人工知能と対話技法　1－2
（1977・9・21）

第5回人工知能国際会議に出席して
―― 自然言語部門 ――

京都大学工学部　長尾　真

第5回人工知能国際会議は1977年8月22日～24日の4日間，マサチューセッツ工科大学で開催された。出席者は約1000名程度と推定される。問題意識が明確で非常に活発な討論の行われた楽しい学会であった。以下は自然言語の部門での発表論文のアブストラクトである。この他に自然言語関係では招待討論として Natural Language Processing と Speech Understanding and AI とがあった。次回（1979年）は日本で行われることにきまった。

MS. MALAPROP, A LANGUAGE COMPREHENSION PROGRAM

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This paper describes Ms. Malaprop, a program (currently being designed) which will answer questions about simple stories dealing with painting, where stories, questions and answers will be expressed in semantic representation rather than English in order to allow concentration on the inferential problems involved in language comprehension. The common sense knowledge needed to accomplish the task is provided by the frame representation of "mundane" painting found in Charniak (1976b). The present paper, after reviewing this representation, goes on to describe how it is used by Ms. Malaprop. Some specific questions of matching, correcting false conclusions, and search, will be discussed.

How to Learn/What to Learn

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Abstract: This paper discusses the kind of information that must be present in a computer program that models the linguistic development of a child. A three stage model is presented that characterizes the development of a natural language parser in a child of ages one, one and a half, and two. Some data from children of these ages is presented. General problems with respect to computer learning are also discussed.

keywords: learning, child development, parsing, conceptual analysis, psychological modelling.

PAM - A Program That Infers Intentions*

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PAM (Plan Applier Mechanism) is a program that understands stories by analyzing the intentions of the story's characters, and relating their intentions to their actions. PAM reads in sentences in English, produces Conceptual Dependency (CD) meaning representations for them, and connects together these CD's to form a story representation. The story representation contains, in addition to the actual events of the story, a Knowledge Structure Interpretation (KSI), which explains why these events occurred.

SKIMMING NEWSPAPER STORIES BY COMPUTER

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FRUMP (Fast Reading Understanding and Memory Program) is a system being developed at Yale to skim newspaper stories. The United Press International news service has recently been connected to the Yale computer to provide FRUMP with real-world data. FRUMP's understanding is based on the concept of a script. A script is a data structure used to represent knowledge about very stylized events.

FOCUS OF ATTENTION IN THE HEARSAY-II SPEECH UNDERSTANDING SYSTEM[1]

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Using the concepts of stimulus and response frames of scheduled knowledge source instantiations, competition among alternative responses, goals, and the desirability of a knowledge source instantiation, a general attentional control mechanism is developed. This general focusing mechanism facilitates the experimental evaluation of a variety of specific attentional control policies (such as best-first, bottom-up, and top-down search strategies) and allows the modular addition of specialized heuristics for the speech understanding task. Empirical results demonstrate the effectiveness of the focusing principles, and possible directions for future research are considered.

Controlling Inference in Story Understanding

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This paper sketches a method of pattern-matching and inference applied by a program called SAM [1] to read newspaper articles about car accidents, state visits, train wrecks, etc. Here is an example of a story SAM has processed, which illustrates the depth of comprehension this method enables it to achieve:

Shortfall and Density Scoring Strategies for Speech Understanding Control

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This note describes two methods of assigning priority scores to partially developed hypotheses about a speech utterance for determining which hypotheses to extend further. These methods guarantee the discovery of the best matching interpretation of the utterance, when used in an appropriate control framework. Although presented in the speech context, the algorithms are applicable to a general class of optimization and heuristic search problems. The density method is especially interesting since it is not an instance of the general A* algorithm of Hart, Nilsson, and Raphael, and appears to be superior to it in the domains in which it is applicable. Proofs of the guaranteed discovery of the best interpretation and some empirical comparisons of the methods are given.

Levels of Complexity in Discourse for Anaphora Disambiguation and Speech Act Interpretation

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Abstract: This paper presents a discussion of means of describing the discourse and its components which makes speech act interpretation and anaphora disambiguation possible with minimal search of the knowledge in the database. A portion of this paper will consider how a frames representation of sentences and common sense knowledge provides a mechanism for representing the postulated discourse components. Finally some discussion of the use of the discourse model and of frames in a discourse understanding program for a personal assistant will be presented.

PROCEDURES FOR INTEGRATING KNOWLEDGE IN A SPEECH UNDERSTANDING SYSTEM

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This paper describes the procedures for integrating knowledge from different sources in the SRI speech understanding system. A language definition system coordinates--at the phrase level --information from syntax, semantics and discourse in the course of the interpretation of an utterance. The system executive uses these contextual constraints in assigning priorities to alternative interpretations, combining top-down, bottom-up, and bidirectional strategies as required Experimental results that demonstrate the effectiveness of context checking are discussed.

THE USE OF A SEMANTIC NETWORK IN A DEDUCTIVE QUESTION-ANSWERING SYSTEM

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The use of a semantic network to aid in the deductive search process of a Question-Answering System is described. The semantic network is based on an adaptation of the predicate calculus. It makes available user-supplied, domain-dependent information so as to permit semantic data to be used during the search process.

Three ways are discussed in which semantic information may be used. These are:
(a) To apply semantic information during the pattern-matching process.
(b) To apply semantic well-formedness tests to query and data inputs.
(c) To determine when subproblems are fully-solved (i.e., they have no solutions other than a fixed, finite number).

An example is provided which illustrates the use of a semantic network to perform each of the above functions.

A DEDUCTIVE QUESTION ANSWERING SYSTEM ON RELATIONAL DATA BASES

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This paper describes a new formalization of a deductive question answering system on a relational data base using a theorem proving technique. A theorem proving procedure for a finite domain is investigated and a direct proof procedure based on substitutions of equivalent formulas which employs the breadth first search is intorudced. The search strategy is then expanded to set operations of the relational algebra which are incorporated into the proof procedure in order to increase the data base search efficiency. Virtual relations are realized by means of introducing several axioms and utilizing the deductive capability of the logical system. Furthermore, a conditional domain is introduced as one of the virtual domains and is used to give a relational view to a pseudo relational data base which can represent exceptional cases using some link information.

A query transformation system called DBAP (Data Base Access Planner) which embodies those features is implemented in QLISP.

THE REPRESENTATION AND USE OF FOCUS IN A SYSTEM FOR UNDERSTANDING DIALOGS

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As a dialog progresses the objects and actions that are most relevant to the conversation, and hence in the focus of attention of the dialog participants, change. This paper describes a representation of focus for language understanding systems, emphasizing its use in understanding task-oriented dialogs. The representation highlights that part of the knowledge base relevant at a given point in a dialog. A model of the task is used both to structure the focus representation and to provide an index into potentially relevant concepts in the knowledge base. The use of the focus representation to make retrieval of items from the knowledge base more efficient is described.

A COMPREHENSION MODEL FOR HUMAN DIALOGUE

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The comprehension of dialogue is an important concern for those interested in natural language processing for several reasons: dialogue gives particularly good access to human communication phenomena, it is less contrived than authored text, and human dialogue provides useful analogies for improving man-machine communication. In naturally occurring dialogues, the goals of the participants play a key role in structuring their language interactions. People know how dialogue is used to achieve goals, and they use this knowledge to comprehend what they hear.

We have represented this knowledge in structures called Dialogue-games, which differ from other multisentential knowledge structures by representing knowledge about how language is used to pursue goals rather than the structure of the content being conveyed. These Dialogue-games, which govern such activities as helping, information seeking, giving instructions, announcing, and testing someone's knowledge, are part of a strongly goal-oriented model of language comprehension. This model is composed of autonomous processes which operate on shared memories. Each of the four memories (a long-term memory and a short-term memory for each of two participants) is a collection of predicate expressions representing the individual's fixed knowledge and current awareness.

MODELLING SIMPLE DIALOGS

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Introduction

A problem that is currently of some interest in connection with the development of conversational systems is that of dealing with the context in which the individual utterances of a dialog are embedded. As researchers like Bruce (Bruce(1975)), Deutsch (Deutsch(1975), and Schank and Abelson (Schank and Abelson (1975)) have pointed out, the plans of the speakers are a crucial element of the context of a dialog.

MAKING INFERENCES IN NATURAL LANGUAGE DIALOGS

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This paper discusses the need in a natural language understanding system for a model of the speaker and of the conversation process itself. Most current programs use models of the domain of discourse to supply the knowledge necessary to understand what is being talked about. (See, e.g., Schank[1973] or Charniak[1972].)

USING PROCESS KNOWLEDGE IN UNDERSTANDING TASK-ORIENTED DIALOGS

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This note outlines research on natural language communication between two parties cooperating to accomplish a task.* Our goal is to formalize the knowledge needed to understand task-oriented dialogs and to develop techniques for representing and coordinating this knowledge in a computer system that can participate in the dialog. Encoding general process knowledge and the dynamics of specific tasks in a manner that is useful for the interpretation and generation of utterances in a dialog is a central issue in this research.

TALE-SPIN, AN INTERACTIVE PROGRAM THAT WRITES STORIES

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ABSTRACT

TALE-SPIN is a program that writes stories by using knowledge about problem solving, physical space, interpersonal relationships, character traits, bodily needs, story structure, and English. For these diverse sources of knowledge, it uses forms of representation which are themselves diverse, and it integrates them to produce the stories. The user may choose some of the initial setting and answer questions during the creation of the story, or he can choose from a list of "morals" such as "Never trust flatterers" and the program will decide what the initial setting must be in order to be able to write a story with that moral. The particular world within the story is not fixed; new characters and objects are introduced as needed.

ON SEMANTIC NETS, FRAMES AND ASSOCIATIONS

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A knowledge representation system is presented, based on the use of a semantic net on which a higher level structure of frames has been superimposed. The system was designed for use with a natural language system for finding the correct senses of ambiguous words in context. An examination of several linguistic examples shows how the representation system facilitates associative searches of context for potentially appropriate senses of ambiguous words, and how the results of such searches can often provide definite referents. The system also embodies novel approaches to the representation of multiple subparts, and of similar, but different, entities.

Frames-based Text Processing

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As part of a larger project to develop an intelligent noticing system, I am designing a module to process textual material. The essential tasks of a text processor can be divided into two operations: 1) Locating a prior context, called a theme, in the story database in which to place new knowledge. I shall call this process Linking; and 2) Mapping the new information in a sentence into that context. I assume that every new sentence in well written text contains a link to some theme.

Goldstein and Roberts (1977) have developed a working frame system (FRL) which forms the basis for our semantics. The frame system is organized as a tree structure, with generic information "bumped" up the tree, while particular frames specify new distinguishing knowledge. The generic knowledge, including procedural information, is inherited automaticly. Each frame consists of a set of slots. A slot is further specified through associated Keys, which can contain procedural knowledge.

COMEX: A COMMODITIES SUPPORT SYSTEM

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We are developing an intelligent support system, COMEX, to manage the data that a commodities analyst receives in agricultural reports. COMEX must have the following capabilities: 1) finding relevant facts, 2) determining implications, 3) checking reliabilities, 4) monitoring, 5) alerting, 6) reporting, 7) answering queries. The research involves natural language, representation, common sense reasoning, qualitative simulation and user modelling. Here, I address representation and reasoning by describing COMEX-0 a working prototype of a module of COMEX.

COHERENCE AND INTERPRETATION IN ENGLISH TEXTS

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A theory and system are described for the semantic analysis of complex, coherent English texts. The principal question addressed in this paper is how the meanings of the smaller elements of language compose into the meanings of larger stretches of text. Within sentence boundaries, this is achieved by an operation, called predicate interpretation, which provides a mechanism for general words, especially those having a spatial flavor, to acquire specific interpretations in context. Beyond sentence boundaries it is achieved by an operation which matches successive sentences against a small number of common patterns and builds up a tree-like structure representing the text's patterns of coherence.

AUTOMATIC ABSTRACTING OF TEXTUAL MATERIAL

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In what follows, we want to describe a system for the automatic abstracting of textual material. In designing the system, major theoretical questions have arisen not unlike those that arise in dealing with any natural language system. In addition, we want to describe some proposed revisions which have important theoretical implications and which should lead to significant improvements in the capabilities of the present system.

OVERVIEW OF "PLANNING SPEECH ACTS"

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We are developing and testing a computer model of conversation by constructing a program that engages its user in purposeful conversation to help him perform some task. Conversation is viewed as a sequence of actions performed by the participants, intentionally affecting each other's model of the world, primarily their beliefs and goals. These actions can only be performed if certain conditions hold.

THE GENERATION OF CONTINUOUS SEMANTIC CONSTRAINTS FROM SEMANTIC PROPOSITIONS

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Language comprehension is an exceedingly complex process which requires the extensive use of many different kinds of information in order to be successfully accomplished. One potentially very important type of information which has to date been largely ignored is the degree to which possible interpretations are sensible. While the sensibleness of candidate interpretations has long been recognized to be important, sensibleness has usually been treated as if it were an all-or-none property. However, it is clear that many things are more-or-less sensible and, therefore, the relative sensibleness of alternative interpretations may well be extremely useful information. For example, Oden (1977) has argued that degree of sensibleness information is required in order to disambiguate sentences to obtain the meaning that people normally do and has proposed language processing mechanisms which would use this information.

ANAPHORA AND LOGICAL FORM: ON FORMAL MEANING REPRESENTATIONS FOR NATURAL LANGUAGE

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We argue, on general grounds, in favor of formal meaning representations for natural language. We then adopt, as a "forcing function" for the adequacy of such a representation, the problem of identifying the possible antecedents of anaphoric expressions. This suggests certain structural properties of a representation which facilitate the identification of possible antecedents. Given an appropriate representation language with such properties, it is then possible to deal with a surprisingly rich class of anaphora.

CONCEPTUAL ANALYSIS OF NOUN GROUPS IN ENGLISH

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An expectation-based system, NGP, for parsing English noun groups into the Conceptual Dependency representation is described. The system is a part of ELI (English Language Interpreter) which is used as the front end to several natural language understanding systems and is capable of handling a wide range of sentences of considerable complexity. NGP processes the input from left to right, one word at a time, using linguistic and world knowledge to find the meaning of a noun group. Dictionary entries for individual words contain much of the program's knowledge. In addition, a limited ability for the handling of slightly incorrect sentences and unknown words is incorporated.

A NOTE ON REPRESENTING ADJECTIVES AND ADVERBS

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ABSTRACT-Representing English adjectives and adverbs using a logically perspicuous notation (extended semantic networks, Schubert, 1974) and their accomodation within a state-based paradigm (Cercone, 1975) are discussed. Where appropriate, explicit comparisons are made with related approaches such as those of Schank (1972,1974), Montague (1972), Bartsch and Vennemann (1972), Zadeh (1972), and Reichenbach (1947).

LANGUAGE GENERATION: THE LINGUISTICS COMPONENT

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Speaking is the result of two processes: first, deciding what to say, and then, determining how that can be said using a natural language, in this case English. The second is a linguistic process, which begins with intentional messages formed by the first process, adds audience and discourse information, and produces fluent, situationally appropriate English utterances as output. This note reports on a theory and program developed for that process, in particular, an English generation grammar, procedural lexicon, and translation process have been designed and implemented as the program MUMBLE, which has been tested by replicating several existing programs improving their capabilities. This work was initially presented in [1]. It has since been completed and is described in detail in [2].

FROM CONVERSATIONS TO STORIES: AN ANALYSIS OF DIFFERENCES BETWEEN ORAL AND WRITTEN LANGUAGE COMPREHENSION

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A traditional view of reading comprehension has been that it is the sum of oral comprehension skills and decoding skills; the educational corollary to this belief has been a heavy emphasis on the teaching of decoding. As part of our work at the Center for the Study of Reading, we are examining some important differences between oral and written language. We hypothesize that, while many of children's highly-developed oral language skills serve them well in the context of reading comprehension, additional processes are necessary for their understanding of text. Children may even exhibit "bugs" which derive from a too-general transfer of oral language processes to the reading situation.

GENERATING NOUN PHRASES TO IDENTIFY NODES IN A SEMANTIC NETWORK

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The Problem

In knowledge-based systems, such as those for doing automatic programming, e.g. <Heidorn 1974, 1976>, information is often stored in the form of a semantic network. In order to present portions of this information to a user, such as when answering a question, it must be converted into natural language form. Since the semantic network shows relationships among objects, part of what is required is to be able to generate phrases to uniquely identify these objects. In many cases they can be identified simply by a canned phrase, possibly a proper noun (e.g. "John"). But when the objects have more complex names (e.g. "the extended price discount percentage field in a customer master record"), a canned phrase is inappropriate, primarily because a node may not have just one identifying phrase that can be used to refer to it in all contexts, especially if the network itself may change during the dialogue.

WRITING A NATURAL LANGUAGE DATA BASE SYSTEM*

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We present a model for processing English requests for information from a relational data base. The model has as its main steps (a) locating semantic constituents of a request; (b) matching these constituents against larger templates called concept case frames; (c) filling in the concept case frame using information from the user's request, from the dialogue context and from the user's responses to questions posed by the system; and (d) generating a formal data base query using the collected information. Methods are suggested for constructing the components of such a natural language processing system for an arbitrary relational data base. The model has been applied to a large data base of aircraft flight and maintenance data to generate a system called PLANES; examples are drawn from this system.

KNOWLEDGE STRUCTURES AND LANGUAGE BOUNDARIES

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The paper discusses the incorporation of richer semantic structures into the Preference Semantics system: they are called pseudo-texts and capture something of the information expressed in one type of frame proposed by Minsky (q.v.). However, they are in a format, and subject to rules of inference, consistent with earlier accounts of this system of language analysis and understanding. Their use is discussed in connection with the phenomenon of extended use: sentences where the semantic preferences are broken. It is argued that such situations are the norm and not the exception in normal language use, and that a language understanding system must give some general treatment of them.

A CONCEPTUAL THEORY OF QUESTION ANSWERING

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A theory of Q/A has been proposed from the perspective of natural language processing that relies on ideas in conceptual information processing and theories of human memory organization. This theory of Q/A has been implemented in a computer program, QUALM. QUALM is currently used by two story understanding systems (SAM and PAM) to complete a natural language processing system that reads stories and answers questions about what was read.

MAXIMAL CONSISTENT INTERPRETATIONS OF ERRORFUL DATA IN HIERARCHICALLY MODELLED DOMAINS

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A method is presented for constructing maximal consistent intepretations of errorful data. The method appears applicable to many tasks (speech understanding, natural language understanding, vision, medical diagnosis) requiring partial-matching of errorful data against complex, hierarchically defined patterns. The data is represented as symbolic structures (word sequences, line segment configurations, disease symptoms). Errors consist of missing data (unrecognized words, occluded lines, undetected symptoms) and extra (possibly inconsistent) data (incorrectly recognized words, visual noise, spurious symptoms). Data interpretations correspond to substructures of a hierarchy of predefined concepts. Constraints on consistent conceptual structures are embedded in the hierarchy. An implementation of the method has correctly interpreted errorful sets of sentence fragments recognized by the HEARSAY-II speech understanding system. The implementation has also correctly interpreted typed-in ungrammatical sentences. Detailed examples illustrate operation of the method on real data.

FOUL-UP

A program that figures out
meanings of words from context

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The inferencing task of figuring out words from context is implemented in the presence of a large database of world knowledge. The program does not require interaction with the user, but rather uses internal parser expectations and knowledge embodied in scripts to figure out likely definitions for unknown words, and to create context-specific definitions for such words.

TWO SEMANTIC WORLDS: A DATA BASE SYSTEM WITH PROVISION FOR NATURAL LANGUAGE INPUT

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This note very briefly describes a data base system with provision for Natural Language Input. No attempt is made here to justify the strategies adopted. Those interested in justification are referred to (Dell'Orco, King, Spadavecchia 1977).

A SIMPLIFIED HEURISTIC VERSION OF RAVIV'S ALGORITHM FOR USING CONTEXT IN TEXT RECOGNITION

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Word-position-independent and word-position dependent n-gram probabilities were estimated from a large English language corpus. A text-recognition problem was simulated, and using the estimated n-gram probabilities, four experiments were conducted by the following methods of classification: without contextual information, Raviv's recursive Bayes algorithm, the modified Viterbi algorithm, and a proposed heuristic approximation to Raviv's algorithm. Based on the estimates of the probabilities of misclassification observed in the four experiments, the above methods are compared. The heuristic approximation of Raviv's algorithm performed just as well as Raviv's and required far less computation.

HUMAN ENGINEERING FOR APPLIED NATURAL LANGUAGE PROCESSING

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Human engineering features for enhancing the usability of practical natural language systems are described. Such features include spelling correction, processing of incomplete (elliptical) inputs, interrogation of the underlying language definition through English queries, and an ability for casual users to extend the language accepted by the system through the use of synonyms and paraphrases. All of the features described are incorporated in LIFER, an applications-oriented system for creating natural language interfaces between computer programs and casual users. LIFER's methods for realizing the more complex human engineering features are presented.

Advantages of a Transformational Grammar for Question Answering

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A number of researchers in artificial intelligence, for example, Woods(1975, p.88 ff.), have asserted that transformational grammars are not a satisfactory basis on which to construct natural language understanding systems, primarily because of efficiency considerations. The evidence for such a claim is by no means strong, Petrick(1976), and it can be argued that transfer of new theoretical insights into a language understanding system based on transformational grammar is facilitated, Plath(1973). This note shows that a transformational parser can also simplify problems of relating canonical representations of queries to data base representations.

AUGMENTING ATNS

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Augmented Transition Networks (ATNs) have become a popular and effective tool for constructing natural language understanding systems. Our own system, PLANES [Waltz 76] is based on a large "semantic grammar" which is implemented as an ATN network. In developing our system, we were frustrated by numerous problems and shortcomings IN the basic ATN formalism. Consequently, we have augmented and extended the model to overcome some of these problems. We have also developed an optimizing compiler for ATN networks which translates them into LISP functions and an interactive program which allows one to easily extend and modify an ATN grammar.

THE USE OF DYNAMICALLY EXTRACTED CONTEXT FOR ANAPHORIC REFERENCE RESOLUTION

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We define anaphora more broadly than is usually done, i.e. to include not only pronoun, proadverb (e.g. here, there, then), pro-verb (e.g. do as in John goes to bed early; I do too.), definite, etc. reference, but also indefinite reference (as in 1 below), as well as reference by an entire sentence or subsentence to a previous sentence or subsentence (as in 2 below).

PRESUPPOSITION-BASED AI NATURAL LANGUAGE SYSTEM

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The first Israeli AI natural language group is developing a system in which the purpose of the semantic analysis of a sentence is to explicate both its own meaning and the whole framework of relevant knowledge associated with it. The latter is covered by the set of presuppositions of the sentence. The emphasis in the research is on justification of the semantic instruments used in the system rather than on originality of its language or notation.