Abstracts of Current Literature

A Competence-Based Theory of Syntactic Closure

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Although a sentence may be structurally ambiguous, it is often the case that perceivers prefer one possible structural analysis over another. A particularly interesting and important research problem in the development of a theory of sentence perception is to explain the structural biases shown in these ambiguous sentences, since the effects observed reflect the operating principles of the human parsing mechanism very directly. In this study, we examine syntactic bias effects and show that they are a joint function of (i) the linguistic rules which define the structures of sentences, (ii) the predicate argument structures and grammatical functions of lexical items, and (iii) a well-defined interaction between rule-driven and data-driven analysis procedures. The theory that is developed in this study directly incorporates the linguistically motivated rules of the lexical-functional grammar and so supports the competence hypothesis in the domain of sentence comprehension.

One Analyzer for Three Languages

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We have been developing a model of natural language use. The primary point of this model is to provide a general framework in which it is possible to conveniently express knowledge about the meaning of a language's utterances. Programs for understanding and producing natural language based upon this model work by interpreting a knowledge base of such facts. Thus, improving this knowledge base directly expands the language processing abilities of the system without any substantial programming effort.

We have recently tested our model by taking the understanding component of our system, called PHRAN (PHRasal ANalyzer), which was originally written to understand English text, and supplying it with knowledge bases for Spanish and Chinese. While we had no theoretical predisposition about what components of this system should be transferable to other languages, we found that we were able to encode the relevant knowledge about these languages using our existing representational scheme. Once this was done, PHRAN was able to understand both these languages to a substantial extent without any modification to its control structure. Moreover, we encountered no problems in describing or processing these languages that would suggest serious difficulties in extending the system's knowledge bases beyond their current capacity.

NLI: A Robust Interface for Person-Machine Communication in Natural Language

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A novel approach to natural language understanding, called goal oriented parsing, is presented. Such a model of comprehension is embedded in the more general framework of interpersonal communication and is applied to the person-machine interaction task. It is based on the claim that understanding imperative natural language is strongly dependent both on the goal of the speaker and on the nature of the hearer. This assumption is proved appropriate for the design of effective and robust natural language interfaces to artificial systems. This approach is supported by the development of an experimental project called NLI for interrogating in Italian a relational data base. NLI is to date running on a PDP 11/34 computer at the Milan Polytechnic Artificial Intelligence Project. In the paper we illustrate the overall architecture of the system along with the basic features of the parsing algorithm. This is based on the new concept of hierarchical parsing and is mainly directed by the semantics of the language. The role of clarification dialog to overcome critical situations is discussed as well. The use of goal oriented parsing in dealing with full query text and anaphora is also exploited. Several meaningful examples are presented. Comparisons with related work are outlined, and promising directions deserving further investigation are presented.

ILIAD: Interactive Language Instruction Assistance for the Deaf

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Report No. 4771, September 1981, 74 pages.

This report describes the syntactic, semantic and tutorial components of the ILIAD language instruction system and the steps that have been taken to implement ILIAD on a microcomputer. The goal of this work has been to design and implement an English language instruction system capable of *generating* a broad range of meaningful sentences as examples or exercises in tutorial lessons. This goal has been reached.

The ILIAD design allows for highly interactive tutorials in which the learner specifies the content of each lesson; ILIAD in turn *creates* an individualized lesson according to the learner's specifications. Because of the *generative* capability of ILIAD, the system continues to present examples of exercises for as long as the learner desires to study a particular grammatical or functional aspect of language use.

The prototype computer implementation of ILIAD has been written in InterLISP on a DEC System-20 computer at Bolt Beranek and Newman. Over the past two years a prototype microcomputer version of ILIAD has been designed and implemented. The microcomputer design has involved evaluation and modification of InterLISP ILIAD components for use in a UCSD-Pascal program. The microcomputer implementation, MicroILIAD, is now a functional language generation system with a subset of ILIAD syntactic capabilities and a flexible system of semantic representation. The MicroILIAD semantic system has allowed for a variety of tests and subsequent improvements of the original ILIAD semantics.

For two years ILIAD has been used by deaf children at the Boston School for the Deaf, by deaf children using a terminal in their homes, and by adults with access to the Deafnet computer communication system in the Boston area. Having deaf children and adults use and comment on prototype versions of ILIAD has been an important component in the design process of the system.

Research in Knowledge Representation for Natural Language Understanding

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Report No. 4785, November 1981, 244 pages.

BBN's ARPA project in Knowledge Representation for Natural Language Understanding is developing techniques for computer assistance to a decision maker who is collecting information about and making choices in a complex system or situation. In particular, we are designing a system with natural language control of an intelligent graphics display of the kind that can be used in a command and control context, both in strategic situation assessment and in more tactical situations. Our work falls into three classes: fluent natural language understanding in a graphics context (including intelligent, helpful systems that go beyond mere passive execution of literal instructions), fundamental problems of knowledge representation and use, and abstract parallel algorithms for knowledge-based inferential operations. The major accomplishment of our work so far is the development of the knowledge representation system KL-ONE.

In this report, we describe the research investigations we have accomplished in the three main areas we are pursuing—parallel algorithms, representation research on KL-ONE, and natural language research. Chapter 2 first updates our 1979 report by discussing extensions and changes in the system since that time. In Chapter 3 we present an overview of the Natural Language system, followed by two chapters on specific parts of that system. One chapter, on the PSI-Klone interface, contains a discussion of changes and extensions to RUS and PSI-KL-ONE. It also presents our new work on a lexical acquisition system. The other chapter contains a discussion of our work on issues related to discourse, primarily research on models of speaker meaning, on reference as a planned act and on one-anaphora. The final chapter presents research on the development of algorithms for abstract parallel machines.

RLL-1: A Representation Language Language

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Report No. HPP-80-9, October 1980, 45 pages.

The field of AI is strewn with knowledge representation languages. The language designer typically designs that language with one particular application domain in mind; as subsequent types of applications

are tried, what had originally been useful features are found to be undesirable limitations, and the language is overhauled or scrapped. One remedy to this bleak cycle might be to construct a representation language whose domain is the field of representational languages itself. Toward this end, we designed and implemented RLL-1, a frame-based Representation Language Language. The components of representation languages in general (such as slots and inheritance mechanisms) and of RLL-1 itself, in particular, are encoded declaratively as frames. By modifying these frames, the user can change the semantics of RLL-1's components, and significantly alter the overall character of the RLL-1 environment.

RLL-1: A Representation Language Language Supplement, Details of RLL-1

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This paper includes many implementation level details about the RLL-1 system, described in a companion paper, RLL-1: A Representation Language Language. The contents are as follows: Special Units, Naming conventions, Legend, Actual units, Index of units, Environment, Top level Functions, Functions needed to Bootstrap RLL-1, Convenience Functions, Advised Functions, and Global Variables.

Dialogue and Process Design for Interactive Information Systems Using TAXIS

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This paper is concerned with both dialogue and process management for interactive information systems (IISs). In particular, the paper describes an extension to TAXIS (Mylopoulos) a language for IIS design, to provide this type of management. Dialogues between a user and the system are described through a small set of primitives incorporated into TAXIS while process control is accomplished by incorporating Hoare's I/O commands for communicating sequential processes. The overall organization and structure of dialogue and process control for a particular IIS is achieved using scripts, a modified version of augmented Petri nets and the TAXIS conceptual framework of properties, classes, and the IS-A relationship. A journal editing procedure is used to illustrate the proposed extension.

Design and Verification of Interactive Information Systems Using TAXIS

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This thesis discusses the syntax and semantics of TAXIS, a language for the design of Interactive Information Systems (IISs). The thesis also examines the design and verification methodologies of programs that TAXIS supports. TAXIS offers (relational) database management facilities, a means of specifying semantic integrity constraints and an exception-handling mechanism, integrated into a single language through the concepts of class, property and the IS-A (generalization) relationship.

The formalization of TAXIS involves a denotational semantics and an axiomatic semantics. The former uses simple mathematical concepts such as sets and functions to assign meaning to TAXIS constructs. The latter provides an axiomatization of TAXIS in the spirit of Hoare. The two definitions are then shown to be consistent by proving that the denotational semantics satisfies (in the logical sense) the axiomatization.

A new design methodology for IISs is also sketched in the thesis. This methodology is based on the concept of stepwise refinement through specialization. According to this method, an IIS is first designed at a fairly high level of abstraction which is later refined by introducing new classes that are specializations of existing ones. This design method is complementary to traditional design methods which are based on the concept of stepwise refinement through decomposition. Parallel to the design methodology, a verification methodology of IISs is established in that the correctness of an IIS is shown in a stepwise manner. Each refinement of an IIS can be specified and proven correct by using the results of the previous refinement. Hence, the verification process is considerably simpler.

Data Base Design for Natural Language Medical Data

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The natural language of clinical reporting exhibits the properties of a sublanguage, having a grammar and vocabulary greatly restricted in comparison to the language as a whole. This paper presents a CODASYL-type (network) data base schema for natural language medical records based on the structures and relationships identified in such material through

computerized language processing. While the schema described is special to the medical sublanguage, the methods of analysis and of schema design are applicable to natural language material in other subject areas.

On beyond Cyrus: Additional Problems Related to Long Term Memory Organization and Retrieval

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In previous research the problem of organizing events in a long term memory, and later retrieving them based on natural language questions, was explored. The results of that research are implemented in a computer program called CYRUS, which stores and retrieves information about important political dignitaries. While CYRUS provides a vehicle for discovering problems of long term memory organization, there are a number of problems important to intelligent fact retrieval and long term memory which were not addressed in that research. This report presents CYRUS and addresses some of the problems illustrated by CYRUS, explaining for each its importance to intelligent fact retrieval and an initial approach to resolving it. The problems addressed are representation and organization of complex events in memory, using knowledge acquired through previous experience to extract implicit information from memory, keeping track of what's in memory and where it can be found, controlling indexing within memory structures, and memory reorganization as a result of memory access. Although the emphasis is on organization and retrieval of events, principles stemming from the representations and processes used for events should be extendible to other types of items in memory.

On the Unification of Language Comprehension with Problem Solving

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Technical Report CS-78, August 1981, (Ph.D. Thesis).

Over the years it has been argued that there ought to be an artificial intelligence system that can do both problem solving and language comprehension using the same database of knowledge. Such a system has not previously been constructed because researchers in these two areas have generally used rather different knowledge representations: the predicate calculus for problem solving and some frame-like representation for language comprehension.

This dissertation describes BRUIN, a unified AI system that can perform both problem-solving and language comprehension tasks. Included in the system is a frame-based knowledge-representation language called FRAIL, a problem solving component called NASL (which is based on McDermott's system of the same name), and a context-recognition component known as PRAGMATICS. Examples that have been tested in this system are drawn from the inventory-control, restaurant, and blocks-world domains.

The main intent of this dissertation is to describe how context recognition can be done in a problem-solving environment. Also discussed is the knowledge representation language FRAIL and the relevant portions of the problem solver NASL. Finally, there is a discussion of problems with the context recognizer PRAGMATICS and possibilities for future research.

Passing Markers: A Theory of Contextual Influence in Language Comprehension

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Technical Report CS-80, September 1981.

Most artificial intelligence theories of language either assume a syntactic component that serves as a "front end" for the rest of the system, or else reject all attempts at distinguishing modules within the comprehension system. In this paper we will present an alternative which, while keeping modularity, will account for several puzzles for typical "syntax first" theories. The major addition to this theory is a "marker passing" component, which operates in parallel to the normal syntactic component.

A Common Representation for Problem-solving and Language-Comprehension Information

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Artificial Intelligence 16, 3 (1981), 225-255.

Many in artificial intelligence have noted the common concerns of problem-solving and language-comprehension research. Both must represent large bodies of real-world knowledge, and both must use such knowledge to infer new facts from old. Despite this, the two subdisciplines have, with minor exceptions, kept arm's length. So, for example, many in language comprehension have adopted some form of "frame" representation, while problem-solving people have tended to use predicate calculus. In this paper I will first show that this is not merely idiosyncratic behavior, but rather stems from the different issues

stressed by the two areas, problem solvers being primarily concerned with deep inferences in narrow domains, while language comprehenders are more concerned with shallow inference in broader areas. I will then suggest a compromise position which will use both frames and predicate calculus and then show how this representation has features desired by both camps.

The Case-Slot Identity Theory

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Cognitive Science 5, 3 (July-September 1981), 285-292.

Many people have noted the similarities between case theories in linguistics and frame representations in artificial intelligence. In particular, the cases of a verb seem to correspond to the slots of a frame. This has led many people, including Fillmore and Winston, to assert that cases and slots are one and the same. This hypothesis has not attracted much attention, probably because the notion of "slot" in frame representations is so underconstrained that the theory would seem to be content free. In this note, we wish to show that this is not true. For one thing, the case-slot identity theory can explain the difficulty linguists have had in deciding how many cases there are. Furthermore, its adoption will place certain interesting, and plausible constraints on the frame and case theories compatible with it.

Parsing and Comprehending with Word Experts: A Theory and Its Realization

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Report No. TR-1039, NSG-7253, April 1981.

The Word Expert Parsing theory and model are described. In this theory, most linguistic and conceptual knowledge relevant to comprehension of language is contained in modular, autonomous "word experts." Our theory is that language comprehension is the interaction of such experts as they construct and exchange information in reaction to input sentences in both discourse and real-world contexts. The Lexical Interaction Language (LIL) and Sense Discrimination Language (SDL), the two sets of primitives from which the theory's model is constructed, are explained drawing on numerous examples taken from running examples of the parser. A full execution trace of the sentence "The man eating peaches throws out a pit." concludes the discussion. Arguments are advanced about why such a theory as this seems to be necessary, and why it is plausible as a theory of human language comprehension.

Truth, Syntax, and Reason

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Report No. TR65, June 1980, 45 pages.

A very broad formalism is developed for analysis of natural language. Properties and symbols are viewed as "real" entities on equal footing in a first-order logic. The main difficulty addressed is self-referential paradox. By extending and modifying the work of Gilmore and Kripke, a provably consistent treatment is found which appears to restore the intuitive character of Frege's approach to propositional variables. Various parallels are drawn to issues in artificial intelligence.

Design of Lexicons in Some Natural Language Systems

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ALLC Journal 1, 2 (Autumn, 1980), 37-54.

An investigation of certain problems concerning the structural design of lexicons used in computational approaches to natural language understanding is intended herewith. Three aspects of lexical design appear especially noteworthy: (1) retrieval of relevant portions of lexical items from the lexicon: (2) the storage requirements of the lexicon; and (3) the representation of meaning in the lexicon. We consider lexicons from a variety of sources; where appropriate, explicit comparisons are made between the lexical structures of Cercone, Winograd, Schank, Wilks, and Woods.

Machine Translation in China

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ALLC Journal 1,2 (Autumn 1980), 60-66.

MT research in China began in 1957. Over the years MT algorithms have been developed for translation into Chinese from English, Russian, German, and French. Chinese MT techniques concentrate on syntactic analysis, including the determination of the hierarchical structure of the sentence and the determination of the axis in the sentence; the full use of fixed phrases; full stress on the key significance of function words in MT; and emphasis on formal analysis without neglecting the function of meaning.

Approximate String Matching

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Approximate matching of strings is reviewed with the aim of surveying techniques suitable for finding an item in a database when there may be a spelling mistake or other error in the keyword. The methods found are classified as either equivalence or similarity problems. Equivalence problems are seen to be readily solved using canonical forms. For similarity problems difference measures are surveyed, with a full description of the well-established dynamic programming method relating this to the approach using probabilities and likelihoods. Searches for approximate matches in large sets using a difference function are seen to be an open problem still, though several promising ideas have been suggested. Approximate matching (error correction) during parsing is briefly reviewed.

Automatic Extension on an ATN Knowledge Base

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A computer program is described that acquires much of its knowledge from conversations among operators on Morse code radio networks. The system consists of a learning component and a language understander. The learning component extends a "core" augmented transition network (ATN) knowledge base by generalizing from sentences taken from scripts of actual conversations. The extensions enable the understanding component to process a large number of sentences that are syntactically and semantically similar to the examples.

Computer Commands in Restricted Natural Language: Some Aspects of Memory and Experience

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In this experiment, two groups of subjects having different levels of experience with computers were tested to compare the learning and recall of computer command definitions that differed in context and redundancy and to study the effect of context change. The results show that inexperienced (naive) subjects have different requirements than do more experienced subjects. The experienced group recalls more meanings than the inexperienced group but is more negatively influenced by the number of competing words (that is, different words used to label the same computer function) than by contextual connotation. For the inexperienced subjects, particularly, it appears that computer-oriented words used as commands are better than more usual words. Besides, inexperienced subjects are more negatively influenced by context changes than are experienced subjects.

User Modelling in Anaphora Generation: Ellipsis and Definite Description

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This paper shows how user modelling can improve the anaphoric utterances generated by a dialogue system. Two kinds of anaphora are examined: ellipsis and the anaphoric use of singular definite noun phrases. In connection with the generation of elliptical utterances, an anticipation feedback loop can help to ensure that the system's utterances are not so brief as to be ambiguous or misleading. When generating noun phrases to characterize specific objects with which the user is not familiar, the system may take into account the existential assumptions, domain-related desires, and referential beliefs ascribed to the partner. These applications of user modelling are illustrated as realized in the dialogue system HAM-ANS, and some extensions of the strategies described are discussed.