AD-A189 056 THE MOBILE REMOTE MANIPULATOR SYSTEM SIMULATOR(U) 1/1
MARYLAND UNIV COLLEGE PARK SYSTEMS RESEARCH CENTER
V SINHA 15 DEC 86 AFOSR-TR-87-1437 AFOSR-87-0073

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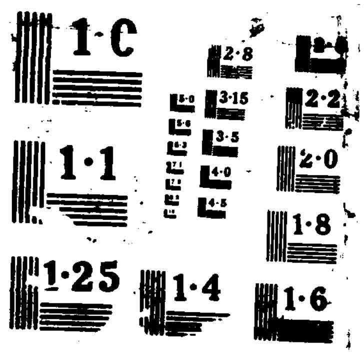
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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

AD-A189 856

1a.	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR- 87-1437
6a. NAME OF PERFORMING ORGANIZATION / 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code)	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION / 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-87-0013
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

12. PERSONAL AUTHOR(S)

13a. TYPE OF REPORT	13b. TIME COVERED FROM ____ TO ____	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

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20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION
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DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

AFOSR-TR- 87-1437

The Mobile Remote Manipulator System Simulator

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December 15, 1986

Abstract

During the spring of 1986 a group of students at the University of Maryland under the leadership of Dr. P. S. Krishnaprasad designed a Mobile Remote Manipulator System for the Space Station In order to test the MRMS design, a simulator was constructed on an Iris 2400 series grahphics workstation. The *MRMS Simulator* allowed the Iris to play the role of the MRMS, and at the same time allow the user to view the MRMS from the perspective which was best suited to the task being viewed. The MRMS Simulator also made extensive use of distributed processing to simulate the actual distributed, wide-spread environment in which the actual MRMS control would occur.

1 Architecture

The simulation was divided into the following tasks:

Command System - the user interface to the simulation tasks, as well as the individual MRMS controls;

Control System - controlling the kinematics of the MRMS. Dealing also with collision avoidance, safety, etc.; and

Display System - a graphical representation of the MRMS with a moveable view-point, allowing for the MRMS to be viewed from any position in its universe.

*This work was supported in part by NSF Grant #85-00108, AFOSR-URI Grant #AFOSR-87-0073, and by a Design Project Grant from NASA through the Universities Space Research Association.

We have implemented these systems across a variety of hardware which is best suited for each task. We have been able to interface these distinct computers over a commcn network. By using different machines for each task, we have distributed our processing needs so that they are more efficiently and effectively performed.

The basic architecture of the simulation system envolves a Pyramid 90x and an Iris 2400. The Pyramid and the Iris are connected via a 10 Mbit ethernet using the TCP/IP protocols. The Pyramid is used for running the control systems used in controlling the Robot, while the Iris is used to display the MRMS motions. The Iris is also used as the User Interface device into the control system - commands are sent to the control system via a user interface window on the Iris.

The graphical features of the Iris can be used independantly of the control system (Pyramid) to allow the user to view the MRMS from any perspective which he/she desires.

2 Command System

The command system provides iconic displays for the various variables which it provides an interface for. The values of these variables can be changed in a "user-friendly" fashion by utilizing a Macintosh [1] type environment.

Once the values of the variables have been changed, the new value is transmitted via the ethernet to the control system on the larger computer. The command system runs on the Iris 2400, and appears to the user as one of the windows on the Iris screen.

3 Control System

The control system is a process which runs on the Pyramid 90x. The control system gets its inputs via the ethernet from the Command System on the Iris. Using the Command information from the Iris, the control system determines trajectories for the different MRMS links, and sends these to the display system is the form of motor velocities.

4 Display System

The display system takes motor velocities and translates them into motions of the links on the Iris screen. Each motor on the MRMS is depicted on the Iris as a graphical object (a la Vista), and the motor velocity information is used to change the transform attributes which control the position of the motors (and thus the links) on the Iris screen.

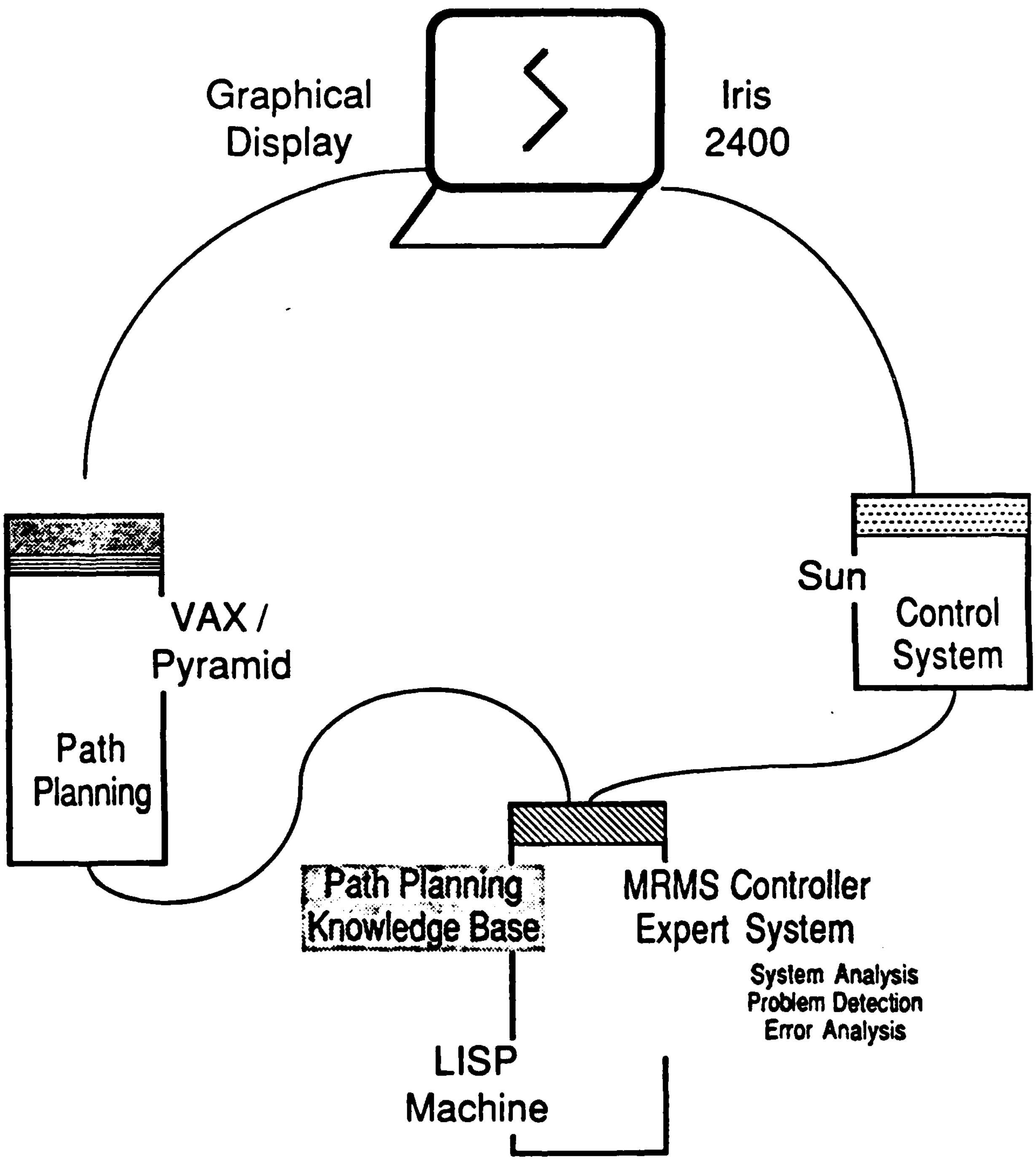
[1] Macintosh is a trademark licensed to Apple Computer.

The display system also allows the viewpoint from which the MRMS is being viewed to be changed. This allows the user to view the different motions from different angles, making it easier for the user to verify correct operation.

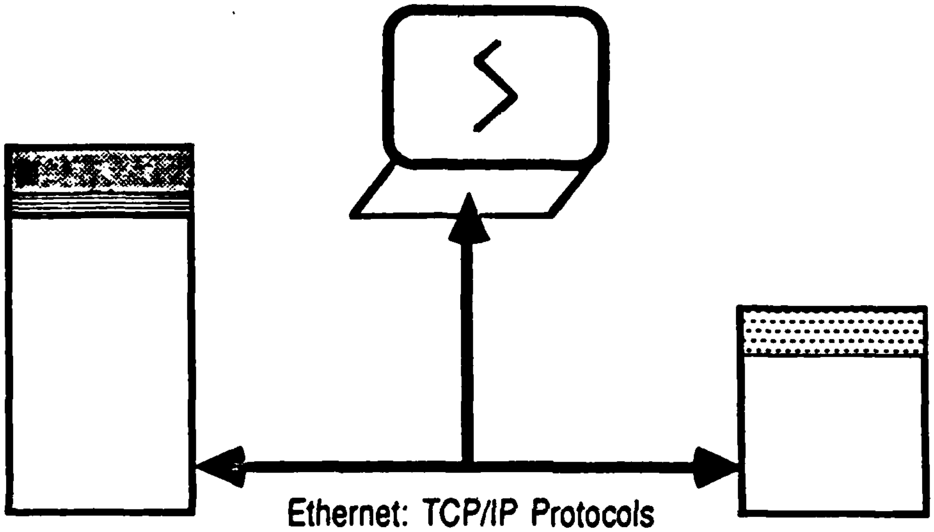
All of the MRMS motions are viewed in real time with respect to the control system calculations. It is also possible for the user to putthe Iris into slow-motion, reverse, rewind, and fast-forward modes - this allows the user to view and evaluate the differnt MRMS motions as a function of time. The user viewpoint can be changed during this "Video-tape" mode, allowing the user to view the same motions many times from different viewpoints.

Simulation Architecture

MRMS Design Project
University of Maryland

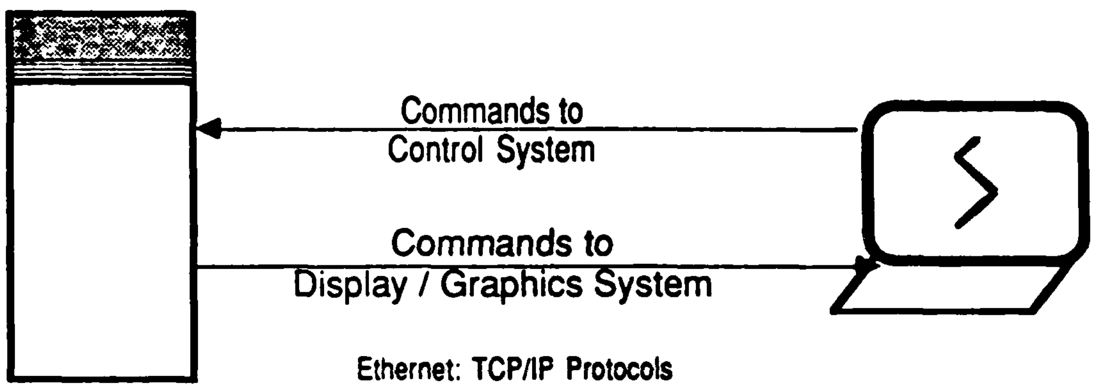


MRMS Simulation: Distributed Processing Description



- Machines connected via a Ethernet
- Machines speak TCP/IP Protocols
  - Remote Login
  - Remote File Access
  - Remote Execution
- Data between machines in fixed format. Easy to exchange!
- Data transfer currently via 'rsh' mechanism of BSD Unix.
- Specialized network servers being considered.

Commanding the
MRMS Simulation from the Iris 2400

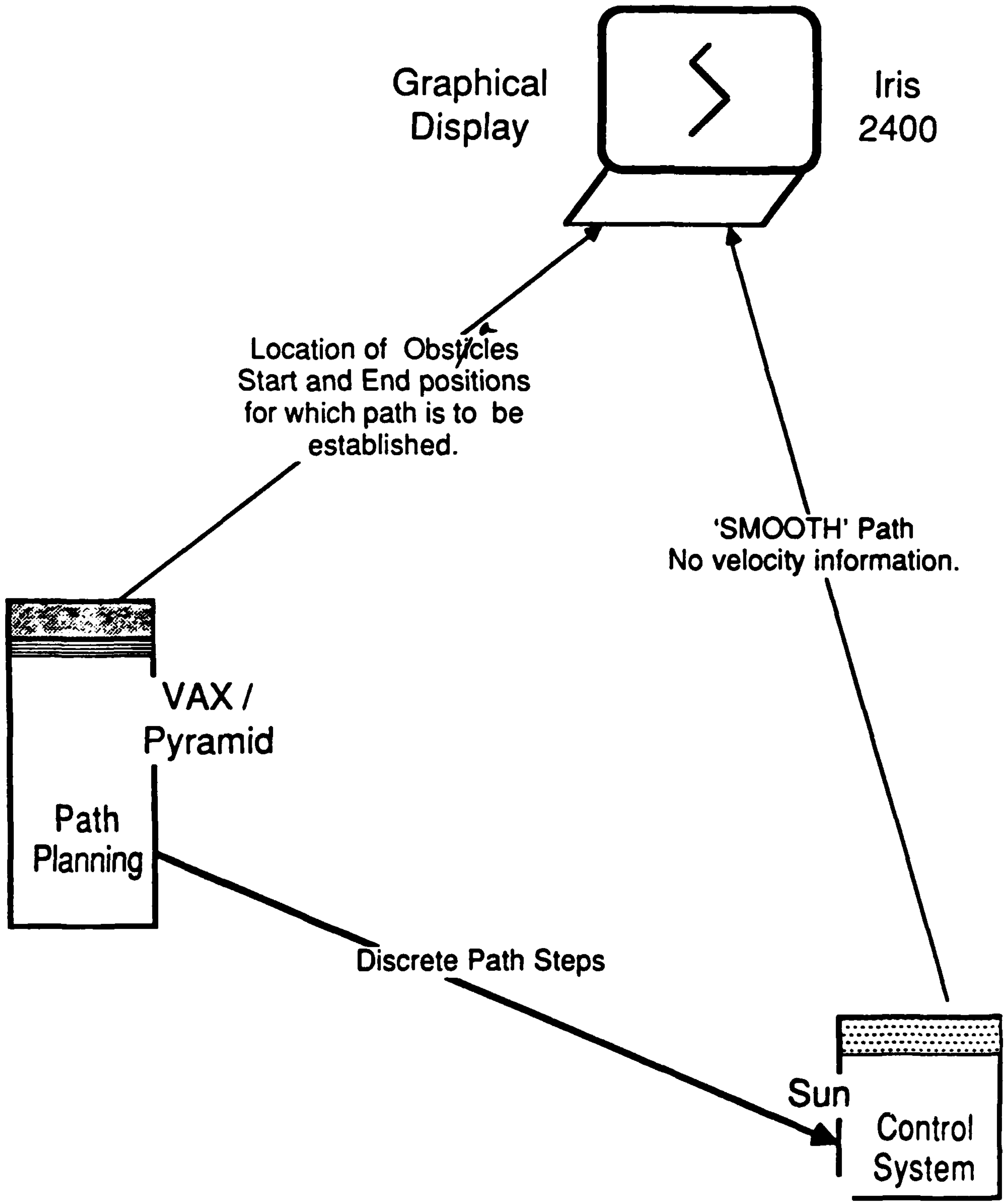


- Using multi-window cluttered desktop type display on Iris.

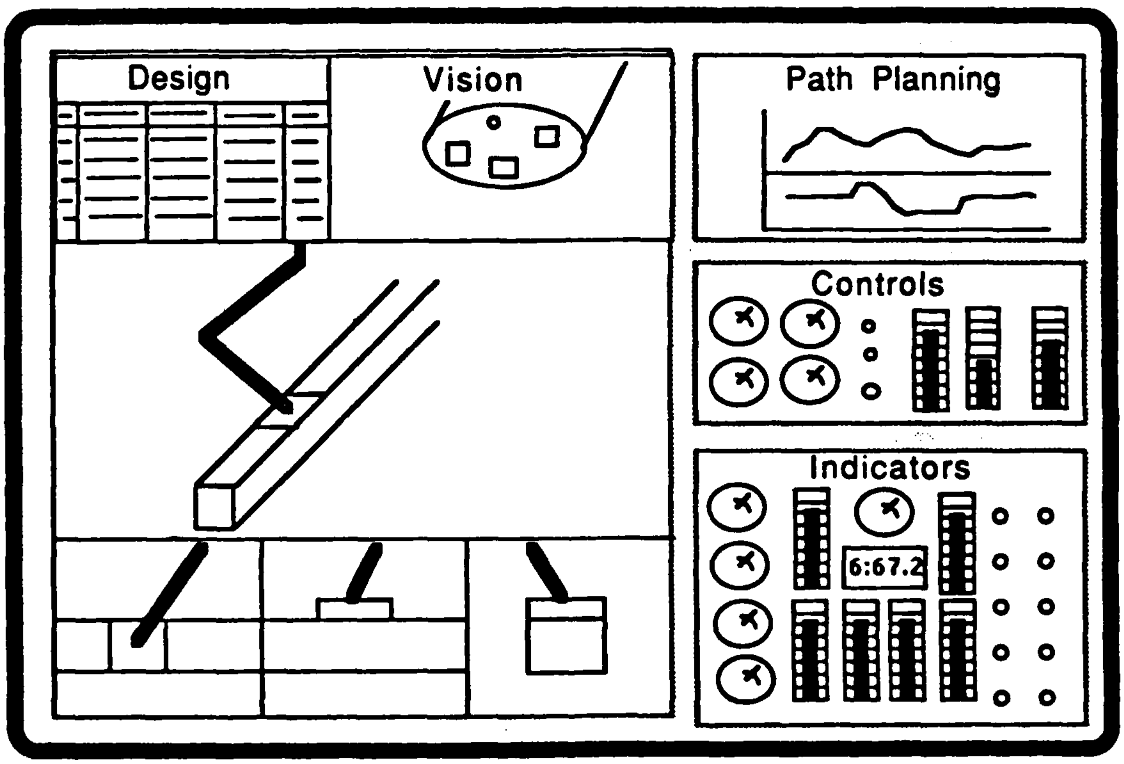
- One window specifically for sending commands to the control system

- Operates by sending initial obst~~i~~acle positions and begin and end MRMS positions to collision avoidance system. Collision Avoidance system then sends output to linear interpolation routines, in lieu of control system.

MRMS Simulation: Dataflow in Simulation



MRMS Planned
Indicators and Controls



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