N94- 26292

A Multitasking Behavioral Control System for the Robotic All-Terrain Lunar Exploration Rover (RATLER)

Paul Klarer
Sandia National Laboratories
Albuquerque, New Mexico

A Multitasking Behavioral Control System for the Robotic All Terrain Lunar Exploration Rover (RATLER)

P. Klarer

Sandia National Laboratories
Advanced Vehicle Development Department
Robotic Vehicle Range
Albuquerque, New Mexico

Abstract

An approach for a robotic control system which implements so called 'behavioral' control within a realtime multitasking architecture is proposed. The proposed system would attempt to ameliorate some of the problems noted by some researchers when implementing subsumptive or behavioral control systems, particularly with regard to multiple processor systems and realtime operations. The architecture is designed to allow synchronous operations between various behavior modules by taking advantage of a realtime multitasking system's intertask communications channels, and by implementing each behavior module and each interconnection node as a stand-alone task. The potential advantages of this approach over those previously described in the field are discussed. An implementation of the architecture is planned for a prototype Robotic All Terrain Lunar Exploration Rover (RATLER) currently under development, and is briefly described.

A Multitasking Behavioral Control System for the RATLER

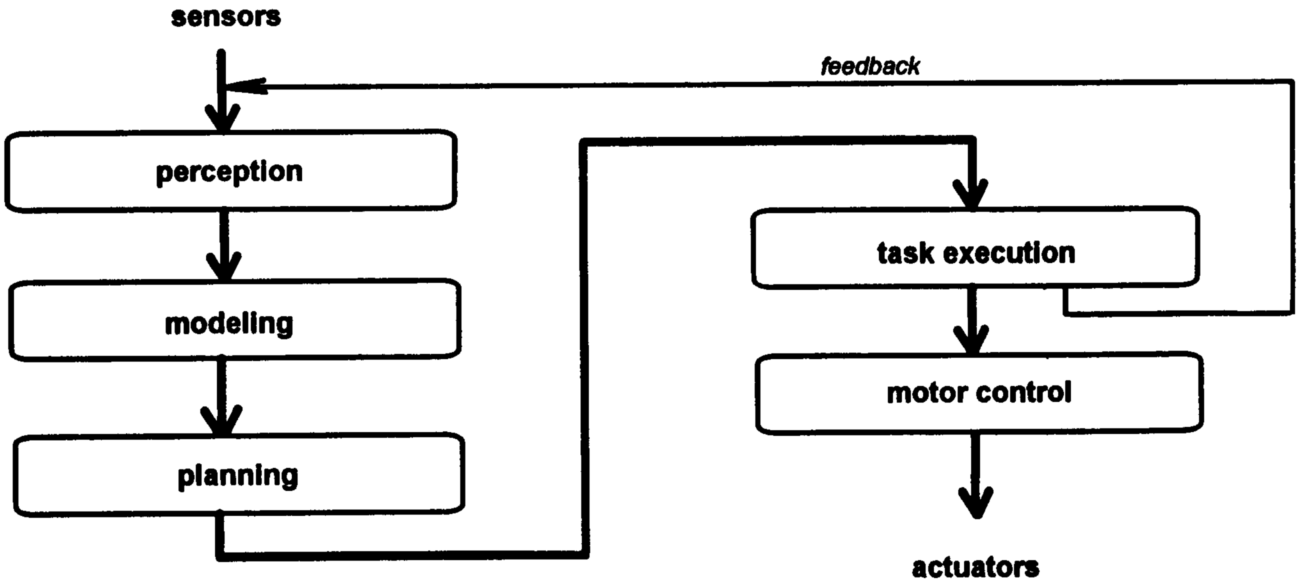
- **Outline**
  - Behavioral 'Minimalist' versus AI 'Traditionalist' Approaches to Autonomous Control
  - Generalized Hybrid System Description (Proposed)
  - Example Implementation Description
  - Summary

This project is funded by the DOE Laboratory Directed Research and Development (LDRD) Program, Sandia National Laboratories LDRD Project Office.

Sandia National Laboratories

A Multitasking Behavioral Control System for the RATLER

- **Traditional 'AI' Paradigm:**



Sandia National Laboratories

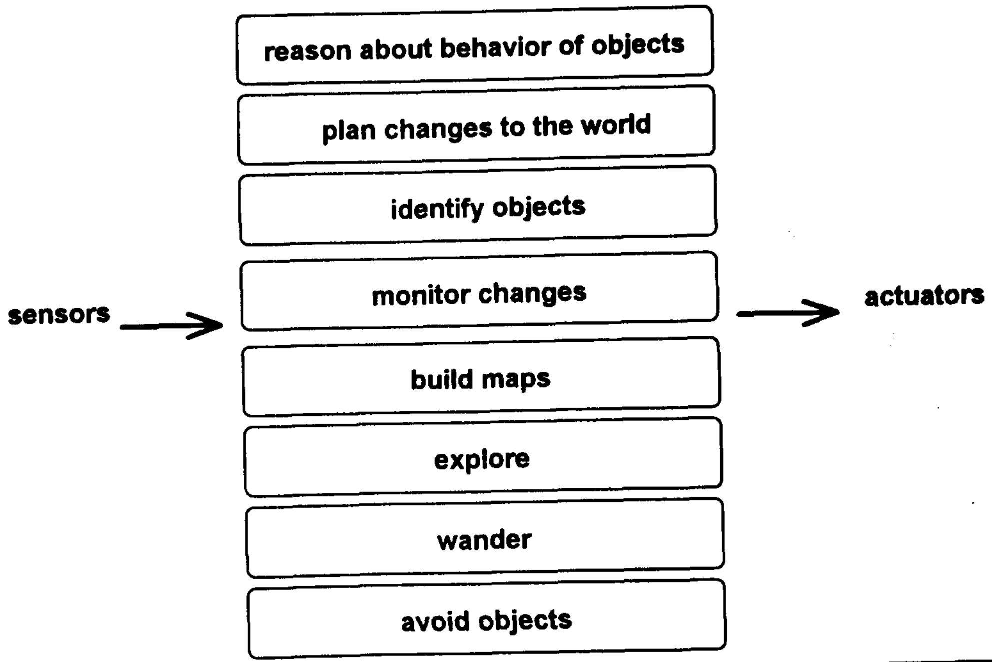
A Multitasking Behavioral Control System for the RATLER

- **Traditionalism**
  - Traditionalism as described by Moravec in 1983 *(The Stanford Cart & the CMU Rover)*
    - » World model is basis for perception and planning
    - » Depends highly on accurate sensor models for uncertainty factors
    - » Highly modularized, with synchronized module interactions
    - » Typically employs considerable computing power to achieve 'real-time' performance
    - » High autonomy, user interfaces generally very good

Sandia National Laboratories

A Multitasking Behavioral Control System for the RATLER

- **Minimalist Behavioral Paradigm:**



Sandia National Laboratories

ROBOTIC VEHICLE RANGE
SANDIA NATIONAL LABS

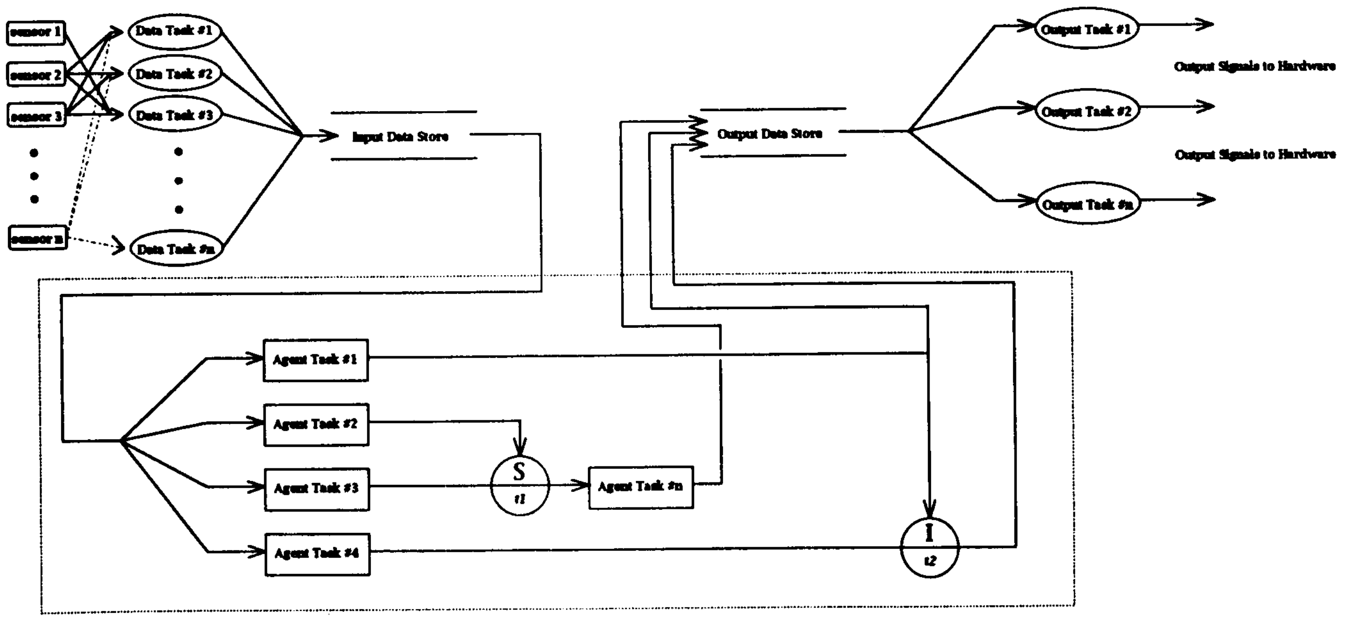
A Multitasking Behavioral Control System for the RATLER

- **Minimalism**
  - Minimalism as proposed by Brooks in 1986: *subsumption architecture*
    - » No internal state or world model is used
    - » Sensors provide real time view of world; ***the world IS the model***.
    - » Embodied as hierarchy of highly modularized ***levels of competence***
    - » Does not require synchronization between modules
    - » Simple computation, many small & inexpensive machines
    - » High autonomy, but user interface is limited

Sandia National Laboratories

A Multitasking Behavioral Control System for the RATLER

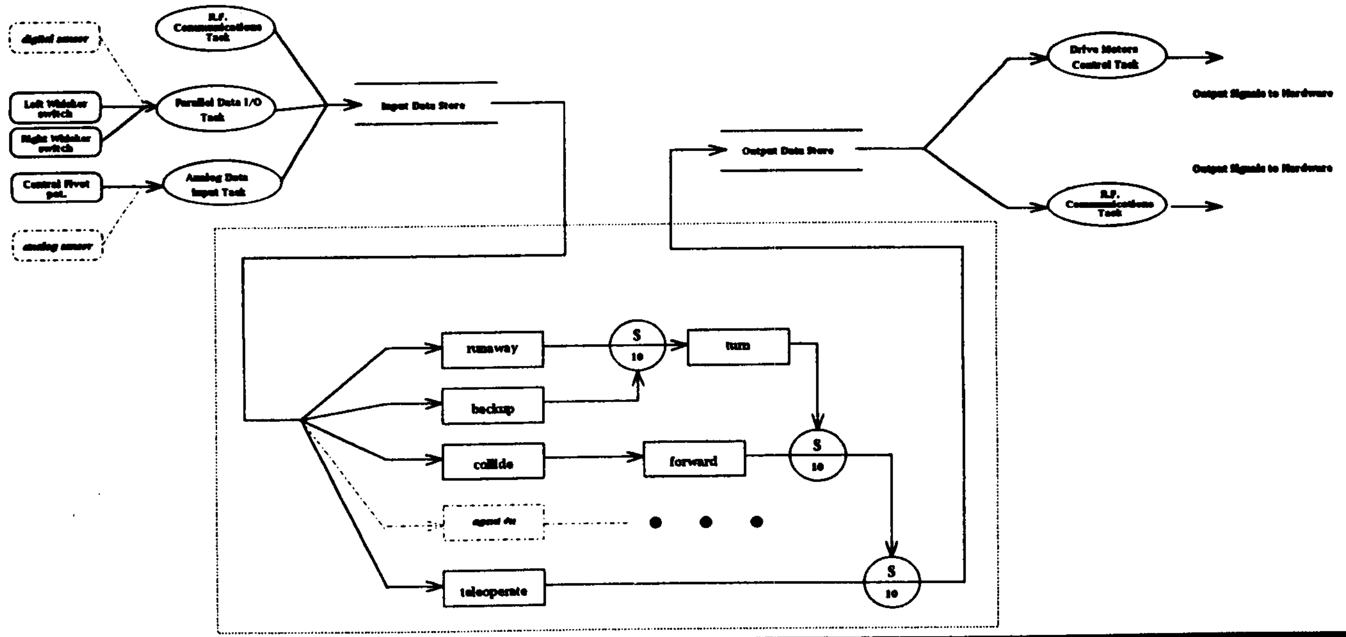
- **Generalized Hybrid System (Proposed)**



Sandia National Laboratories

A Multitasking Behavioral Control System for the RATLER

- **Example Implementation for RATLER**



Sandia National Laboratories

A Multitasking Behavioral Control System for the RATLER

- **Summary**
  - Realtime multitasking implementation proposed attempts to hybridize traditional and subsumption architectures.
  - Will specifically attempt to link a teleoperation capability with an 'anti-collision' behavior module.
  - Will be implemented on a multiprocessor machine, on a 32 bit backplane.
  - Expandable system will allow more processors, each is programmed independent of the others.
  - Coding will be done in C and C++.
  - Current scheduled target for initial operational capability is August 1993.

Sandia National Laboratories

PART II
Tour Presentations

Automated Structural Assembly Laboratory (ASAL)

Ralph Will
NASA Langley Research Center
Hampton, Virginia

A single robot arm constructs a 102 member planar truss with hexagonal reflector panels autonomous.y. The arm travels on as X-Y carriage and the truss is assembled on a rotating turntable. The truss hardware and end-effectors were developed in-house. Technology efforts have included automated error recovery, machine vision guidance, end-effector microprocessor control, path planning, sequence planning, artificial intelligence, automated end-effector change-out, and software design.

Intravehicular Automation and Robotics

Kelly Willshire
NASA Langley Research Center
Hampton, Virginia

A full-scale mockup of Space Station Freedom's Laboratory Module has been built. A robotically controlled 7-DOF arm rides on a track for mobility in the mockup. The purpose is to investigate how automation and robotics technology can improve the productivity of SSF experiments, especially when astronauts are absent. The facility will address protein crystal growth and furnace experiments in 1993 and 1994.

Flight Telerobotic Servicer Hydraulic Manipulator Testbed (FTS HMTB) and Vehicle Emulator System (VES)

Wallace Harrison and Robert L. Williams
NASA Langley Research Center
Hampton, Virginia

The FTS HMTB is the ground-based testbed for the FTS arm which will be delivered to NASA JSC in June 1993. The HMTB and its control system is identical to the flight arm, except that hydraulic actuation is required to lift representative space payloads in 1-G.

The VES is a six-legged hydraulic Stewart platform mechanism which is used to study disturbance compensation for external operations of space telerobotic systems. The class of devices modeled is compound manipulators, such as SPDM attached to the end of SSRMS, or a manipulator on a free-flying satellite. Manipulator arms will be mounted to a load cell on top the platform. Based on the inertial forces, an admittance model will drive the platform to emulate the motion of compliant manipulator vehicles in space.

Intelligent Systems Research Laboratory (ISRL)

Robert L. Williams and Ed Hogge
NASA Langley Research Center
Hampton, Virginia

The ISRL has developed dual arm, shared control of sensor-rich telerobotic systems. Several representative space tasks have been demonstrated over the years. Simultaneous control is possible combining hand controller inputs, automatic position commands, machine vision guidance, force control, and laser proximity control. Two standard PUMA arms have been used for some time, and two redundant 8-axis arms are recent additions.

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1993	Conference Publication

4. TITLE AND SUBTITLE
Selected Topics in Robotics for Space Exploration

5. FUNDING NUMBERS
WU 233-03-01-01

6. AUTHOR(S)
Raymond C. Montgomery and Howard Kaufman, Editors

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA Langley Research Center
Hampton, VA 23681-0001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
NASA CP-10131

11. SUPPLEMENTARY NOTES
Raymond C. Montgomery: Langley Research Center, Hampton, Virginia
Howard Kaufman: Rensselaer Polytechnic Institue, Troy, New York

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified-Unlimited

Subject Category 12

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The papers and abstracts contained in this report represent both formal presentations and experimental demonstrations at the Workshop on Selected Topics in Robotics for Space Exploration which took place at NASA Langley Research Center, March 17 and 18, 1993. The workshop was cosponsored by the Guidance, Navigation, and Control Technical Committee of the NASA Langley Research Center and the Center for Intelligent Robotic Systems for Space Exploration (CIRSSE) at Rensselaer Polytechnic Institute,Troy, New York. Participation was from industry, government, and other universities with close ties to either Langley Research Center or to CIRSSE. The presentations were very broad in scope with attention given to space assembly, space exploration, flexible structure control, and telerobotics.

14. SUBJECT TERMS
Robotics, Telerobotics, Space Exploration, Space Assembly
Flexible Structure Control

15. NUMBER OF PAGES
294

16. PRICE CODE
A13

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
unclassified	unclassified		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

END DATE APRIL 7, 1994