

## Yale Artificial Intelligence Project

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The Yale Artificial Intelligence Project, under the direction of Professor Roger C. Schank, supports a number of research projects. Most of this research is in the area of attempting to model the processes involved in human understanding, with a current emphasis on memory models and the processes involved in learning.

It has been a consistent philosophy of research at Yale that these projects should build on each other's contributions, sharing representational strategies and attempting to work towards a unified concept of representation. Aspects of the representation which has been developed may be found in the literature [1, 2].

Yale also supports a Cognitive Science program, which is under the direction of Professors Roger C. Schank and Robert P. Abelson. The Cognitive Science program works closely with the AI project in attempting to do experiments which test predictions made by the theories developed in writing AI programs and provide input to AI researchers about the processes they are attempting to model. [20, 21, 22, 23, 24, 25].

In addition to the work on natural language, Assistant Professor Drew McDermott is working on a project in spatial reasoning.

The following is a list of most of the projects currently being worked on at Yale, with a brief discussion of the goals of each project and selected references.

### Existing Projects

#### *IPP*

Mike Lebowitz (now at Columbia University), Steve Lytinen

*IPP* implements a theory of generalization based on the features of stories it reads from the UPI wire. Starting with a high level representation of knowledge about its domain of interest—terrorism—it generalizes from stories with common features, it creates new memory structures which serve as more specific representations of knowledge about terrorism and can thus be used in understanding future stories. In order to do this generalization, *IPP* parses directly into the high level knowledge structures—with each memory structure guiding the understanding of text about the type of event that it represents [3, 4, 5]

#### *Cyrus*

Janet Kolodner (now at Georgia Tech), C J Yang, Martin Korsih

*Cyrus* implements a theory of long term memory. Its task orientation is to keep track of events in the lives of important people (formerly Cyrus Vance, now Edmund Muskie), and to answer English questions about them. The program uses

summaries of wire stories produced by the FRUMP program [19] as input. The *Cyrus* program organizes the events into memory structures, and uses a reconstructive approach to produce answers to questions based on the content of these structures, hopefully in a way similar to the way these people themselves would. The major goals of *Cyrus* are to point the way towards the construction of self-organizing memory system and to implement search techniques on this memory which are psychologically plausible. [5, 7, 8]

#### *Abdul*

Margot Flowers, Larry Birnbaum, Rod McGuire

*Abdul* is a program which attempts to model human argument behavior. A theory of argument relations has been developed, and applied to the representation of a sample argument. The program focuses on how to use high level argument strategies to manipulate these local argument relationships, and on the interaction between general reasoning rules and such argument strategies. [9]

#### *Boris*

Wendy Lehnert, Michael Dyer, Tom Wolf, Brian Reiser

*Boris* is an effort to utilize all the memory structures which have been developed in the course of research at Yale to represent a story which is considerably more complicated than what AI programs have traditionally dealt with. To do this, it has been necessary to view the actions of the story from multiple perspectives, and to develop methods for keeping these diverse points of view integrated in memory. In addition, the theory of affect units developed by Lehnert is being implemented in *Boris*. [10, 11, 12, 13]

### New Projects

#### *Space*

Drew McDermott, Ernest Davis

The *Space* program deals with the problem of representing incomplete and inexact spatial knowledge in such a way as to allow inferences about relative locations, topological relations, and best routes between given locations to be made. The metric portion of the program is complete, and the navigational and topological portions are being worked on. [14, 15]

#### *Failure Driven Reminding*

Roger Schank, Gregg Collins

One of the most important phenomena in human behavior is that of reminding. People seem to be able to come up with episodes from the past which share important features with the ones they are currently processing: in short they can produce the right example at the right time. The ability to do this must underide our ability to make generalizations and therefore to learn. The thesis in this project is that such memories pop out because they are stored in the right places. One important reason for this, we believe, is that in situations where an episode contradicts a prediction we have made, the episode is stored by indexing it to the prediction rule that failed. The goal of this project is to produce a program which

can be reminded, across domains, of episodes that produced the same type of prediction failure, and which, furthermore, can utilize such reminders to generalize new and better prediction rules. [16]

### *Alfred*

Chris Riesbeck, Mark Burstein, Gregg Collins

The *Alfred* project also makes use of a *failure driven memory* scheme. The goal here is to produce a program which can simulate untutored adult learning in a complex domain; namely, political economics. The program begins with a reasonable model of the type of high-level memory organization structures an adult non-expert would have in the domain, and proceeds to learn by its own prediction failures in attempting to understand news items concerning the domain [17]

### *IT*

Jerry DeJong, Alan Cypher, Chris Hammond, Martin Kossin

*IT* is an attempt to build an integrated text understanding program combined with a long-term memory. *IT*, like *IPP*, uses interest to guide parsing and (as planned) will construct generalizations about the stories it has processed. However, unlike *IPP* it parses with different levels of intensity based on the extent of its interest and it makes generalizations on the basis of its ability to explain the input in terms of its prior knowledge rather than on strict feature matching, as *IPP* does

### *Conversation*

Pete Johnson, Scott Robertson

This project is an attempt to model the process of conversation, with special attention being given to the goals of the participants. The thesis of this project is that people involved in a conversation have goals on a number of different levels simultaneously and thus that much of the art of conversation is to balance these levels and to construct responses in such a way that as to fulfill goals on as many levels as possible [18]

### *Machine Translation*

Steve Lytinen, C J Yang

The *Machine Translation* project is an effort to do machine translation in a true understanding system, where the input language is parsed into an internal knowledge representation from which the target language is generated. The project serves at the same time to help clean up the commonly used knowledge representation structures to insure that they are not language dependent, and to increase our understanding of what types of memory structures are natural to use by studying the organization of knowledge in other languages.

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## AI at AI&DS

edited by Brian P McCune

### Company Overview

Advanced Information & Decision Systems (AI&DS) is a relatively new, employee-owned company that does basic and applied research, product development, and consulting in the fields of artificial intelligence, computer science, decision analysis, operations research, control theory, estimation theory, and signal processing. AI&DS performs studies, analyses, system design and evaluation, and software development for a variety of industrial clients and government agencies, including the Departments of Defense and Energy. The AI&DS technical staff has training and experience in mathematical sciences and engineering, with most members holding advanced degrees. The staff is augmented by a number of university experts who serve as consultants.

AI&DS is located in the San Francisco Bay area near Stanford University. An in-house computing facility for symbolic, numeric, and word processing, based on a DEC VAX-11/750, is on order. Current computing resources

include numerous hardcopy and display terminals and a Cromemco System Three with Digital Graphic Systems CAT-200 for displaying grayscale images and local printing. Major computation is done via remote access to a number of DECsystem-10s and DECsystem-20s on the ARPAnet, as well as a VAX-11/780.

### AI Interests

Two major themes of AI&DS are relevant to its AI interests. One theme is *technology transfer*. AI&DS has assumed the role of an agent for transferring technology from the basic research found primarily in universities to the applications found in government and industry. In this role AI&DS is concentrating on applied research, while maintaining strong components of basic research and development as well.

The second theme is *interdisciplinary research*. For example, AI, control theory, and decision analysis are three disciplines that often attack similar problems, but with different tools and under different assumptions about the nature of the problems. As examples, all three disciplines involve aspects of hypothesis formation and decision making, and all three may use search trees as a tool. AI&DS is involved in projects (e.g., the last three described in the next section) to understand when one technology is better than another and how technologies may be fruitfully combined.

AI is currently applied in seven AI&DS research projects in five overlapping areas: software aids, image understanding, hypothesis formation, distributed AI, and AI for decision making. In addition, AI&DS has an interest in the areas of knowledge-based system development for various applications, advanced user interfaces, robotics, integration of information from multiple sources [Drazovich & Wishner-81], and fuzzy aids for control [Tong-80] and decision making [Tong & Bonissone-80].

### Current AI Research Projects

This section briefly describes each research project at AI&DS that has some AI component. After the title of each research project, the principal investigator is listed.

#### *Advanced Tools for Software Maintenance*

Brian P McCune

This research is to evaluate the need for and to design prototype tools that apply advanced software technologies to the problem of maintaining large software systems written in ADA. The technologies being considered include artificial intelligence, automatic programming, program verification, very high-level languages, program transformations, program optimization, and interactive programming aids.

The effort is directed primarily toward tools that will improve productivity, increase reliability, and lower costs during the maintenance phase of the software life-cycle. One such tool is an intelligent program editor that understands the