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Future Applications of Artificial Intelligence to Mission Control Centers

Peter Friedland
Chief, AI Research Branch (FIA)

Control Center Technology Conference
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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
    - Combinatoric, 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

Author List