Future Applications of Artificial Intelligence to Mission Control Centers

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Basic Objectives of the NASA-Wide AI Program

• To Conduct Artificial Intelligence Research, Tool Development, and Application Construction in the Context of Short, Medium, and Long-Term Agency Needs

• To Build Internationally Recognized Artificial Intelligence Laboratories at Ames Research Center and the Jet Propulsion Laboratory

• To Promote Technology Transfer at All of the NASA Research, Manned Space Flight, and Space Science Centers

• To Develop an Academic/Industrial/Governmental Team of Collaborative Scientists and Engineers to Further Both NASA and the Nation's Goals in Artificial Intelligence Research and Development
Inhouse Research Program

- **Major Thrusts in:**

  - **Planning**
    - Combinatorial, Constraint-Based Scheduling
    - "Anytime" Re-Scheduling
    - Multi-Agent Planning
    - Reactive Planning (Intelligent Agents)

  - **Learning**
    - Data Analysis and Classification
    - Theory Formation
    - Learning Architectures
    - Automatic Improvement in Problem-Solving

  - **Design of and Reasoning about Large-Scale Physical Systems**
    - Knowledge Acquisition during Design
    - Model-Building and Simulation
    - Knowledge Maintenance and Retrieval
    - Symbolic Control
Constraint-Based Scheduling

Goals: Applying AI methods to the solution of complex scheduling and resource allocation problems. Particular focus on "satisficing solutions" and anytime re-scheduling.

Project Leader: Monte Zweben

Major Collaborators: Lockheed AI Center (Bob Gargan), Lockheed Space Operations Company, KSC Systems and Technologies Office (Astrid Heard)

Inhouse Effort: 3.5 FTE

Characterization: Basic and Applied Research, Tool Development, Applications

Current Domains: STS Orbiter Processing at KSC, Wind Tunnel Operations

Start Date: 10/87

Projected Length: Indefinite

Fund Source: OAET AI Program, OSF Code MD
Learning and Performance Improvement for Scheduling

Goals: The integration of machine learning methods with scheduling systems to develop schedulers which improve their performance over time.

Project Leader: Steve Minton

Major Collaborators: STSCI (Mark Johnston)

Inhouse Effort: 2 FTE

Characterization: Basic Research, Applied Research, Tool Development

Domain Applicability: HST Science Scheduling

Start Date: 10/88

Projected Length: 5 Years

Funding Source: OAET AI Program
GEMPLAN Multi-Agent Planner

Goals: Develop methods for generating multi-agent plans for domains with complex coordination requirements.

Project Leader: Amy Lansky

Inhouse Effort: 2 FTE

Characterization: Basic Research, Tool Development

Domain Applicability: EOS Operations Planning (u. i.)

Start Date: 12/89

Projected Length: 5 Years

Fund Source: OAET AI Program, NSF
Planning, Scheduling, and Control

Goals: Research on planning systems capable of monitoring plan execution, noting and correcting plan failures, and re-planning when appropriate. This involves the integration of AI-based systems with classical scheduling and discrete event control theories.

Project Leader: Mark Drummond

Major Collaborators: Teleos Research (Stan Rosenschein), DARPA/ISTO

Inhouse Effort: 5 FTE

Characterization: Basic Research, Applied Research

Domain Applicability: Planetary Rover

Start Date: 10/88

Projected Length: 10 Years

Fund Source: OAET AI Program, AFOSR, DARPA/ISTO
Bayesian Learning

Goals: Development and application of Bayesian data analysis techniques to classification of large-scale, potentially noisy NASA databases.

Project Leader: Peter Cheeseman

Inhouse Effort: 5.5 FTE

Characterization: Basic and Applied Research, Tool Development

Domain Applicability: IRAS Data, CalSpace Cloud Data, LandSat Data

Start Date: 10/86

Projected Length: Indefinite

Fund Source: OAET AI Program
Efficient Learning Algorithms

Goals: Develop efficient methods to predict normal and abnormal operations of complex devices from telemetry data analysis. Allow such systems to adapt to changing conditions.

Project Leader: Phil Laird

Inhouse Effort: 2 FTE

Characterization: Basic Research

Domain Applicability: Future Life Support and Vehicle Monitoring Systems

Start Date: 2/88

Projected Length: Indefinite

Fund Source: OAET AI Program
ICARUS: An Integrated Architecture for Learning

Goals: Develop a software architecture that can recognize and classify complex physical objects, generate actions plans, and control the execution of motor skills. Utilize the cognitive model of expanding and improving a long-term memory by use of machine learning techniques.

Project Leader: Pat Langley

Inhouse Effort: 6 FTE

Characterization: Basic Research

Domain Applicability: Autonomous Assembly and Exploration Tasks, Diagnosis Tasks, DTA/GC Data Classification

Start Date: 10/89

Projected Length: 10 Years

Funding Source: OAET AI Program
Design Knowledge Acquisition and Retention

Goals: Develop an "electronic designer's notebook" capable of retaining conceptual design knowledge (including alternative designs and tradeoffs) in a form usable throughout the device life-cycle both by humans and automated systems.

Project Leader: Catherine Baudin

Major Collaborators: Stanford University Center for Design Research (Larry Leifer)

Inhouse Effort: 1.5 FTE

Characterization: Applied Research, Tool Development

Domain Applicability: SIRTF Tertiary Mirror Design, NASP Design (u. i.)

Start Date: 10/88

Projected Length: 5 Years

Fund Source: OAET AI Program, DARPA/ISTO
Computer-Integrated Documentation

Goals: Integration of AI and hypermedia technology to provide enhanced access to voluminous documentation. Use of dynamic knowledge acquisition techniques to build user models and provide context-dependent indexing.

Project Leader: Guy Boy

Major Collaborators: ARC Code FL (Irv Statler), SSF Level I Engineering (Mark Gersh), SSF Level II TMIS (Mike Freeman)

Inhouse Effort: 2.5 FTE

Characterization: Applied Research, Tool Development

Domain Applicability: STS Mission Control Center and Onboard Manuals, SSF Documentation Stored in TMIS

Start Date: 10/89

Projected Length: 3 Years

Fund Source: OAET AI Program, SSF AD Program
Some Speculation on Future Applications

- Planning and Scheduling
  - Reactive Re-Scheduling of Missions under Prevailing Time Constraints
  - Assistance in Playing "What If" Games During Missions
  - Coordination of Different Discipline Decisions

- Knowledge Acquisition and Maintenance
  - Ready Access to Life-Cycle Information
  - Electronic Documentation Integrated with Diagnostic Systems

- Physical Systems Reasoning
  - Model-Based Fault Detection and Recovery
  - Assistance in "on-the-Spot" Procedure Development

- Machine Learning
  - Automatic Induction of Fault Detection Rules
  - Learning to Diagnose in the Presence of System or Sensor Faults
  - Learning Apprentice Systems
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