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NASA Intelligent Systems Project: Results, Accomplishments and Impact on Science Missions.

Abstract

The Intelligent Systems Project was responsible for much of NASA's programmatic investment in artificial intelligence and advanced information technologies. IS has completed three major project milestones which demonstrated increased capabilities in autonomy, human centered computing, and intelligent data understanding. Autonomy involves the ability of a robot to place an instrument on a remote surface with a single command cycle, human centered computing supported a collaborative, mission centric data and planning system for the Mars Exploration Rovers and data understanding has produced key components of a terrestrial satellite observation system with automated modeling and data analysis capabilities. This paper summarizes the technology demonstrations and metrics which quantify and summarize these new technologies which are now available for future NASA missions.

Key Accomplishments

Autonomy Milestone 3.4 Completed 9/2004

- Milestone: Simulated autonomous science exploration mission
- Completion date for milestone: 9/30/2004
- Indicator: Demonstrate goal-directed commanding of science rovers in order to increase the science productivity of these missions
- Metric: Conclusion of a successful analogue science mission (terrestrial rover or simulated spacecraft) demonstrating goal-directed systems for exploration missions. Technologies: planning/scheduling, science data priority assignment, system executives, and diagnostic systems.

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Key Technical Accomplishments

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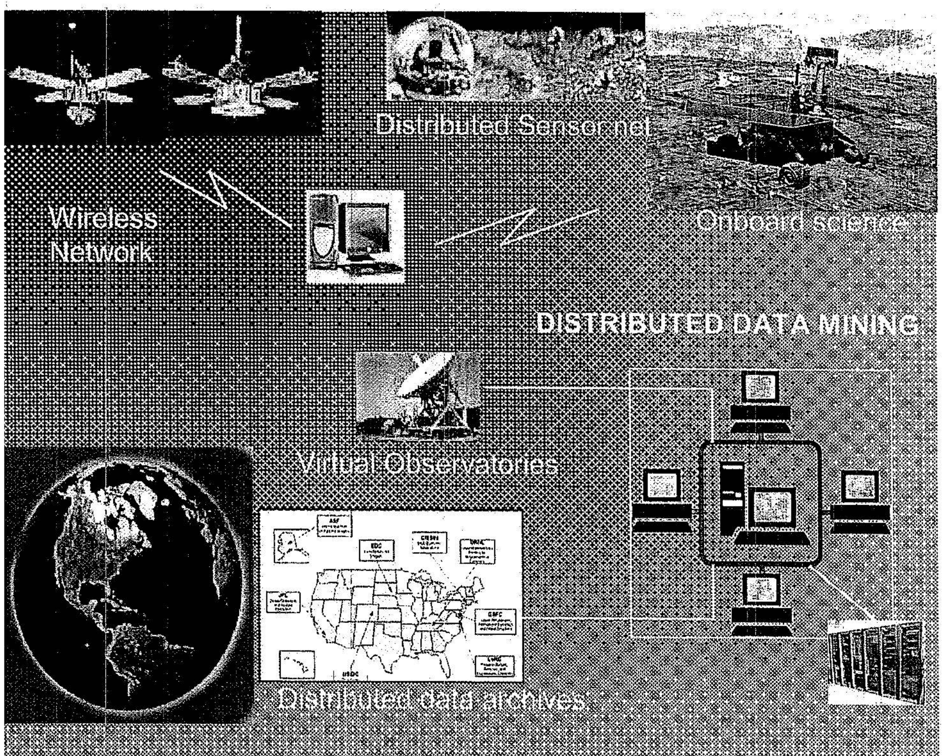
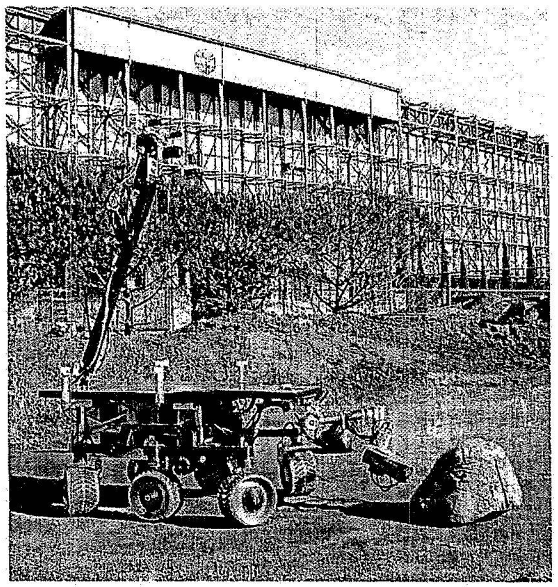


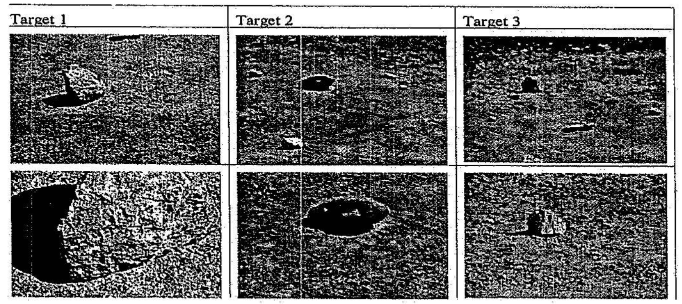
Demonstrate ability to perform data mining on a mixed format database containing at least 2 distributed data sets with different formats

Distributed mining:

- Mining NASA Data Assimilation Office data & NOAA AVHRR data.
- Mining virtual observatory: Sloan Digital Sky Survey (SDSS) and the 2MASS All-Sky Survey.
- Data Mining Capabilities:
  - Distributed statistical aggregates
  - Distributed Bayesian network learning.
  - Distributed decision tree learning
- Learn local models with sampling and then transmit model summaries.
- Tradeoff between minimizing site-to-site data transfer and maximizing data mining accuracy.
- With method, experimentation shows 10% communication cost (compared to sending the full data set) yields 90% accuracy (compared to the mining the full data set).

•Project 1: Automomous Instrument Placement. Build capabilities for an exploration rover to rapidly and reliably do multiple close-up and *in situ* contact measurements of objects in an unstructured, unpredictable environment, *without* continuous operator supervision. (PI: Pedersen, NASA ARC)

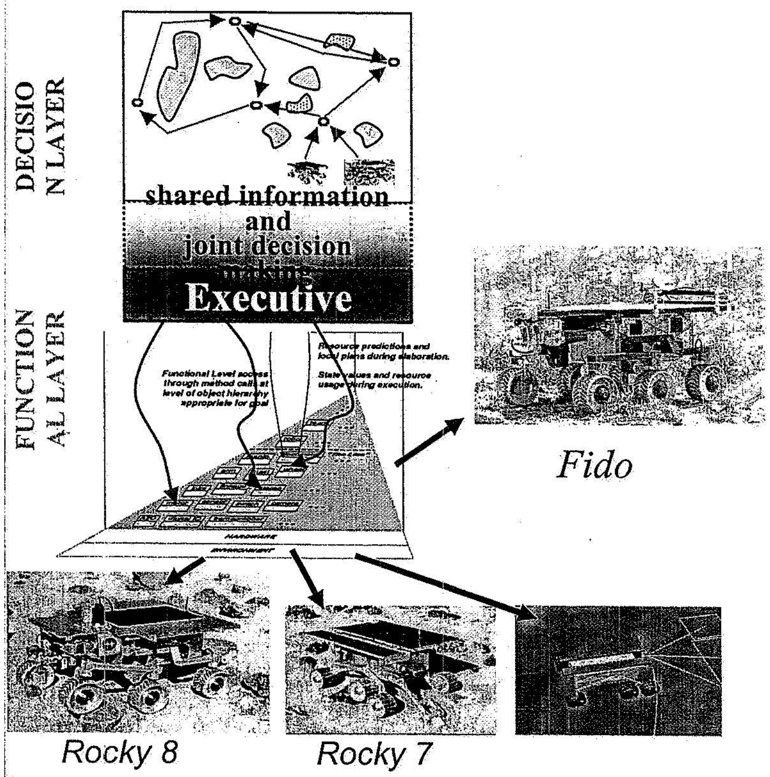


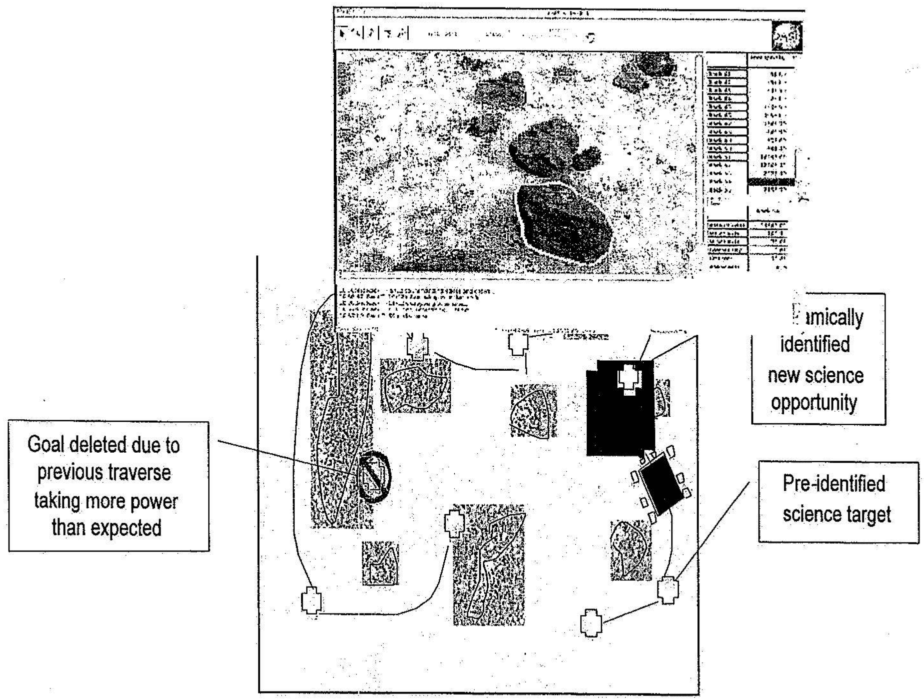


	Target 1 (5m)	Target 2 (7.5m)	Target 3(10m)
Time to reach target	25 minutes	+ 27 minutes	+23 minutes
Tracker accuracy (keypoint tracker)	~ 0.3 – 2.3 cm	Tracker failed (below)	1.7 cm
Hand-off accuracy (3D mesh registration)	3.5 cm	~20cm	4.2 cm
Final placement accuracy*	~6.3 cm	~11 cm	~ 3 cm

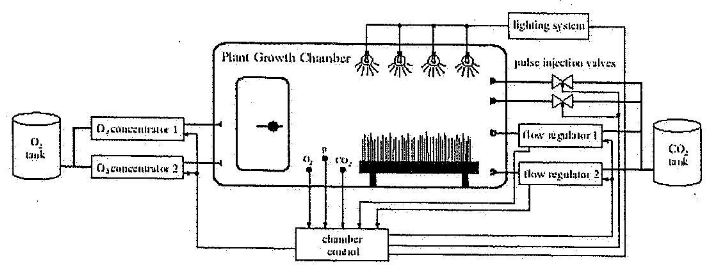
Intelligent Systems

Project 2: Continuous Planning and Execution. Build capabilities for continuous planning and execution as part of a rover's onboard software. Accept science and engineering goals, create command sequences to achieve the goals, execute the sequence, and dynamically modifie the sequence based on changing goals and state. (PI: Tara Estlin, JPL)





Project 3:Robust Model-Based Execution and Health Management for Space Vehicles: Create robust command, monitoring, diagnosis and repair capability for collections of robotic explorers by developing model-based embedded programming languages that think from commonsense models. Create a hybrid monitoring, diagnosis and model learning capability for physical devices that exhibit complex discrete and continuous behaviors. (PI: Brian Williams, MIT)



BIO-Plex plant growth chamber