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SHINE (Spacecraft Health Inference Engine) Expert System & its Applications

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Abstract—*Spacecraft Health Inference Engine (SHINE) is a software-development tool for knowledge-based systems and has been created as a product for research and development by the Artificial Intelligence Group, Information Systems Technology Section at NASA/JPL to meet many of their demanding and rigorous AIgoals for current and future needs. The system is now in regular use in basic and applied AI research at JPL. SHINE was developed as a system that was designed to be efficient enough to operate in a real-time environment and to be utilized by non-LISP applications written in conventional programming languages such as C and C++. [1]*

These non-LISP applications can be running in a distributed computing environment on remote computers or on a computer that supports multiple programming languages. It provides a variety of facilities for the development of software modules for the primary functions in knowledge-based reasoning engines. The system may be used to develop artificial intelligence applications as well as specialized tools for research efforts. It used for various applications at NASA (National Aeronautics & Space Administration) in fields of Artificial intelligence automatic aircrafts and fields of robotics. [3]

In this I have focused on working procedure of SHINE expert system and NASA different mission in space by used SHINE expert system. It also contains

The architecture of the JPL (Jet Propulsion Laboratory).

Keywords: *Artificial intelligence, SHINE(Spacecraft Health Inference Engine) architecture, SHARP (Spacecraft Health Automated Reasoning Pilot), JPL (Jet propulsion Laboratory), NASA deep space network. [5]*

1. INTRODUCTION

SHINE is based on technology first developed by James and Atkinson for the "STAR*TOOL" system. SHINE itself resulted from applying this technology in a project called "Spacecraft Health Automated Reasoning Pilot" (SHARP). SHARP aimed to automate and provide expert system consultation to space flight operations personnel who monitor and diagnosis robotic spacecraft on science missions, such as the Voyager spacecraft. [5]

The SHINE authors from the NASA Jet Propulsion Laboratory, M. James and D. Atkins, previously received a Space Act Award and Software Award for "SHINE Inference Engine" in 2005 additional SHINE related Space Act Awards including "A Data Flow Compiler for Spacecraft Models of Vehicle Flight Systems", and "Optimal Rule Ordering by a Multi-variant Density Transfer Function Using Data Flow Path Analysis" were received in 2005 and 2006. According to co-developer, Mark James, who is also a consultant to VIASPACE Security, "The SHINE development objective was to produce a real world, practical expert system that enables the effective delivery of a class of applications that were previously intractable because o performance and system resource bottlenecks. SHINE can be used in applications in which high performance, real-time capabilities, and ease of deployment are of critical importancesystems. SHINE programs are executed directly by the LISP interpreter and compiled directly by the LISP compiler. This means much greater speed and better portability to other machines. SHINE is a set of high level and low level software tools designed to assist in building stand-alone knowledge-based system applications, shells and tools. SHINE is an optimizing compiler-based system. When an application is developed using SHINE, it is first translated into Common LISP code and then passed through an extensive optimizer. SHINE generates tailored code for each application. There are no intermediate levels of interpretation for execution unlike many commercial [4]

SHINE comes with libraries that implement most common problem solving techniques and representations. This means that you can make use of classical AI solutions that have been extensively used and tested by other users. These libraries can also be extended by your own problem solving techniques and representations. SHINE facilities are invoked directly by a programmer in the Common Lisp language. For improved efficiency, an optimizing compiler is included that generates highly optimized Common LISP code. SHINE allows embedded software written in other programming languages such as C, C++, and also permits software developed with the system to be part of larger, non-Common LISP applications.[1][6]

2. ARTIFICIAL INTELLIGENCE

The artificial intelligence is the branch of the computer science. It has responsibility to making the intelligent machine to perform the automatic work by help of machine.

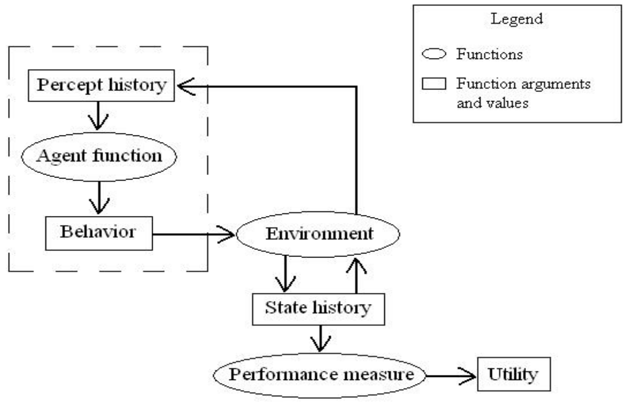

Fig. 1: Artificial intelligence

3. SHINE ARCHITECTURE

It is intended for those areas of inferencing where speed, portability and reuse is of critical importance. Such areas would include spacecraft monitoring, control and health, telecommunication analysis, medical analysis, financial and stock market analysis, fraud detection (e.g. banking and credit cards), robotics or basically any area where rapid and immediate response to high-speed and rapidly changing data is required. [7]

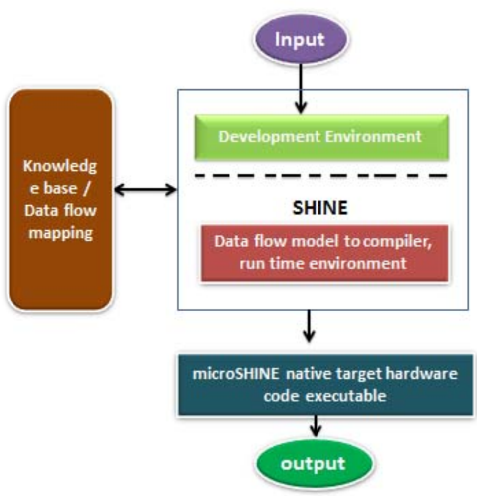

Fig. 2: Block diagram of SHINE Expert system

SHINE was independently evaluated by UC Berkeley and was shown to significantly outperform commercially available inference engines such as RTI and ART. It executes approximately 500,000,000 plus rules a second running on a standard Windows PC. [3]

- SHINE is written in Common LISP and can be easily run on any system that supports the language. It has been successfully interfaced to many non-LISP systems without any problems.
- VIASPACE has the Caltech licensing rights to most commercial applications of SHINE. They are currently working on both product and commercial enhancements to the SHINE technology as well as several Expert System applications in both the Defense and Security markets.

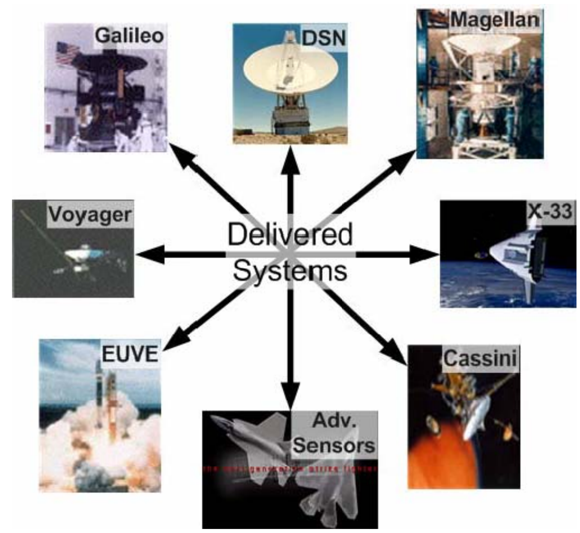

Fig. 3: Various applications of SHINE expert system

3.1. Galileo

Galileowas a robotic NASA spacecraft which studied the planet Jupiter and its moons, as well as several other Solar System bodies. Named after the astronomer Galileo Galilei, it consisted of an orbiter and entry probe. It was launched on October 18, 1989, carried by Space Shuttle Atlantis, on the STS-34 mission.[8]

Fig. 4: Galileo spacecraft mission

3.2. DCN (Deep Space Network)

The Deep Space Network (DSN) is a world-wide network of large antennas and communication facilities, located in California, Spain, and Australia, that supports interplanetary spacecraft missions. It also performs radio and radar astronomy observations for the exploration of the solar system and the universe, and supports selected Earth-orbiting missions. DSN is part of the NASA Jet Propulsion Laboratory(JPL). Similar networks are run by Europe, Russia, China, India, and Japan.[5]

Fig. 5: Deep space network Antennas system

3.3. Magellan

The Magellan spacecraft, also referred to as the Venus Radar Mapper, was a 1,035-kilogram (2,282 lb) robotic space probe launched by NASA on May 4, 1989, to map the surface of Venus by using synthetic aperture radar and to measure the planetary gravitational field.[8]

Fig. 6: Magellan mission

3.4. X-33

The Lockheed Martin X-33 was an unmanned, sub-scale technology demonstrator suborbital space plane developed in the 1990s under the U.S. government-funded Space Launch Initiative program. The X-33 was a technology demonstrator for the Venture Star orbital space plane, which was planned to be a next-generation, commercially operated reusable launch vehicle. [5]

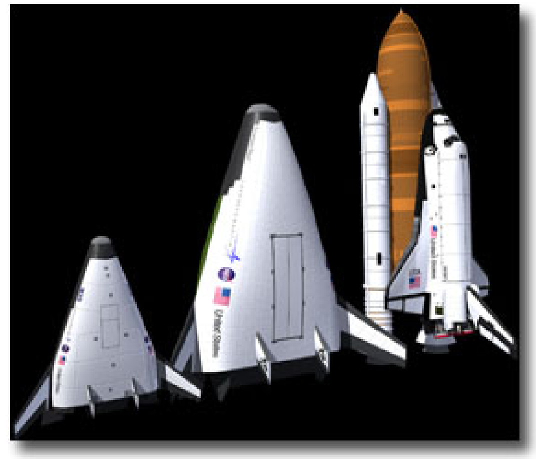

Fig. 7: X-33 Space plane

3.5. EUEV

The Extreme Ultraviolet Explorer (EUVE) was a space telescope for ultraviolet astronomy, launched on June 7, 1992. With instruments for ultraviolet (UV) radiation between wavelengths of 7 and 76 nm, the EUVE was the first satellite mission especially for the short-wave ultraviolet range. [2][4]

Fig. 8: EUEV space telescope

Advanced Very High Resolution Radiometer (AVHRR) instruments are a type of space-borne sensor that measure the reflectance of the Earth in 5 relatively wide (by today's standards) spectral bands. Most AVHRR instruments are or have been carried by the National Oceanic and Atmospheric Administration (NOAA) family of polar orbiting platforms (POES). [4]

3.6 VOYAGE

The Voyager program is a continuing American scientific program that employs two robotic probes, Voyager *1* and Voyager *2*, to study the outer solar system. They were launched in 1977 to take advantage of a favorable alignment of Jupiter, Saturn, Uranus, and Neptune, and are now exploring the outer boundary of the heliosphere. Although their original mission was to study only the planetary systems of Jupiter and Saturn, Voyager *2* continued on to Uranus and Neptune, and both Voyagers are now tasked with exploring interstellar space.

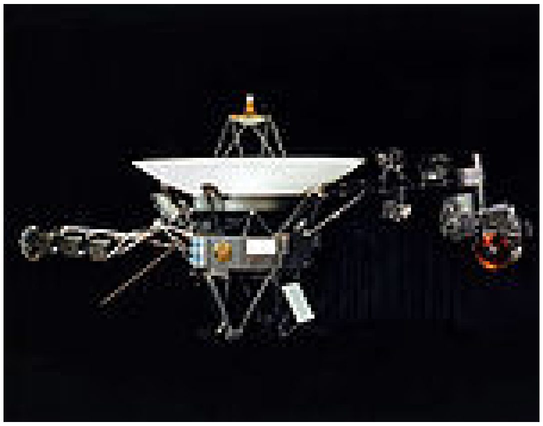

Fig. 9: Voyager program

4. JPL (JET PROPULSION LABORATORY)

The JPL is managed by the nearby California Institute of Technology (Caltech) for the National Aeronautics and Space Administration. The laboratory's primary function is the construction and operation of robotic planetary spacecraft, though it also conducts Earth-orbit and astronomy missions

The Jet Propulsion Laboratory (JPL) is a federally funded research and development center and NASA field center located in La Canada Flintridge, California, United States.

Fig. 10: Control center of JPL

The JPL is managed by the nearby California Institute of Technology (Caltech) for the National Aeronautics and Space Administration. The laboratory's primary function is the construction and operation of robotic planetary spacecraft, though it also conducts Earth-orbit and astronomy missions. It is also responsible for operating NASA's Deep Space Network. [8]

- The tools JPL has developed for space exploration have also proved invaluable in providing new insights and discoveries in studies of Earth, its atmosphere, climate, oceans, geology and the biosphere. The ongoing invention of ever more-sensitive space sensors has also resulted in a myriad of technology applications widely used for medical, industrial and commercial uses on Earth. JPL is a federally funded research and development facility managed by the California Institute of Technology for the National Aeronautics and Space Administration
- JPL's history dates to the 1930s, when Caltech professor Theodorevon Kármán oversaw pioneering work in rocket propulsion.Von Kármán was head of Caltech's Guggenheim AeronauticalLaboratory.[5]

4.1 Mission of the JET (Jet Propulsion Laboratory)

The JPL (Jet Propulsion Laboratory) is useful for handling the many operation by help of SHINE expert system. The SHINE expert system has many responsibilities under the JPL (Jet propulsion Laboratory). JET also contains the many departments of many fields like robotics, artificial intelligence, space mission, flight research and so own

- Explorer program
- Ranger program
- Surveyor program
- Mariner program
- Pioneer 3 & 4& others

5. SHARP (SPACECRAFT HEATH AUTOMATED INFERENCE PILOT)

The Spacecraft Health AutomatedReasoning Prototype (SHARP) introduces automation and artificial intelligence technologies to the process of monitoring spacecraft operations. One of the goals of SHARP is the elimination of much of the mundane processing and tedious analysis currently required of operations personnel. Another goal is to provide faster and more reliable identification of errors that occur during a spacecraft mission than is currently available. The major automated functions provided by the SHARP system include. [5][1]

- Real-time anomaly detection and diagnosis;
- Visualization of channelized data and system status;
- Acquisition and centralization of operations data in a single workstation, including real-time spacecraft and ground system engineering data, sequence of events, and alarm tables;

- Real-time analysis of spacecraft performance predictions;
- Integration with specialized numerical analysis software, e.g., fast Fourier transforms for determining spacecraft antenna pointing accuracy.[5][4]

The SHARP prototype was developed for use in the Voyager telecommunications (telecom) monitoring area. The SHARP system provides telecom personnel with an environment that allows them to have a more complete understanding of how the telecommunications link is functioning between a spacecraft and the Deep Space Stations (DSS). Deep Space Station sites are located at Goldstone, California, Madrid, Spain, and Canberra, Australia, and collectively form the Deep Space Network (DSN).[2]

The SHARP Technology Transfer work unit will initiate the process of making the technology embodied in SHARP available for support of space flight operations. Specific objectives are to: Provide expert system capabilitiesfor monitoring spacecraft health in the SFOC environment in a manner that utilizes SFOC data sources and operates gracefully with other SFOC features. [2]

6. APPLICATION AREA OF SHINE EXPERT SYSTEM IN NASA AND NON–NASA FIELDS

- Spacecraft Health Automatic Reasoning Pilot (SHARP) for the diagnosis of telecommunication anomalies during the Neptune Voyager (VGR) Encounter.
- Galileo (GLL) mission for diagnosing problems in the Power and Pyro Subsystem (PPS).
- Engineering Analysis Subsystem Environment (EASE) which is an operations environment to operate a large number of spacecraft simultaneously, maintain high reliability levels and increase productivity through shared resources and automation.
- Extreme Ultraviolet Explorer (EUVE) mission for labor 3 to 1 shift reductions through the use of artificial intelligence..
- Stochastic Problem Obviation Tracker (SPOT) for the EUVE mission which captures and reports relevant statistical information to the user based on operations within the FIDO environment.
- Under consideration by a medical company for real-time diagnosis of rectal colon cancer.
- Under consideration by a medical company for an expert system for the control of the robotic systems used in eye surgery.[1]

7. FUTURE WORK

The Spacecraft Health Inference Engine (SHINE) is a software-development tool for knowledge-based systems and has been created as a product for research and development by the Artificial Intelligence Group and various application of JPL (Jet Propulsion Laboratory) of NASA (National Aeronautics & Space Administration). In this paper I have focused on some approach that is used in the handling the various application in NASA and many research operation. The SHINE expert system has responsible to handling the huge and very complex application of space. In future some technologies remove the limitation of SHINE and improve its complexity and also generate the new technology that can handle the more complex task and can improve the speed of operations.

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