TR-I-0070

Research Activities
of the
Natural Language Understanding Department
and the
Knowledge and Data Base Department
for 1988

ATR Interpreting Telephony Research Laboratories

February 28, 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 for 1988.

The current research areas of the Natural Language Understanding Department include:
(1) Dialogue Modeling
  · Identifying Zero Pronouns in Japanese Dialogue
  · Functional Analysis of Intention
  · Parsing Japanese Honorifics
  · Disambiguating Japanese Negative Sentences
  · Politeness Strategies in American English Telephone Dialogues
  · Phrase Structure Grammar for Japanese Dialogue Analysis
(2) Mechanisms for Dialogue Comprehension
  · Plan Recognition Model for Dialogue Understanding
  · Context Processing Based on Situation Theory
  · Noun Phrase Identification in Dialogue
  · Inference Mechanisms for Dialogue Understanding
  · Dialogue Meaning Processing
(3) Dialogue Translation Method
  · Analysis of Japanese Dialogue
  · Transfer of Japanese Dialogue into English
  · Generation of English Dialogue
  · Typed Feature Structures and Rewriting Systems
  · User Interface for Processing Feature Structures

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
  · Inferring the omitted words Using Valency patterns
  · Reducing the number of candidates using the KAKARI-UKE semantic relationship

(5) Knowledge Base
  · Defining Knowledge Base

· Inference on the Knowledge Base
· Application to Speech and Language Processing Integration
(6) Linguistic Database
· Construction of Linguistic Database
· Linguistic Database Management System

Table of Contents

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

1
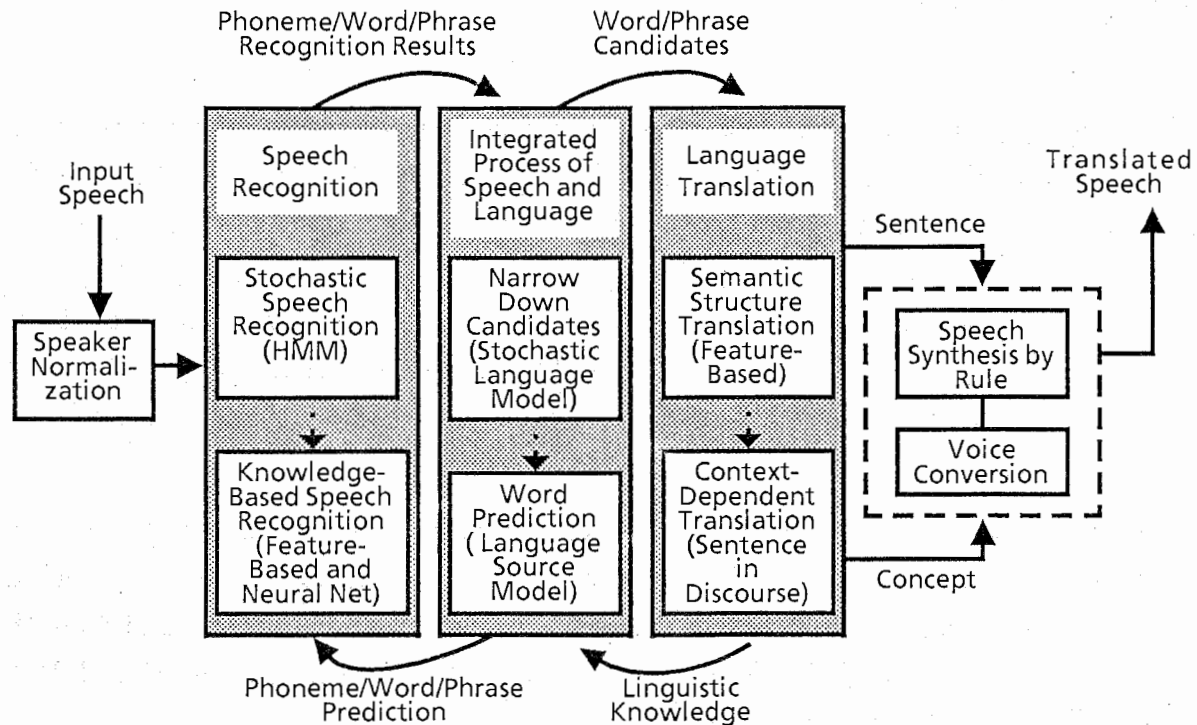
Figure 1. Proposed Automatic Telephone Interpretation System.

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* reserch group is working on developing a continuous speech recognition mechanism and a sifting mechanism, and defining some linguistic rules for their use.

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, considerable 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 1988 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 Identifying Zero Pronouns in Japanese Dialogue [Yoshimoto]

An approach was proposed to automatically analyze Japanese dialogue containing zero pronouns (i.e. omitted obligatory case NPs). The key idea is *topic*. It has been shown that mainly non-human zero pronouns can be identified by means of topic, and, to do so, a discourse structure on the basis of recursively appearing topic is formalized. Other zero pronouns, mainly human ones, are identified using cognitive and sociolinguistic information conveyed by honorific, deictic, and speech-act predicates. These are integrated into the model. An intrasentential treatment of Japanese topic has been proposed on the basis of a HPSG and JPSG.

Technical Publications: [Yoshimoto 88-3][Yoshimoto 88-8]

2.1.2 Functional Analysis of Intention [Kume, Sato]

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). Based on speech act theory, IFTs are classified into 8 types for our sample dialogues composed of various inquiries about an international conference. In Japanese, IFTs are conveyed mainly by certain combinations of kernel verbs, auxiliaries, and sentence-final particles. A basic method of extracting IFTs from a surface utterance is also being studied. As for the DPs, four types are introduced for analyzing both interpersonal relations and intentions, and converting these aspects in the source language into appropriate expressions in the target language. Certain relationships between IFTs and DPs were shown for the sample dialogues.

Technical Publications: [Kume 88-3][Kume 88-9][An application to dialogue translation will be presented at the ACL European Chapter '89]

2.1.3 Parsing Japanese Honorifics [Maeda]

A unification-based approach to Japanese honorifics was proposed. Japanese has a rich grammaticalized system of honorifics to express the speaker's honorific attitudes toward discourse agents. Basic honorific attitude types are defined for specifying pragmatic constraints on the use of Japanese honorifics. A range of honorifics are classified into subtypes from a morphological and syntactico-semantic perspective. Utterance parsing is based on the lexical specifications of a range of honorifics. It is shown that the possible word orders of Japanese honorific predicate constituents can be automatically deduced in the proposed framework without independently specifying them.

Technical Publications: [Maeda 88-3][Maeda 88-6]

2.1.4 Disambiguating Japanese Negative Sentences [Hattori]

A syntactic and pragmatic approach to deciding the preferred interpretations of Japanese negative sentences has been studied. Japanese, like most languages, shows ambiguity in the scope of negation, though the range of preferred interpretations is constrained by such factors as appearance/nonappearance and the position of the contrastive particle '*wa*', the surface order of complement/adjuncts, and so on. These are formalized on the basis of an HPSG with enriched semantic features, and a special feature, ELEMENT-STORE. After the feature structure for the whole sentence is determined, a heuristic

procedure yields the likely negation scopings.

Technical Publications: [Hattori 88-12]

2.1.5 Politeness Strategies in American English Telephone Dialogues
[Sato]

To contribute towards the translation of intentions from Japanese into English, a study of politeness strategies in American telephone dialogues was conducted. A data base of telephone conversations was first constructed and then described from a socio-linguistic viewpoint. In particular, attention is paid to the difference between respect and friendliness as main components of politeness in American speech, since in Japanese speech friendliness is not considered part of politeness whereas in American English it is an integral part.

Twelve kinds of dialogues were constructed: (1) starting a request, (2) maintaining a request, (3) ending a request, (4) requesting a meeting, (5) making and confirming reservations, (6) making and changing appointments, (7) calling a taxi, (8) placing an order, (9) having something sent, (10) leaving and following up a message, (11) inviting, and (12) asking directions. When these dialogues were analyzed, *eight politeness strategies* were identified: (1) degree of politeness, (2) use of "please", (3) use of "may/could/would", (4) orienting the receiver, (5) softening requests, (6) connecting a series of requests, (7) ending a request dialogue, and (8) friendliness. Friendliness subclassified into informality, intimacy, sharing of information, and display of personality.

These politeness strategies have been applied to the definition of "Decision Parameters" (see **2.1.2**).

2.1.6 Phrase Structure Grammar for Japanese Dialogue Analysis
[Yoshimoto, Kogure]

On the basis of HPSG and its Japanese version JPSG, a grammar has been built up to deal with Japanese inter-keyboard conversation that has the same fundamental features as spoken utterances. It emphasizes the treatment of complex predicates that are the most important in analyzing Japanese spoken-style conversation , which abunds with omitted subjects and objects.

In a Japanese predicate phrase the head stipulates the part of speech, modal category, conjugational type, and conjugational form of the complement occurring on its left. This is dealt with effectively by using the SUBCAT feature. The feature MODL is added to specify the sixteen different modal categories the complement can belong to. However, Japanese predicate phrase is so complex that a lexical description is often necessary for a complement that can pose conditions on its own head. Since this can never be managed by SUBCAT, a new feature COH(< constraint on head) was added. This presents a sharp contrast

with the original version of HPSG.

Another important characteristic of our grammar is its production of pragmatic information for the sentence. This is dealt with by specifying the PRAG($<$ pragmatics) feature in each honorific or deictic lexical item.

Technical Publications: [Yoshimoto 88-9a][Yoshimoto 88-9b]

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 [Arita, Iida]

A plan recognition model (T-plan model; Tri-Layered 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. Three kinds of plans are used: *domain plans*, which represent the structure of the dialogue topics; *discourse plans*, which manage the global change of topics; 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: [Arita 88-3][Iida 88-7b][Arita 88-9][Iida 89-1]

2.2.2 Context Processing Based on Situation Theory [Dohsaka]

A computational model for context processing was proposed to resolve ellipses in utterances in a task-oriented dialogue. Context in this model is defined as dialogue participants' mental states, or more precisely, as mutual beliefs and

shared goals between dialogue participants. The inference method uses constraints on mental states and domain events, and derives information from the context. The constraints and the derived context information are represented in terms of Situation Theory. Context information, i.e. dialogue participants' mental states, is described as conditions on three mental states: the mutual belief situation, the task-oriented shared goal situation, and the communicative shared goal situation. The inference method, based on the deviation of condition with constraints, follows the Minimum Assumption Principle. It has the advantage of integrating the recognition process and the prediction process for ellipsis resolution into a uniform framework.

Technical Publications: [Dohsaka 88-9]

2.2.3 Noun Phrase Identification in Dialogue [Nogaito]

Different words are often used in dialogue to indicate the same thing/concept. A way to identify differently expressed noun phrases on the basis of domain knowledge has been investigated as the first step toward a general mechanism for dialogue meaning inference.

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 88-3][Nogaito 88-6]

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, *"I don't know how to register."* cannot be followed by *"Please try harder."*; this helps plans to be recognized.

Technical Publications: [Kudo 88-9]

2.2.5 Dialogue Meaning Processing [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 contextual meaning understanding model for natural dialogue under a direct memory access paradigm was proposed to resolve disambiguations with handling higher contextual restriction. The model integrates all knowledge used on each processing level from words to speaker's plan-goals into a uniform memory model, and incorporates the plan hierarchies of two dialogue participants. Four processing levels are introduced; Lexicon, Concept, Concept-Sequence, and Plan-Hierarchy. This enables the system to construct a memory state at a given point of a dialogue and make predictions about subsequent utterances by utilizing Concept-Sequence and Plan-Hierarchy knowledge. The technique used is a massively parallel marker passing.

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 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.

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

In our translation method, the basic object to be translated is a communicative

act representation. This representation consists of illocutionary force structures that mainly represent relationships which are not primitive but language independent such as Request, Promise and so on, and proposition structures that represent language dependent relationships. The analysis process then consists of 1) extraction of the surface communicative act representation from an input utterance, and 2) extraction of a representation with language independent illocutionary force structures. The former uses a typed-feature-structure-based lexico-syntactic approach and the latter uses plan recognition inference.

The analysis system for obtaining surface communicative act representations consists of Japanese grammatical descriptions such as general syntactic rules and lexical items, a rule reader and a unification-based parser. Section **2.1.6** above gives an outline of our grammar formalism. The rule reader compiles source descriptions into CFG rules with feature structures representing equations. The parser is based on an active chart parsing algorithm with rule application control. One of the important characteristics of the feature structure unification algorithm is that it allows unification of looped structures, which are necessitated by our grammar having both SUBCAT and COH features.

As of December 1988, the parser on a Symbolics Lisp machine can output a surface communicative act representation for a typical Japanese dialogue sentence within 20 seconds. The bulk of the time is consumed on unification operations. In order to improve the processing time, a parallel parsing technique is now being studied.

Technical Publications: [Kogure 88-3][Kato 88-3][Kogure 88-6]

2.3.2 Transfer of Japanese Dialogue into English [Hasegawa, Nogaito]

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 is now being implemented. It has various parameters to control the transfer process flexibly.

2.3.3 Generation of English Dialogue [Ueda]

The bi-directional use of a grammar/lexicon is one of the most favorable features of our generation system. An experimental system to test the bi-directionality is now being implemented.

The input to the system is a part of the feature structure which may be

obtained by analyzing and transferring a sentence. A bi-directional grammar was built from an existing analysis grammar as a set of CFG rewriting rules with unification specifications. The generation process proceeds by top-down extension of the phrase structure using the CFG rewriting rules in the reverse direction. Each rule has a kind of meta-description called an *assertion* which enables the system to efficiently select an appropriate rule to develop the phrase structure. The surface sentence can be obtained by collecting the terminal nodes in the final phrase structure.

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

A new and uniform model for transfer and generation in machine translation was proposed using a rewriting system for typed feature structures, based on the formal semantics developed by Aït-Kaci (1984). The first version of the rewriting system has been 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. The specifications include definitions about equality of abstract speech act types, manner, and pragmatic features; definitions relating syntactic features; and lexical definitions relating predicate-argument structures. For the lexical part, the type system describes a hierarchy of concepts, where a sub-concept inherits all of the properties of its super-concepts. Due to the logical properties of the rewriting formalism, the transfer grammar is reversible, and can even generate all possible transfer pairs given the initial symbol with no more information.

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.

Another type system for feature structures, different from that of Aït-Kaci, has been developed in terms of an initial algebra theory of abstract data types. This system has essentially two kinds of feature structures: atomic and complex types. Operations on atomic types enable us to reduce computational cost. An Earley-like parser using this system has been implemented to demonstrate the effectiveness of this system.

Technical Publications: [Zajac 88-9][Nicolas 88-9][The transfer model will be presented at ACL'89]

2.3.5 User Interface for Processing Feature Structures [Itsumi]

A user interface which can help build and revise the experimental inter-keyboard dialogue translation system is now being developed. The current main interest is developing an effective method for displaying and manipulating a variety of feature structures in unification-based grammars. A new method to determine a special layout of feature structures (more generally, labeled directed acyclic graphs) was developed. Effectiveness of this method has been examined for debugging lexical descriptions.

Technical Publications: [Itsumi 88-7][Itsumi 88-8]

2.4 Integration of Speech and Language Processing

The Integration of Speech and Language Processing reserch group is working on developing a continuous speech recognition mechanism and a sifting mechanism, and defining some linguistic rules for their use.

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

A continuous speech recognition mechanism which combined the HMM and Generalized LR-parsing (proposed by Tomita,1986) methods was proposed. This method is calld as HMM-LR. At present as an intermediate step, the HMM-LR can only deal with those utterances made phrase (Japanese BUNSETSU) by phrase. As a language model for BUNSETSUs, their syntax grammar is defined, compiled and converted in advance as an LR-table. For input phoneme data, the next phonemes that will probably be uttered are predicted by looking at the LR-table, then verified by using the HMM. The probability is calculated for each phoneme string and only those with high scores are kept (that is "beam search"). All phoneme strings are syntactically correct because the grammar is used for phoneme verification. Phrase recognition rates currently attained, in speaker dependent cases, is 72% for the top candidate and 95% for the best five candidates.

Technical Publications: [Kita 88-10-1] [Kita 88-10-2]

2.4.2 Inferring the Omitted Words Using Valency Patterns
[KAKIGAHARA]

In general, the speech recognition system has tendency to misrecognize the ending part of phrases and sentences. The method of inferring function words

(Japanese FUZOKUGO) such as postpositional particles or auxiliary verbs from content words (Japanese JIRITSUGO) such as nouns or verbs, and the method of inferring a correct verb when verbs are recognized less accurately than nouns have been studied. Both of these methods use basically the valency patterns obtained from collected dialogue sentences in a restricted task domain.

Technical Publications: [Kakigahara 88-3b] [Kakigahara 88-3b]

   [Kakigahara 88-8] [Kakigahara 88-9]

2.4.3 Reducing the Number of Candidates Using the KAKARI-UKE Semantic Relationship   [KAKIGAHARA]

The method which reduces the number of the candidates from the HMM-LR is being studied. In this method, the Japanese KAKARI-UKE relationship is used. This relationship is a kind of semantic relationship between two BUNSETSUs (strictly speaking, between pairs of independent words, one from each 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 KAKARI-UKE relationship and its frequency for two BUNSETSUs are extracted. Using this information, only probable BUNSETSU candidates are selected from the HMM-LR output. Preliminary experiments indicated the usefulness of this method; the number of candidates was reduced to less than one-third the number of raw candidates.

2.5 Knowledge Base

The Knowledge Base reserch group is trying to define the semantic relationship between words, and applying it to reduce the number of candidates. 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 Knowledge Base   [INOUE, GEDDIS]

The KAKARI-UKE 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, can be regarded as a kind of word 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.

Technical Publications: [Inoue 88-9]

2.5.2 Inference on the Knowledge Base [INOUE]

The inference mechanism developed is based on the spreading activation.When one node becomes active, it spreads the activation through the links to other nodes. Activation strength is calculated according to the input strength and weight on the link.

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 (iteration of) inference, only those which have a mutual relationship remain active. Some experiments have been done and refinement of the inference algorithm or knowledge base itself is now being carried on. In next step, we are planing to combine the "domain plan" to this knowledge base to enhance inference ability.

Technical Publications: [Inoue 88-12]

2.6 Linguistic Database

The Linguistic Database reserch group is engaged in constructing a Japanese spoken language text database. To enhance the usefulness of this database, considerable 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 [OGURA, SHINOZAKI, INOUE]

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". A specific domain, an international conference registration domain, was selected and conversational texts over it have been gathered through simulation with keyboard or telephone. Gathered texts were analyzed and much

information added. This information is "word information" such as part of speech, "KAKARI-UKE semantic relationship", or "corresponding translated English" etc..

Technical Publications: [Morimoto 88-3] [Shinozaki 88-3] [Ogura 88-3]

[Inoue 88-3] [Shinozaki 88-9] [Inoue 88-9]

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 KAKARI-UKE relationship between these BUNSETSUs 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. This system constitutes a vertically distributed system. A workstation (Lisp machine) on a user site is connected to the central processor, and data on it is defined in an object oriented data structure. Object oriented data structure is suitable for defining logical relationship between data (such as, as mentioned above, compositional relationship between words and a BUNSETSU, the semantic relationship between two BUNSETSUs, and so on), and to access them based on these logical relationships. When a user wants to retrieve certain data, the corresponding portion of the relational database is read, transferred to the workstation, and converted into object oriented data structure automatically. For an expert user, direct access to the RDB is also supported.

Technical Publications: [Ogura 88-9] [Hashimoto 88-9] [Ogura 88-12]

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 1988.

Natural Language Understanding Department

Name	Position	Home company	Period
Teruaki Aizawa	Department Head	NHK	April, 1986 ~
Hitoshi Iida	Senior Researcher	NTT	April, 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	April, 1986 ~
Yoshihiro Ueda	Researcher	Xerox	Mar., 1988 ~
Susumu Kato	Engineer	Nihon Symbolics	April, 1987 ~
Ikuo Kudo	Researcher	CSK	April, 1987 ~
Hiroyuki Maeda	Researcher	Sharp	Sep., 1986 ~ Aug., 1988
Koji Dohsaka	Researcher	NTT	Mar., 1988 ~
Toshiro Hasegawa	Researcher	CSK	Nov., 1987 ~
Ken-ichi Itsumi	Researcher	CSK	Sep., 1986 ~ Aug., 1988
Rémi Zajac	Invited Researcher	GETA, France	Mar., 1988 ~
Christian Boitet	Invited Researcher	GETA, France	April~July., 1988
Gayle K. Sato	Invited Researcher	Hawaii-Manoa Univ.	April, 1988 ~
Tadasu Hattori	Invited Researcher	Kyoto Univ.	May, 1988 ~
John K. Myers	Invited Researcher		Sep., 1988 ~
Martin C. Emele	Invited Researcher	Stuttgart Univ.	Sep., 1988 ~
Yves Nicolas	Intern student	ENST, France	April~Nov., 1988

Knowledge and Data Base Department

Name	Position	Home company	Period
Tsuyoshi Morimoto	Department Head	NTT	March, 1987 ~
Kentaro Ogura	Researcher	NTT	Sep., 1986 ~
Koji Kakigahara	Researcher	Matsushita	Oct., 1986 ~
Kenzi Kita	Researcher	Oki	Sep., 1987 ~
Naomi Inoue	Researcher	KDD	Aug., 1987 ~

Kazuo Hashimoto	Researcher	Osaka Gas	Sep., 1987 ~
Toshiya Sakano	Researcher	Sharp	Sep., 1988 ~
Zyunko Hosaka	Invited Researcher	Stuttgart Univ.	Sep., 1988 ~
Naoko Shinozaki	Engineer	TIS	Sep., 1986 ~
Donald Geddis	Intern student	Stanford Univ	July~Sept., 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 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 Lispand 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 1988

General Form

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

[Iida 88-3] Hitoshi Iida, Kiyoshi Kogure, Izuru Nogaito, Hidekazu Arita, and
(28)   Teruaki Aizawa:
        「端末間対話通訳の実験システムの構成」
        "An Experimental Machine Interpretation System for Inter-
        Keyboard Dialogues",
        IPSJ Spring Meeting, 1U-1 (1988-3).

[Kato 88-3] Susumu Kato and Kiyoshi Kogure:
(30)   「素性構造の単一化アルゴリズムの評価」
        "Evaluation of Feature Structure Unification Algorithm",
        ISPJ Spring Meeting, 2T-5 (1988-3).

[Kogure 88-3] Kiyoshi Kogure, Masako Kume, Hiroyuki Maeda, and
(32)   Hitoshi Iida:
        「対話翻訳のための日本語発話の理解」
        A Method of Understanding Japanese Utterances for Dialogue
        Translation",
        IPSJ Spring Meeting, 3T-4 (1988-3).

[Nogaito 88-3] Izuru Nogaito, Hitoshi Iida:
(34)   「対話における名詞句の同一性の理解」
        "A Method of Semantic Identification for Noun Phrases in Dialogs",
        IPSJ Spring Meeting, 3T-7 (1988-9).

[Yoshimoto 88-3] Kei Yoshimoto:
(36)   「日本語談話中のゼロ代名詞の同定」
        "Identification of Zero Pronouns in Japanese Discourse",
        IPSJ Spring Meeting, 3T-8 (1988-3).

[Kume 88-3] Masako Kume, Kiyoshi Kogure, Hiroyuki Maeda, and
(38)   Hitoshi Iida:
        「日本語対話文における発話意図の解析の方法」
        "Analysis of Speech Act Type in Japanese Dialogue",
        IPSJ Spring Meeting, 3T-9 (1988-3).

[Maeda 88-3] Hiroyuki Maeda, Kiyoshi Kogure, Masako Kume, and
(40)   Hitoshi Iida:
「日本語対話文における敬語表現の解析」
"Analyzing Honorific Expressions in Japanese Dialogues",
IPSJ Spring Meeting, 3T-10 (1988-3).

[Arita 88-3] Hidekazu Arita and Hitoshi Iida:
(42)   「プラン・レコグニション・モデルを用いた対話構造の構築」
"Construction of a Discouse Structure Using a Plan Recognition Model",
IPSJ Spring Meeting, 5T-3 (1988-3).

[Kakigahara 88-3a] Koji Kakigahara and Teruaki Aizawa:
(44)   「自立語列からの対話文生成 -- 対話文音声認識への応用 --」
"Generating a Whole Sentence by Use of Contents Words -- Application to Speech Recognition in Dialogues --",
IPSJ Spring Meeting, 1T-2 (1988-3).

[Kakigahara 88-3b] Koji Kakigahara and Teruaki Aizawa:
(46)   「対話文音声認識における言語情報の適用」
"Application of Lingustic Information to Speech Recognition in Spoken Dialogue",
IEICE Spring Meeting (1988-3).

[Shinozaki 88-3] Naoko Shinozaki, Kentaro Ogura, and Tsuyoshi Morimoto:
(48)   「言語データベースの品質管理」
"Quality Control for Linguistic Database",
IPSJ Spring Meeting, 4U-3 (1988-3).

[Ogura 88-3] Kentaro Ogura, Naoko Shinozaki, and Tsuyoshi Morimoto:
(50)   「言語データベース収集支援システム」
"Tools for linguistic data compilation",
IPSJ Spring Meeting, 4U-4 (1988-3).

[Morimoto 88-3] Tsuyoshi Morimoto, Kentaro Ogura, and Hitoshi Iida:
(52)   「自動翻訳電話研究用言語データベースの収集について」
"Constructing Linguistic Database for Automatic Telephone Interpreting Research",
IPSJ Spring Meeting, 4U-5 (1988-3).

[Inoue 88-3] Naomi Inoue, Kentaro Ogura, and Tsuyoshi Morimoto:
(54)   「係り受け意味関係の問題点とその考察」
"The Problems of Semantics Relation and the consideration",
WGNLC Meeting of IEICE, NLC87-25 (1988-3).

[Boitet 88-6] Christian Boitet:
(61)   "Hybrid PIVOTS Using m-Structures for Multilingual Transfer-Based MT Systems",
IEIEC Technical Report, NLC88-3 (1988-6).

[Maeda 88-6] Hiroyuki Maeda, Susumu Kato, Kiyoshi Kogure, and
(67)   Hitoshi Iida:
            "Parsing Japanese Honorifics in Unification-Based Grammars",
            26th Annual Meeting of the ACL (1988-6).

[Kogure 88-6] Kiyoshi Kogure, Hitoshi Iida, Kei Yoshimoto, Hiroyuki Maeda,
(75)   Masako Kume, and, Susumu Kato:
            "A Method of Analyzing Japanese Speech Act Types",
            2nd International Conference on Theoretical and Methodological
            Issues in Machine Translation of Natural Languages (1988-6).

[Nogaito 88-6] Izuru Nogaito and Hitoshi Iida:
(87)   "Noun Phrase Identification in Dialogue and its Application",
            2nd International Conference on Theoretical and Methodological
            Issues in Machine Translation of Natural Languages (1988-6).

[Iida 88-7a] Hitoshi Iida:
(98)   「自然言語対話の言語運用特性と対話処理の研究課題」
            "Pragmatic Characteristics of Natural Spoken Dialogues and
            Dialogue Processing Issues",
            Journal of JSAI, Vol. 3, No. 4 (1988-7).

[Iida 88-7b] Hitoshi Iida and Hidekazu Arita:
(106)   「対話理解のためのプラン認識モデル」
            "Plan recognition model for dialogue understanding",
            2nd Annual Meeting of JSAI, 9-4 (1988-7).

[Itsumi 88-7] Ken-ichi Itsumi and Kiyoshi Kogure:
(110)   「素性構造の単一化過程の視角化手法」
            "How to Represent Feature Structure Unification Process",
            WGNL Meeting of IPSJ 67-1 (1988-7).

[Itsumi 88-8] Ken-ichi Itsumi and Kiyoshi Kogure:
(118)   「グラフ構造の視角化手法」
            "How to Represent Graph Structures",
            14th Meeting of System Symposium (1988-8).

[Yoshimoto 88-8] Kei Yoshimoto:
(124)   "Identifying Zero Pronouns in Japanese Dialogue",
            12th International Conference on Computational Linguistics
            (COLING '88) (1988-8).

[Kakigahara 88-8] Koji Kakigahara and Teruaki Aizawa:
(130)   "Completion of Japanese Sentences by Inferring Function Words
            from Content Words",
            12th International Conference on Computational Linguistics
            (COLING '88) (1988-8).

[Kudo 88-8] Ikuo Kudo,Hideya Koshino (CSK Research Institute),
(136)   Moonkyung Chung (CSK Research Institute), and Tsuyoshi Morimoto:
    "Schema Method: A Framework for Correcting Grammatically Ill-formed Input",
    12th International Conference on Computational Linguistics (COLING '88) (1988-8).

[Kakigahara 88-9] Koji Kakigahara and Teruaki Aizawa:
(143)   「名詞列からの述語推定 -- 対話文音声認識への応用 --」
    "Inferring a Predicate fron Nouns -- Application to Speech Recognition in Dialogues --",
    IPSJ Fall Meeting, 3C-3 (1988-9).

[Kume 88-9] Masako Kume, Hiroyuki Maeda, and Kei Yoshimoto:
(145)   「発話の力のタイプの機械翻訳への利用」
    "Utilization of Illocutionary Force Types for Machine Translation",
    IPSJ Fall Meeting, 4B-4 (1988-9).

[Zajac 88-9] Rémi Zajac:
(147)   "Feature Structures as Hierarchical Sets",
    IPSJ Fall Meeting, 5C-4 (1988-9).

[Yoshimoto 88-9a] Kei Yoshimoto and Kiyoshi Kogure:
(149)   「日本語端末間対話解析のための句構造文法」
    "Phrase Structure Grammar for Inter-Terminal Dialog Analysis",
    IPSJ Fall Meeting, 5C-5 (1988-9).

[Kudo 88-9] Ikuo Kudo and Tsuyoshi Morimoto:
(151)   「対話における Assumption の役割」
    "The Role of an Assumption in Dialogue",
    IPSJ Fall Meeting, 6C-3 (1988-9).

[Arita 88-9] Hidekazu Arita and Hitoshi Iida:
(153)   「目標指向型対話における次発話の予測」
    "Prediction of the Next Utterance in a Task-Oriented Dialogue",
    IPSJ Fall Meeting, 6C-4 (1988-9).

[Dohsaka 88-9] Kohji Dohsaka and Hitoshi Iida:
(155)   「対話における意図構造の表現の枠組み」
    "On intentional structure in task-oriented dialogue",
    IPSJ Fall Meeting, 6C-5 (1988-9).

[Yoshimoto 88-9b] Kei Yoshimoto:
(157)   「日本語対話文解析の句構造文法」
    "Phrase Structure Grammar for Japanese Dialogue Analysis",
    Mathematical Linguistic Society of Japan (1988-9).

[Shinozaki 88-9] Naoko Shinozaki, Kentaro Ogura, and Tsuyoshi Morimoto:
(158) 「言語データベース作成のためのシミュレーション会話会話 -- データのリアリティ改善 --」
"Simulating Conversations for Linguistic Database"
IPSJ Fall Meeting (1988-9).

[Ogura 88-9] Kentaro Ogura, Kazuo Hashimoto, and Tsuyoshi Morimoto:
(160) 「言語データベース統合管理システム」
"An Integrated Linguistic Database Management System",
IPSJ Fall Meeting, 5B-6 (1988-9).

[Kita 88-9] Kenji Kita and Tsuyoshi Morimoto:
(162) 「テキスト・データベースからの慣用表現の自動抽出」
"Automatic Idiom Extraction from Text Database",
IPSJ Fall Meeting, 7B-6 (1988-9).

[Hashimoto 88-9] Kazuo Hashimoto, Kentaro Ogura, and Tsuyoshi Morimoto:
(164) 「言語データベース統合管理システムのマンマシンインタフェース」
"A Man-Machine Interface for an Integrated Linguistic Database Management System",
IPSJ Fall Meeting (1988-9).

[Inoue 88-9] Naomi Inoue, Kentaro Ogura, and Tsuyoshi Morimoto:
(166) 「言語データベース用単語間の関係データ」
"Semantics and Syntactics Relations described in the Integrated Linguistic Database",
IPSJ Fall Meeting (1988-9).

[Kogure 88-10] Kiyoshi Kogure:
(168) 「解析過程の制御を考慮した句構造文法解析機構」
"A Unification-Based Phrase Structure Grammar Parser with Rule Application Control",
IEICE Technical Report, NLC88-7 (1988-10).

[Nicolas 88-10] Yves Nicolas:
(176) "Pragmatic Extensions to Unification-Based Formalisms",
IEICE Technical Report, NLC88-8 (1988-10).

[Kita 88-10-1] Kenji Kita, Takeshi Kawabata, and Hiroaki Saito:
(183) 「HMM音韻認識と予測LRパーザを用いた文節認識」
"HMM Continuous Speech Recognition Using Predictive LR Parsing"
ASJ Fall Meeting, 2-P-29 (1988-10).

[Kita 88-10-2] Kenji Kita, Takeshi Kawabata, and Hiroaki Saito:
(185) 「HMM音韻認識と予測LRパーザを用いた文節認識」
"HMM Continuous Speech Recognition Using Predictive LR Parsing"
WGSP Meeting of IEICE, SP-88-88 (1988-10)

[Kogure 88-12] Kiyoshi Kogure, Izuru Nogaito, and Hiroyuki Maeda:
(192)　　　　　「第26回計算言語学会年次大会報告」
"The Report on the 26th Annual Meeting of the Association for Computational Linguistics",
WGNL Meeting of IPSJ, NL69-8 (1988-12).

[Iida 88-12] Hitoshi Iida:
(200)　　　　　「異言語間対話を目指す端末間通訳モデル」
"An Interpretation Model for Inter-keyboard Dialogues",
『認知科学の発展 第1巻』(Advances in Japanese Cognitive Science, Vol. 1) (1988-12)

[Hattori 88-12] Tadasu Hattori and Kei Yoshimoto:
(229)　　　　　"Disambiguating Japanese Negative Sentences",
The 63rd Annual Meeting of the Linguistic Society of America (1988-12).

[Ogura 88-12] Kentaro Ogura, Kazuo Hashimoto, and Tsuyoshi Morimoto:
(243)　　　　　「言語データベース統合管理システム」
"An Integrated Linguistic Database Management System"
WGNL Meeting of IPSJ, NL69-4 (1988-12).

[Inoue 88-12] Naomi Inoue, Tsuyoshi Morimoto, and Kentaro Ogura:
(251)　　　　　「連想型知識ベースの構成とその音声・言語統合処理への応用」
"The Structure of Knowledge Base and the Application to the Integration of Speech and Language Processing",
WGNLC Meeting of IEICE, NLC88-16 (1988-12).

[Iida 89-1] Hitoshi Iida:
(258)　　　　　「対話における文脈知識とその蓄積利用」
"Contextual Information in Natural Dialogues",
Proceedings of IEICE Symposium「文法的知識と意味的知識の蓄積管理」(1989-1).

[Aizawa 89-1] Teruaki Aizawa and
(264)　　　　　Sho-ichi Matsunaga (NTT Human Interface Labaratories):
「第12回計算言語学国際会議(COLING'88)報告」
"A Report on the 12th International Conference on Computational Linguistics (COLING'88)",
IEICE Technical Report, SP88-132 (1989-1).

[Morimoto 89-1] Tsuyoshi Morimoto, and Akira Kurematsu:
(268)　　　　　「自動翻訳電話をめぐる研究課題」
"Research Themes of Automatic Interpretong Telephony",
WGCOMP Meeting of IEICE, COMP88-87 (1989-1).

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

1987 *through* 1988

Number	Title	Author(s)	Date
TR-I-0001	Automatic Telephone Interpretation: A Basic Study	Akira Kurematsu	1987-5
TR-I-0002	通訳を介した電話会話の特徴分析 Analysis of Telephone Conversation through an Interpreter	Hitoshi Iida, Kiyoshi Kogure, Izuru Nogaito, Teruaki Aizawa	1987-5
TR-I-0007	通訳を介した電話会話収集データ Collection of Interpreted Telephone Conversation Data	Hitoshi Iida, Masako Kume, Izuru Nogaito, Teruaki Aizawa	1987-10
TR-I-0008	日本語品詞の分類 Classification of Japanese Parts of Speech	Kei Yoshimoto	1987-11
TR-I-0014	Generalizing Unification in Semantic Networks toward Natural Language Understanding	Nadine Lerat Teruaki Aizawa	1987-11
TR-I-0015	A Description of English Dialogues by Structural Correspondence Specification Languag: SCSL	Rémi Zajac Teruaki Aizawa	1097-11
TR-I-0016	Comparison of Telephone and Keyboard Conversation	Hidekazu Arita, Kiyoshi Kogure, Izuru Nogaito, Hiroyuki Maeda, Hitoshi Iida	1987-12
TR-I-0017	Summaries of Workshop on Natural Language Dialogue Interpretation	Teruaki Aizawa	1987-12

Number	Title	Author(s)	Date
TR-I-0022	Research Activities of the Natural Language Understanding Department and the Knowledge and Data Base Department (April, 1986 through December, 1987)	Teruaki Aizawa, Tsuyoshi Morimoto	1988-3
TR-I-0026	A Method of Analyzing Japanese Speech Act Types (1): Combining Unification-Based Syntactico-Semantic Analysis and Plan Recognition Inference	Kiyoshi Kogure	1988-3
TR-I-0027	テキスト・データベースからの慣用表現の自動抽出 Automatic Idiom Extraction from Text Database	Kenji Kita, Tsuyoshi Morimoto	1988-5
TR-I-0029	言語データベース用格・係り受け意味体系 Semantic Relations for the Language Database	Naomi Inoue, Kentarou Ogura, Tsuyoshi Morimoto	1988-5
TR-I-0031	音声・言語インタフェースの予備検討 Preliminary Research on the Interface between Speech Recognition and Natural Language Processing	Tsuyoshi Morimoto, Koji Kakigahara, Kenji Kita	1988-6
TR-I-0032	素性構造とその単一化アルゴリズムに関する検討 A Study on Feature Structures and Unification	Kiyoshi Kogure, Susumu Kato	1988-7
TR-I-0035	Representation and Computation of units of translation for Machine Interpretation of spoken texts	Christian Boitet	1988-7
TR-I-0036	An Integrated Linguistic Database Management System	Kentaro Ogura, Kazuo Hashimoto, Tsuyoshi Morimoto	1988-8

Number	Title	Author(s)	Date
TR-I-0038	動詞敬語の相互承接について：句構造文法理論を用いた構文論的説明 Word Order of Japanese Honorific Predicate Constituents: Explanation by Unification-Based Phrase Structure Grammar	Hiroyuki Maeda	1988-8
TR-I-0039	解析用辞書開発作業に関する一考察 How to Make Correct Lexical Descriptions	Ken'ichi Itsumi	1988-9
TR-I-0041	The Formalization of a Knowledge Base for English	Donald Geddis, Naomi Inoue, Tsuyoshi Morimoto	1988-9
TR-I-0042	目標指向型対話における次発話の予測 Prediction of the Next Utterance in a Task-Oriented Dialogue	Hidekazu Arita, Hitoshi Iida	1988-9
TR-I-0043	言語データベース作成のための日英対訳対応付け Corresponding Japanese and English Text for Linguistic Database	Naoko Shinozaki, Kentaro Ogura, Tsuyoshi Morimoto	1988-9
TR-I-0044	Record of Six Work Sessions on Concepts, Methods, and Tools from Existing Running Real-Size MT Systems	Christian Boitet	1988-10
TR-I-0045	Operations on Typed Feature Structures : Motivations and Definitions	Rémi Zajac	1988-10
TR-I-0046	キーボード会話収録システムについて A Keyboard Dialogue-Collecting System	Ikuo Kudo, Tsuyoshi Morimoto	1988-10
TR-I-0049	句構造文法にもとずく日本語文の解析 Japanese Sentence Analysis by means of Phrase Structure Grammar	Kei Yoshimoto, Kiyoshi Kogure	1988-10
TR-I-0054	Pragmatic Extensions to Unification-Based Formalisms	Yves Nicolas	1988-11

Number	Title	Author(s)	Date
TR-I-0055	Typed Feature Structures : The Language and its Implementation	Rémi Zajac	1988-12
TR-I-0060	電子メール及びニュースに関するユーザーズ・マニュアル The "E-mail" & "News" Users' Manual	Izuru Nogaito, Katsuteru Maruyama, Kenji Kita, Shuichi Aoi	1988-12
TR-I-0062	対話文翻訳における英文生成システムの検討 An Experimental Study on English Sentence Generation System for the Natural Dialogue Translation	Yoshihiro Ueda	1988-12
TR-I-0064	解析過程の制御を考慮した句構造文法解析機構の検討 A Study on Unification-Based Phrase Structure Grammar Parser with Rule Application Control	Kiyoshi Kogure	1988-12