

Research at Jet Propulsion Laboratory (JPL)

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AI research at JPL started in 1972 when design and construction of an experimental "Mars Rover" began. Early in that effort, it was recognized that rover planning capabilities were inadequate. Research in planning was begun in 1975, and work on a succession of AI expert systems of steadily increasing power has continued to the present. Within the group, we have concentrated our efforts on expert systems, although work on vision and robotics has continued in a separate organization, with which we have maintained informal contacts. The thrust of our work has been to build expert systems that can be applied in a real-world environment, and to actually put our systems into such environments, taking a consultative responsibility for meeting user requirements. Several supportive tools for AI are also being built. The current computational environment includes a large main-frame as well as high-performance personal LISP machines. A separate group has been engaged in the design of an intelligent work station with advanced graphic displays intended to interface with AI systems.

Planning

A general-purpose planner called DEVISER has been implemented which correctly accounts for time. Thus it has a capability for scheduling actions. The initial application has been to generate commands for the on-board spacecraft

computer of the VOYAGER mission. This code generation, till now, has been done by a team of programmers responding to requests from scientists. The performance of DEVISER in generating code to meet similar requests was impressive enough to cause the VOYAGER spacecraft project to form a users group to write knowledge bases that would exploit the capabilities of DEVISER. This group, which has almost no knowledge of the internal workings of DEVISER, has been successfully expanding the knowledge base to form a model of VOYAGER activities. Various improvements requested by them have been incorporated in DEVISER. The VOYAGER mission also organized another group that has constructed the intelligent work station interface. VOYAGER plans to use DEVISER during its encounter with Uranus.

Participant: Steven Vere (contact)

Replanning/Resource Allocation

Research is also being undertaken for a military application. The Army collects raw data at the request of intelligence officers. The task of managing this activity is called Collection Management, and calls for both resource allocation and scheduling. DEVISER has been successfully modified to handle the assignment of non-consumable resources, which is an np-complete problem. In addition, various interface programs are being added to deal with replanning. One of these replans when requests for new in-

formation are received before the completion of the plan being executed. Another deals with failures to execute planned steps. Still another interface program does real-time processing of external-world events and compares predictions of DEVISER with actual events. It also translates comparisons of predicted and observed events into natural language statements. Such interfaces transform a research tool into a useful component of real organizations.

Participant: Harry Porta (contact)

Diagnostics

A general-purpose diagnostician, FAITH, has been implemented with an initial application to monitoring VOYAGER (and other spacecraft) telemetry. Detection and diagnosis of errors is a major activity of mission operations that FAITH is well suited to handle. Both FAITH and DEVISER are predicate logic systems with "natural" knowledge base representations. FAITH represents declarative knowledge in essentially a frame format which the system expands into logical assertions as required. Much of the declarative representation is, in effect, a substitute for a combined system and circuit diagram. The remainder of the declarative knowledge is a natural representation of problem knowledge, similar to the hierarchy of diseases in medicine. Procedural knowledge is handled by productions. Universal modes of troubleshooting employed by humans have been modelled so that many productions are incorporated as permanent system features. The diagnostician also has a special interface package, an Execution Monitor, to monitor the telemetry stream for errors and to generate alarms. FAITH has just reached the demonstration phase, ready for testing in a real environment.

Participant: Leonard Friedman (contact)

AI Architecture

Conceptual design work is now being undertaken on a new, much more powerful reasoning engine. This would be somewhat analogous in software to a microprogrammable computer that is capable of changing instruction sets dynamically. The design goal is to dynamically specify the control structure of the reasoning engine, employing declarative and procedural knowledge bases for different control regimes. This engine will be used for research in reasoning that requires great flexibility in backward and forward chaining. An area of application may be found in carrying out G2 functions, the interpretive process of military intelligence.

Participant: Mark James (contact)

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