Research in Progress

AI Research at NASA Langley Research Center

Nancy Orlando

Kathy Abbott

James Rogers

NASA Langley Research Center
Hampton, Virginia 23665

RESEARCH IN THE FIELD of artificial intelligence is developing rapidly at the various NASA centers, including Langley Research Center in Hampton, Virginia. AI studies at Langley involve research for application in aircraft flight management, remote space teleoperators and robots, and structural optimization.

Intelligent Flight Management

The Flight Management Branch in the Flight Control Systems Division of Langley Research Center is exploring the use of AI concepts to aid flight crews in managing aircraft systems. Areas of AI that are of particular interest are expert systems, knowledge representation, and qualitative reasoning. This research effort, called Intelligent Cockpit Aids [ICA], consists of two distinct but related areas. The first area deals with the basic AI concepts necessary to provide an intelligent system. Under this area, an expert system is being developed to perform on-board fault monitoring and diagnosis. Current expert systems technology is insufficient for this application, because the flight domain consists of dynamic physical systems and must respond in real time. A frame-based system has been designed that includes a frame associated with each subsystem and sensor on the aircraft. Among other information, the frame includes a deep-level mechanism model that can be used by the diagnosis expert for hypothesis verification and predictive purposes.

Another research project in this area involves the use of a simulation model of a physical system to generate the knowledge base for fault diagnosis of that system. Failures are simulated in the model, the associated symptoms are detected from the simulation, and both fault and symptoms are automatically stored to form a "fault dictionary." Since an exhaustive fault dictionary is not feasible, use of the model for hypothesis verification is being explored. Another issue being explored is the use of qualitative reasoning, and the conditions under which qualitative knowledge is more appropriate than quantitative knowledge in a diagnostic system. This research project is being done in cooperation with Rutgers University.

The second area within the ICA research effort is the crew interface with intelligent systems. This area explores the human factors aspects of humans interacting with the intelligent on-board systems, and the underlying philosophy is the "display by exception" concept. In the currently existing cockpits, the crew must assimilate information from a vast assortment of instruments. At any time in a flight, the crew only needs to know a subset of the available information, and that subset will change depending on the phase of flight. The goal of this area is to provide information only as needed (or as requested), thereby reducing the amount of information that the crew must assimilate at any point in time. However, an intelligent system is required to determine what information the crew needs at any point in time,

and to provide an intelligent interface. The relevant areas of AI being researched for support of this area include natural language understanding, voice recognition, expert systems, and knowledge representation.

Participants: Kathy Abbott (contact)

Teleoperators and Robots for Space

The Automation Technology Branch (ATB) of the Flight Dynamics and Control Division at Langley is presently involved in researching the use of teleoperator (remotely controlled manipulation), and robotic (autonomously controlled manipulation), devices for remote space applications. The expense and the time limitations of astronauts doing extravehicular activities in space suggest the development of adjunct or alternative means of accomplishing such tasks as satellite servicing and space construction. In order to realize these capabilities, the ATB is conducting research in six major areas:

1. manipulator dynamics and control,
2. end effectors,
3 sensors,
4 operator-machine interface to automated systems,
5. distributed computers and network systems, and
6 intelligent task planning and supervision.

As a tool in this research, ATB has developed DAISIE (Distribute Artificially Intelligent System for Interacting with the Environment). This system links artificial intelligence techniques and algorithms for task planning and supervision to both a simulation environment and to actual robotic hardware in the ATB's Intelligent Systems Research Lab. This hardware includes such robotic peripherals as manipulator arms, end effectors, sensor systems, and image processors. DAISIE is also designed to serve as a supervisory controller for a human operator at a teleoperator control station.

DAISIE uses a hierarchical control structure and a network mailbox communication protocol to implement a multilingual software system on distributed processors. Hierarchical abstraction space representations of the environment are used for task decomposition and planning. Procedural "task primitives" activate the robotic peripherals and organize the sensor feedback.

Verification of the DAISIE system has been done using both LISP and PROLOG at the highest hierarchical level in a blocksworld environment. The knowledge base is now being extended to encompass realistic scenarios for satellite servicing and space construction. In addition, AI research is also being done in the area of syntax programming under an Intergovernmental Mobility Program with the College of William and Mary. Investigations are under way to determine if the power of compiler construction technology, in particular bottom-up parser generation techniques, can be harnessed to offer an efficient, highly-structured alternative to logic programming. The concept has proven feasible, and a robot

controller for DAISIE is presently being implemented using this technique.

AI algorithms are also being researched to enhance the peripheral functions of DAISIE, especially that of machine vision. Techniques of particular interest are those needed to locate objects, enhance video images, generate graphic representations of targets, and direct semi-autonomous primitive operations in remote teleoperator tasks.

Participants: Nancy Orlando (contact), Stefan Feyock, Plesent W. Goode, F. Wallace Harrison.

Structural Optimization

The Multidisciplinary Analysis and Optimization Branch in the Loads and Aeroelasticity Division is interested in expert system applications to structural optimization. The first application combines an expert system with a new optimization program called ADS (Automated Design Synthesis). ADS contains nine strategies, ten optimizers, and ten search algorithms with over 150 combinations available to a user. According to the developer, "A principal difficulty with a program of such broad capability as this is the development of a precise set of guidelines identifying the best candidate algorithms for a given class of problems." The expert system will be a rule-based system modelling the knowledge of several experts in optimization and will be used to guide an engineer in choosing the best combination of strategy, optimizer, and search algorithm for a particular problem.

When completed, this expert system can be applied in three ways:

1. The system is the expert and the user is the student. This application should be particularly useful in a classroom where the student uses his knowledge to determine his choice of options and verifies his selection with the system. If there is a difference, the user can query the system as to "why" and "how" it made its choices.

2. The machine is a colleague of the user. In this application, the user may be an engineer in industry and an expert in his own field, but may have a limited knowledge of optimization. The system would function as if it were a colleague working on a particular problem with the engineer.

3. The system is an assistant and the user is an expert in optimization. This type of user uses the system to verify that his choice of options is correct and that he has not overlooked an option.

Both LISP and PROLOG are being evaluated to determine which is preferable for this particular project. This expert system should be of great value when ADS is distributed to the public via NASA's COSMIC (COmputer Software Management and Information Center), as there presently are very few structural optimization experts in industry.

Participants: Jim Rogers (contact)