Japanese Aerospace Literature This month: *Artificial Intelligence*

N94-10251 Functional reasoning, explanation, and analysis. B. H. FAR, *Japan Atomic Energy Research Inst.,* Tokyo. 104 pp.

Functional Reasoning (FR) enables people to derive the purpose of objects and explain their functions, JAERI's 'Human Acts Simulation Program (HASP)', started from 1987, has the goal of developing programs of the underlying technologies for intelligent robots by imitating the intelligent behavior of humans. FR is considered a useful reasoning method in HASP and applied to understand function of tools and objects in the Toolbox Project. First, the results of the diverse FR researches within a variety of disciplines are reviewed and the common core and basic problems are identified. Then the qualitative function formation (QFF) technique is introduced. Some points are: extending the common qualitative models to include interactions and timing of events by defining temporal and dependency constraints, and binding it with the conventional qualitative simulation. Function concepts are defined as interpretations of either a persistence or an order in the sequence of states, using the trace of the qualitative state vector derived by qualitative simulation on the extended qualitative model. This offers solutions to some of the FR problems and leads to a method for generalization and comparison of functions of different objects. (DOE)

A93-16053 Design of composite materials by using an intelligent finite-element method. II—Consideration of strength, weight and cost. MASARU ZAKO and TETSUYA TSUJIKAMI, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 41, No. 468, Sept. 1992, pp. 1440–1445.

A PC program has been developed by using an intelligent FEM to analyze the construction and stacking sequence of laminates by which some design objectives can be satisfied. The strength, weight, and cost of the laminate are selected as the design goals.

N92-23011 A study on information analysis aids system for sea surface temperature maps. HAJIME KOSHIISHI, MASAO NAKA, HIROMICHI YAMAMOTO, KOHTARO MATSUMOTO, KOHZO HOMMA, SATSUKI MATSUMURA, HIDEO TAKAHASHI, SATORU NAKAMURA, HIDEO TAMEISHI, YOSHIHIRO OKADA et al., *National Aerospace Lab.,* Tokyo (Japan).

In this study, a feasibility study on information analysis aids system for sea surface temperature image data using knowledge based processing technology has been performed. Oceanic conditions such as fronts, ocean currents, and eddies are very useful for fisheries. For extracting these oceanic conditions, the accumulated knowledge and inherited experience are indispensable, and the simplicity of the processing and the objectivity of the result are important. The knowledge based processing system has great possibilities of dealing with these problems. In this paper, the existing expert knowledge and experience used in the process of recognizing oceanic conditions are analyzed for the systematization. Furthermore, the basic structure and the implementation of a prototype knowledge based system are described. The system has been proven to work successfully in a set of experiments using MOS-1 (Marine Observation Satellite-1) VTIR (Visible and Thermal Infrared Radiometer) data.

N92-21394 Automatic recognition of facility drawings, part 1. C. NAKAJIMA and T. YAZAWA, *Central Research Inst. of Electric Power Industry,* Tokyo (Japan). 24 pp.

By applying artificial-intelligence pattern recognition technology, a technology was developed to automatically read the contents of a facility's configuration drawings, and efficiently computerize them. The image identification by the first system stage determines, after optically reading figures automatically, what kind of figures are used in the drawing. The second stage is the meaning-understanding process which identifies the meaning of the drawings and stores them in a data base. The identification was tested using an electronic circuit drawing expressing a binary adder as an example. The image identification process identified correctly the symbols indicating logic elements and the wiring diagram. However, the process committed some erroneous identifications in characters. As a result of comparing a drawing model describing the general circuitry of the binary adder with the result obtained from the above figure identification process, it was found that the meaning-understanding process also makes a correct determination.

A92-23675 Self-organization in cellular robotic system (CEBOT) for space application with knowledge allocation method. TOSHIO FUKUDA, TSUYOSHI UEYAMA, and YOSHIO KAWAUCHI, *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 101–104.

A hardware is developed for a cellular robotic system (CEBOT) which is designed for the application to a space robot, and automatic docking between cells is realized by using air thrusters. As an analysis of CEBOT software, matrices are proposed; a knowledge-based structure matrix and task matrix are shown which can describe various states of the cell connection and knowledge allocation. By using these proposed matrices, the automatic knowledge allocation is performed effectively and the simulation results are also dealt with.

A92-23728 Concept and exemplary realization of intelligent robot control in space. E. FREUND and CH. BUEHLER, *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 341–344.

The integration of autonomous multiple robot systems in a space environment is a challenging problem concerning the design of the entire system and the related control structure. Components of different levels of intelligence and activity have to cooperate in the overall system, where the direct intervention of human operators should be possible in case of contingency. Since the development and implementation of the full capabilities of such a complex, intelligent system cannot be realized all at once, the automation concept has to be modular and open for new extensions in the future. In this context the development of control structures for space robots is of special interest. Here components for planning, knowledge based diagnosis, coordinated motion control based on multiple sensors, collision avoidance and man-machine communication are of high importance to provide autonomous and flexible responses of the system in a changing environment. Such kind of hierarchical control architecture for intelligent robot control in space is presented. The benefit of the proposed control structure for space robotic systems is studied on the exemplary realization of a fully automated space laboratory.

A92-23704 Intelligent perturbation algorithms for space scheduling optimization. CLIFFORD R. KURTZMAN, National Aeronautics and Space Administration, Washington, DC. *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 233–236.

The optimization of space operations is examined in the light of optimization heuristics for computer algorithms and iterative search techniques. Specific attention is given to the search concepts known collectively as intelligent perturbation algorithms (IPAs) and their application to crew/resource allocation problems. IPAs iteratively examine successive schedules which become progressively more efficient, and the characteristics of good perturbation operators are listed. IPAs can be applied to aerospace systems to efficiently utilize crews, payloads, and resources in the context of systems such as Space-Station scheduling. A program is presented called the MFIVE Space Station Scheduling Worksheet which generates task assignments and resource usage structures. The IPAs can be used to develop flexible manifesting and scheduling for the Industrial Space Facility.

A92-23691 A Thermal Expert System (TEXSYS) development overview—AI-based control of a Space Station prototype thermal bus. B. J. GLASS and E. C. HACK, National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA. *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 175–178.

A knowledge-based control system for real-time control and fault detection, isolation and recovery (FDIR) of a prototype two-phase Space Station Freedom external thermal control system (TCS) is discussed in this paper. The Thermal Expert System (TEXSYS) has been demonstrated in recent tests to be capable of both fault anticipation and detection and real-time control of the thermal bus. Performance requirements were achieved by using a symbolic control approach, layering model-based expert system software on a conventional numerical data acquisition and control system. The model-based capabilities of TEXSYS were shown to be advantageous during software development and testing. One representative example is given from on-line TCS tests of TEXSYS. The integration and testing of TEXSYS with a live TCS testbed provides some insight on the use of formal software design, development and documentation methodologies to qualify knowledge-based systems for on-line or flight applications.

A92-23690 Approach in construction of diagnostic expert system for environmental control equipment in space. NOBUYOSHI MUROI, YUICHI MIYAMOTO, and IKUO AKEYAMA, *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 171–174.

The development of a fault-diagnosis expert system is described in terms of the component systems such as the inference engine and aerospace applications. The fault-diagnosis system is a knowledge-based system that employs functions of qualitative and continuous simulations and the inference engine to construct the suitable knowledge base. The concept is applied to the construction of a knowledge base for environmental control equipment. Rules for directed relationships between the functional blocks are generated automatically, interrelations between factors are extracted, and state changes are identified that can cause problems. A backtrack function is also incorporated which permits the system to trace the cause and effects of the problem phenomenon. The environmental control system shows the effectiveness of the general-purpose expert-systems building tool.

A92-23703 Autonomic spacecraft system in future. JUN-ICHI AOYAMA, MASAO FURUICHI, MASA-AKI KIMURA, YUKIO AMANO, KATSUO SINOZUKA, and KIMIO UCHIYAMA, *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 229–232.

The significance of the autonomic system is to reduce the burden of an earth station, and by reducing abnormal condition response time, make an effective use of limited spacecraft lifetime. One of the key elements of such self-diagnostic capabilities would be an inference system. Based on a knowledge data base equivalent to spacecraft experts, the inference system's function is to identify the cause of an abnormal condition from condition data monitors on each part of a spacecraft and take appropriate action. This report focuses on the inference system and introduces a few examples to meet the trends in the future spacecraft development.

A92-23696 Structuring a knowledge base for real-time diagnosis. RICK SMITH, *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 197–200.

This paper describes a knowledge base (KB) organization useful for real-time diagnostic systems. The organization is based upon previous work in diagnostic systems, and is modeled after the typical diagnostic process employed by human experts. The basic structure involves breaking the KB into three major sections: information gathering, hypothesizing, and solutions. Benefits of this KB organization include efficient use of the system knowledge, a structured KB which helps verification and validation, and a 'natural' knowledge organization which helps simplify the knowledge acquisition process. The organization is most readily applied to rule-based knowledge representations, however, the general concepts are applicable for other knowledge representations. To illustrate these concepts, a knowledge-based system (KBS) for real-time monitoring and diagnosis in the spacecraft electrical power domain is described.

A92-23695 LDEXPT, an intelligent database system for the Composite Load Spectra project. H. HO, J. F. NEWELL, D. HOPKINS, and C. C. CHAMIS, National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 193–196.

The Composite Load Spectra project develops probabilistic models to simulate the probabilistic loads for selected components of a generic space propulsion system. Tremendous information such as engine load variables and their distributions is needed by the simulation program. An intelligent data base system was constructed and integrated with the probabilistic load simulation program to manage and maintain the knowledge base of the Composite Load Spectra project. The intelligent data base system takes care of the data retrieval and storage functions and has expert knowledge on engine load models and associated engine variables. The integration of the intelligent data base into the load simulation program achieves a smooth coupling between the numeric processing (load simulation calculation) and the symbolic processing (intelligent load information management).

A92-23693 AI technology and application development on the Shuttle project. DOC SHANKAR, *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 185–188.

Projects related to artificial intelligence (AI) are reviewed that are designed to support Space Shuttle activities including applications concepts and technological developments. Specific descriptions are given of performance tests for flight software and hardware to analyze relevant applications. Reference is given to launch-abort analysis, shuttle hardware diagnostics, mission-data determination, Shuttle/Spacelab interface diagnostics, cold start initialization, and software code reviews. AI technological developments include a real-time embedded expert system, knowledge acquisition, neural networks for improving productivity, automated program composition, software reengineering and AI coprocessors. Some of the AI expert systems are in use as production systems, and the areas for AI applications are growing.

N92-15388 Numerical simulation of biped locomotion robot. ETSUO KUME, *Japan Atomic Energy Research Inst.,* Tokyo. 89 pp.

The Human Acts Simulation Program (HASP) has been performed since 1987 at JAERI. In this program, a human-shaped robot reads and understands instructions written in natural languages such as Japanese, planning and producing a required sequence of actions, approach to a device or an instrument recognizing its entity and does the ordered work for plant maintenance. All of these processes are simulated by logical and numerical computations. The major aim of the HASP is to develop fundamental technologies for the design of intelligent robots. This report will describe the simulation methods and results of a human-shaped robot motions. The simulation methods of the robot's arms and robot's start and stop motions have been newly developed based on the steady walking model with fixed arms developed by M. Vukobratovic. The influence of arm motions to the stable walking and the continuous connection from start to steady walking, etc. will be discussed.

A92-23689 Automated Spacelab Stowage Expert System for SLS missions. C. Y. KAO, National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX. *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 167–170.

Issues related to the development of the Automated Spacelab Stowage Expert System (ASSESS) are examined including the problem domain, design, and status. The ASSESS concept is designed to configure stowage items into Spacelab lockers with an expert-system approach in which knowledge is available for every item and locker and for the complete heuristics. ASSESS employs the Knowledge Engineering Environment for development, and graphic displays present data on the items, lockers, and general system status. The automatic and manual modes are presented; the former provides the capability for an automatic solution to the stowage of a set of items into Spacelab lockers based on stowage heuristics defined and/or set by the user. The approach and heuristics algorithms are shown to permit the effective practical solution of NP-hard problems.

A92-23683 The Katydid system for compiling KEE applications to Ada. ROBERT E. FILMAN, CONRAD BOCK, and ROY FELDMAN, National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 141–144. 5 Refs.

Components of a system known as Katydid are developed in an effort to compile knowledge-based systems developed in a multimechanism integrated environment (KEE) to Ada. The Katydid core is an Ada library supporting KEE object functionality, and the other elements include a rule compiler, a LISP-to-Ada translator, and a knowledge-base dumper. Katydid employs translation mechanisms that convert LISP knowledge structures and rules to Ada and utilizes basic prototypes of a run-time KEE object-structure library module for Ada. Preliminary results include the semiautomatic compilation of portions of a simple expert system to run in an Ada environment with the described algorithms. It is suggested that Ada can be employed for AI programming and implementation, and the Katydid system is being developed to include concurrency and synchronization mechanisms.

A92-23663 SAOTS—An operator assistant system for robot telemanipulation. FREDERIC VAUTE and MARIO DELAIL, *Proceedings of the International Symposium on Artificial Intelligence, i-SAIRAS '90; Robotics and Automation in Space,* Kobe, Japan, Nov. 18–20, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 53–56.

The operator-assistant system known as SAOTS is described in terms of the knowledge-acquisition and representation methodologies of the computer system for robotics applications. The SAOTS system is designed to give a human operator a user-friendly interface for facilitating the piloting of the remote arm with a real-time computer. The knowledge-based system is based on object-oriented representation, and the system hardware includes multiprocessored dedicated calculators and two 3-DOF joysticks. The key feature of the operator-assistant concept is that it is well integrated in an asynchronous dynamic reactive process. Flexibility and modularity are considered critical features of the system since these qualities permit evolutionary use. The system is presently employed for laboratory investigations of studying a satellite effecting an in-flight grasping mission with a telemanipulated robotic arm.

N91-32033 Application of AI to engineering problems. SETSUO OHSUGA, Tokyo Univ. (Japan). Research Center for Advanced Science and Technology. *Proceedings of the 8th NAL Symposium on Aircraft Computational Aerodynamics, National Aerospace Lab.,* pp. 1–9 (SEE N91-32032 24-01)

A computer was developed, which showed its effectiveness as a support tool to solve deterministic problem. This computer accepts computing procedures and numerical quantities written in advance and processes these rapidly. There are some problems, however, that are not suited to be solved in this framework of computer. A typical example of such types of problems is design problem. AI (Artificial Intelligence) is expected to realize a new method of information processing and expand the scope of applications over the current computers involving non-deterministic problems such as design. Recently Expert Systems were developed as an implementation of AI concept. But these systems are not yet powerful enough for being applied to the problems in the real world. The reason why current Expert Systems are not powerful enough is analyzed. A new framework of AI systems is proposed. A system named KAUS is presented with some applications to design problems.

A91-46594 The role of intelligence for aircraft. KOHTARO MATSUMOTO and AKIRA WATANABE, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 38, No. 437, 1990, pp. 276–283. 25 Refs.

The concept of the intelligent cockpit is described, and the use of expert systems and artificial intelligence in aviation is discussed. The general context of the discussion is the implementation of fly-by-wire systems. A table listing the characteristics of various intelligent and expert systems in aviation is provided, including such systems as EPES, the Expert Navigator, FLES, HEAT, the Pilot's Associate, SARA, and CAS.