara and Tsuyoshi Morimoto:
「SL-TRANSにおける文節候補の削減–係り受け関係を用いた文節候補選択」
"Reducing the Number of Candidates in SL-TRANS",
IPSJ Fall Meeting (1989-10) - - - (204).

[Hosaka 89-10] Junko Hosaka and Tsuyoshi Morimoto:
「文節間の連鎖制約を取り入れたHMM-LRの音声認識実験」
"Speech Recognition with ordering constraint of bunsetsu",
IPSJ Fall Meeting, 7E-4(1989-10) - - - (206).

[Sakano 89-10] Toshiya Sakano, Kenji Kita and Tsuyoshi Morimoto:
「音声認識候補の正規化認識確率に関する考察」
"A Study of Normalized Probabilities for Speech Recognition Candidates",
IPSJ Fall Meeting, 7E-3(1989-10) - - - (208).

[Inoue 89-10] Naomi Inoue, Tsuyoshi Morimoto and Kentaro Ogura:
「連想型知識ベースの推論方式」
"The Inference Method of the Associative Knowledge Base",
IPSJ Fall Meeting(1989-10) - - - (210).

[Kume 89-10] Masako Kume and Kiyoshi Kogure:
「発話意図の翻訳のための発話行為推論部」
"Inference Mechanism of Illocutionary Force Types for MT Systems"
IPSJ Fall Meeting, 3F-5(1989-10) - - - (212).

[Dosaka 89-10-2] Koji Dosaka and Kiyosi Kogure:
「対話参加者に関するゼロ代名詞の同定」
"Identifying Japanese Zero-Pronouns Referring to Dialogue Participants"
IPSJ Fall Meeting, 5F-5(1989-10) - - - (214).

[Iida 89-10-3] Hitoshi Iida, Toshirou Hasegawa, Yoshihiro Ueda and Teruaki Aizawa :
「SL-TRANS における変換.生成手法」
"Transfer and Generation Method in SL-TRANS "
IPSJ Fall Meeting, 4G-8(1989-10) - - - (216).

[Sumita 89-10] Eiichiro Sumita:
「用例に基づく音声認識の絞り込み」
"Disambiguation of Speech Recognizer Output based on Examples"
IPSJ Fall Meeting, 7E-6(1989-10) - - - (218).

List of ATR Technical Reports
of the
Natural Language Understanding Department
and the
Knowledge and Data Base Department

Feb. 1989 *through* Oct. 1989

Number	Title	Author(s)	Date
TR-I-0067	対話翻訳のための階層型プラン認識モデル Tri-Layered Plan Recognition Model for Dialogue Machine Translation	Hidekazu Arita Hitoshi Iida	1989-2
TR-I-0068	目標指向型対話におけるドメイン知識の調査 Extracting Domain Knowledge from Goal Oriented Dialogues	Hidekazu Arita	1989-2
TR-I-0070	Research Activities of the Natural Language Understanding Department and the Knowledge and Data Base Department for 1988	Teruaki Aizawa Tsuyoshi Morimoto	1989-2
TR-I-0071	A Rewriting System for Typed Feature Structures	Martin Emele Rèmi Zajac	1989-3
TR-I-0074	The ATMS Manual Version 1.1	John K.Myers	1989-2
TR-I-0075	Politeness Strategies in American English Telephone Dialogues	Gayle K.Sato	1989-3
TR-I-0077	形態素情報利用解説書 (兼作業マニュアル) User's Manual for Morpheme Information	Naoko Shinozaki Yasuko Mizuno Kentaro Ogura Kei Yoshimoto	1989-3
TR-I-0080	否定文の理解に関する研究 A Study on the Understanding of Negative Sentences	Tadasu Hattori	1989-3

Number	Title	Author(s)	Date
TR-I-0082	HMM音韻認識と拡張LR構文解析法を用いた連続音声認識 **HMM Continuous Speech Recognition Using Generalized LR Parsing**	Kenji Kita Takeshi kawabata Hiroaki Saito	1989-6
TR-I-0083	対話参加者の心的状態に関する制約に基ずく発話解釈モデル **Utterance Interpretation based on Constraints on Dialogue Participants' Mental States**	Kohji Dohsaka	1989-5
TR-I-0093	素性構造書き換えシステムマニュアル **The Feature Structure Rewriting System Manual**	Toshiro Hasegawa	1989-8
TR-I-0094	対話における名詞句の同一性の理解とその応用 **Noun Phrase Identification in Dialogue and its Applications**	Izuru Nogaito Hitoshi Iida	1989-8
TR-I-0102	音声言語日英翻訳実験システム(SL-TRANS) **Spoken Language Translation Experimental System from Japanese to English**	Kentaro Ogura Toshiya Sakano Junko Hosaka Tsuyoshi Morimoto	1989-8
TR-I-0104	結合価情報を用いた誤認識単語の推定手法 **Inferring the omitted Words Using Valency Patterns**	Koji Kakigahara Teruaki Aizawa	1989-8
TR-I-0105	単語間の連接確率を用いた付属語列の生成実験 **Generating the Function Words Using the Probability of Bigram Model**	Koji Kakigahara	1989-8
TR-I-0109	係り受け関係を用いた文節候補選択処理 **Selecting the Phrase Candidates Using Dependency Relationship**	Koji Kakigahara Tsuyoshi Morimoto	1989-9
TR-I-0110	SL-TRANSにおける、文節候補選択処理、問合せ処理 **Selecting the Phrase Candidates in SL-TRANS**	Koji Kakigahara Noriyuki Okeya Masaaki Izumi	1989-9

Number	Title	Author(s)	Date
TR-I-0111	文節候補選択処理のための係り受けデータ **Dependency Relationship[Database for Selecting the Phrase Candidates**	Koji Kakigahara Masaaki Izumi	1989-9
TR-I-0114	**Multiple Inheritance in RETIF**	Martin Emele Rémi Zajac	1989-9
TR-I-0117	対話登場人物を指示する日本語ゼロ代名詞の同定 **Identifying Zero-Pronouns Referring to Persons in Japanese Dialogue**	Kohji Dohsaka	1989-10
TR-I-0121	日英機械翻訳システムにおける生成文の評価 **Evaluation of the Output in Japanese to English MT System**	Mutsuko Tomokiyo Kentaro Ogura Terumasa Ehara	1989-10