Intelligent Taskable System Colonies with Learning for Small Unit Operations[1]

First Quarter Report

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[1] **Also available at:**
http://www.usc.edu/dept/robotics/personal/gaurav/DARPA_report9.97.ps

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Chapter 1

Introduction

This document is the first quarter report for the DARPA contract titled **Intelligent Taskable System Colonies with Learning for Small Unit Operations**. The contract is administered by Los Angeles Air Force Base (contact person Lt. Col Joe Hernandez, HERNANDEJE@afbmd.laafb.af.mil).

The contract is to design and prototype a group of robots acting as an aid to a remote warfighter. The main deliverable is the intelligent tasking software which will enable a warfighter to use such a robot group easily and efficiently.

The next four Chapters are organized as follows:

1. Unmanned aerial vehicle (UAV) system requirements and preliminary design.

2. Unmanned ground vehicle (UGV) system requirements and a candidate commercial of the shelf (COTS) solution.

3. Robot colony simulation survey.

4. Preliminary user interface design.

The system requirements for the UAV and UGV system are driven by the mission requirements. The main difference between the two systems is that the UAV system will be largely custom designed and built at the USC robotics laboratory whereas the UGV system will be COTS. A preliminary choice of vendor and platform for the UGVs is given in Chapter 3. To study re-tasking and other mission level strategic algorithms it was proposed to perform a simulation study before implementation on the physical robots. The results of a preliminary survey of simulations available is given in Chapter 4. This study is ongoing. Efforts are being made to find an existing simulation that fits the requirements of this contract.

This report and other documents (including an organization chart, personnel biosketches, project timeline etc.) are available at the project web-site:

http://www.usc.edu/dept/robotics/personal/gaurav/DARPA_main.html

Chapter 2

UAV System Requirements and Preliminary Design

2.1 UAV System Requirements

The Unmanned Aerial Vehicle (UAV) system requirements are driven by the needs of the mission scenario. First, the UAV must have the ability to autonomously interact in a dynamic environment in coordination with other UAVs and Unmanned Ground Vehicles (UGVs). Second, the UAV must provide situation information to remote warfighters (RWs) and be capable of being re-tasked by the RW if deemed necessary. In order to meet these needs, the UAV is required to have:

2.1.1 flight capabilities

- hover
- minimum flight speed 10 mph
- minimum payload (e.g., sensors and computers) 20 pounds
- minimum flight time 30 minutes

2.1.2 sensors

- for control

  - take-off and landing
  - hover to within 20 feet of desired x,y,z position
  - low-speed flight control
  - obstacle avoidance

- for gathering situation information

2.1.3 on-board computing capabilities

- processes sensor data
- provides UAV flight control
- provides autonomous operation and on-line learning

2.1.4 two-way wireless communication link

- re-tasking commands from RWs to UAV
- system telemetry and situation information from UAV to RWs and other UVs
- minimum range 300 feet
- minimum bandwidth To Be Determined (TBD)

2.1.5 one-way wireless communication link

- dedicated link for differential GPS corrections to UAV
- minimum range 300 feet
- minimum bandwidth TBD

2.1.6 one-way wireless video link

- live video feed from UAV to RWs
- minimum range 300 feet
- minimum bandwidth 10 frames/sec, video frame rate preferable

2.1.7 adequate power for on-board electronics

- on-board power generation for long-term (nominal mission) operation [minimum time: 45 minutes]
- battery back-up for short-term (abort mission) operation [minimum time: 5 minutes]

2.1.8 off-board computing capabilities

- used during system development, integration, test, and maintenance
- provides software development environment
- provides wireless operator test interface
- provides long-term storage for flight test data

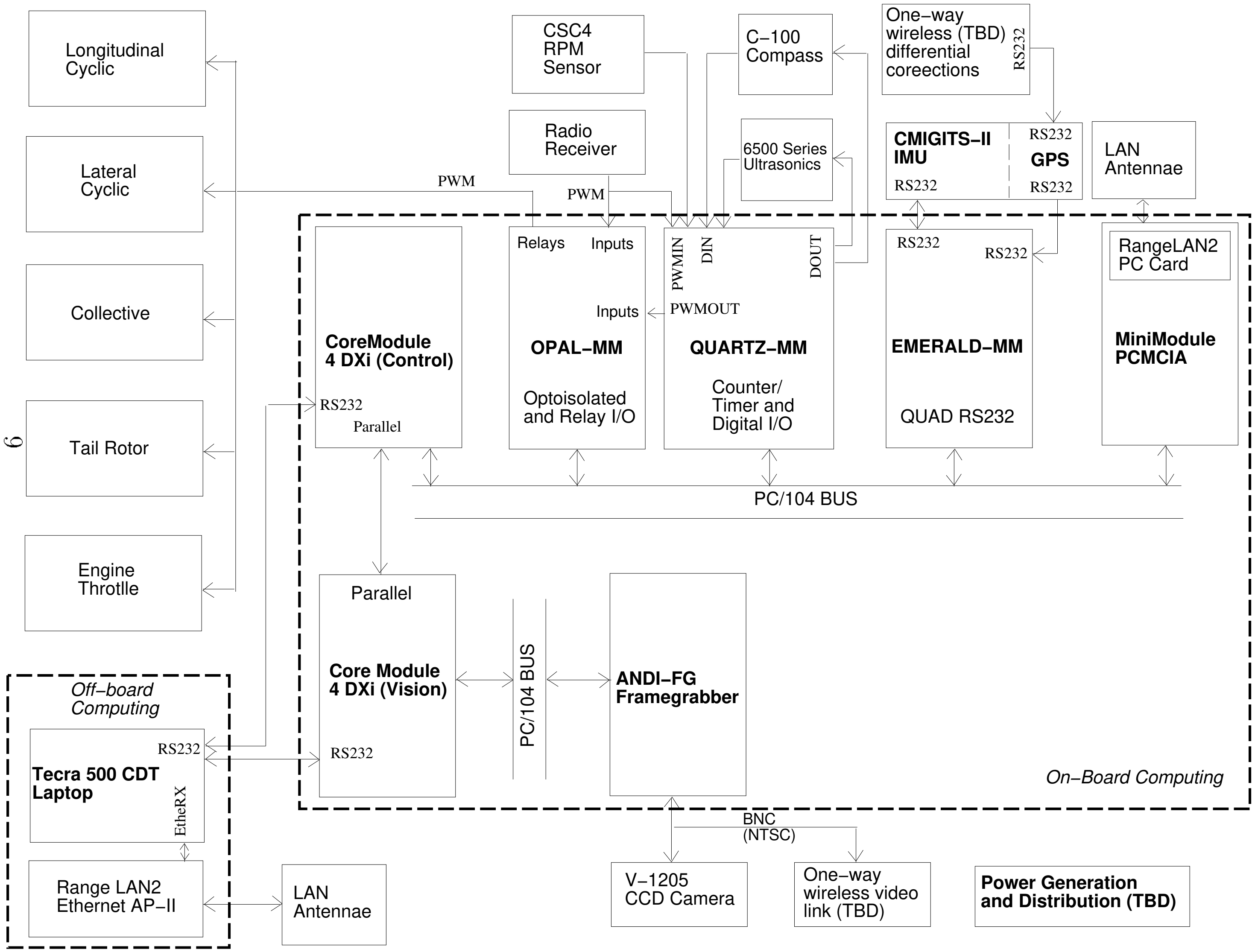
2.2 UAV Preliminary Design

In this section, we will map the requirements from the previous section to a preliminary design. Refer to the UAV System Block Diagram shown in Figure 2.1 throughout this discussion.

2.2.1 flight capabilities

The Bergen Industrial Helicopter shall be used as the UAV flight platform. This helicopter meets the hover, flight speed, payload, and flight time requirements specified earlier.

The Industrial Helicopter is a radio control (RC) model helicopter with a six feet diameter main rotor and powered by a twin-cylinder gas engine. It has five degrees of control: main rotor lateral and longitudinal cyclic pitch, tail rotor pitch, main rotor collective pitch, and engine throttle. The first three control the roll, pitch, and yaw of the helicopter while the last two control its thrust. The helicopter can be controlled by a human pilot using a hand held transmitter which relays pilot control inputs to an on-board radio receiver using the 72 MHz frequency band. The receiver is connected to five



UAV System Block Diagram

Figure 2.1: UAV System Block Diagram

actuators, one for each degree of control on the helicopter. For autonomous operation, these pilot control inputs will be replaced by computer generated control inputs.

2.2.2 sensors

The UAV makes use of a variety of sensors that provide information about the state of the UAV and the environment in which it operates in order to meet sensing requirements.

2.2.2.1 Rockwell C-MIGITS II Miniature Integrated GPS/INS System

The C-MIGITS II provides position (latitude, longitude, and altitude), velocity (horizontal and vertical), attitude (roll and pitch), heading (yaw), time (GPS and/or UTC), delta theta, and delta velocity information. This information is used in controlling the main rotor lateral and longitudinal cyclic pitch, main rotor collective pitch, and tail rotor pitch actuators.

2.2.2.2 Robbe CSC 4 Speed Regulator (Main rotor RPM Sensor)

The CSC 4 provides direct measurement of the main rotor RPM which is used in controlling the engine throttle actuator.

2.2.2.3 Polaroid 6500 Series Ultrasonic Ranging System

The 6500 Series provides measurement of proximity to objects, used for take-off, landing and obstacle avoidance.

2.2.2.4 KVH Industries C-100 Fluxgate Compass

The C-100 provides heading information and is used in conjunction with the C-MIGITS II.

2.2.2.5 Marshall V-1205 CCD Camera

The V-1205 provides visual situational information for the RW.

2.2.3 on-board computing capabilities

The on-board computing capabilities requirement is met through a combination of hardware and software. Embedded PC technology, based upon the PC/104 architecture, provides a COTS computer hardware solution.

2.2.3.1 Hardware

2.2.3.1.1 Ampro CoreModule/4DXi The CoreModule/4DXi is a PC/104 format 100 MHz 486DX4 CPU. It has 4M bytes of DRAM, with support for up to 16M bytes of DRAM, 14 interrupt channels, 7 DMA channels, 3 programmable counter/timers, standard PC/AT keyboard port, and battery-backed real-time clock and CMOS RAM. It also has many embedded-PC system enhancements, including a watchdog timer, 2K-bit configuration EEPROM (storing system SETUP parameters), and a 32-pin byte-wide memory socket. In the memory socket, a 8M byte solid state disk on chip (DOC) is installed, providing a more robust alternative to a traditional hard drive. The DOC contains the QNX real-time operating system and flight software which executes during UAV operation. The DOC also provides permanent storage capability for a variety of information such as system telemetry.

Two CoreModule/4DXi's are used, one as a dedicated host for the ANDI-FG Color Video Frame Grabber (see below) and the other for all other UAV computing needs such as flight control and interfacing with other PC/104 cards.

2.2.3.1.2 Ampro MiniModule/PCMCIA Interface The MiniModule/PCMCIA is a PC/104 format module that allows the integration of PCMCIA memory and peripheral cards into systems based upon the CoreModule CPU. It provides a convenient means for connecting one or two PCMCIA cards into an embedded system.

The MiniModule/PCMCIA is used to integrate the RangeLAN2 PC (PCMCIA) Card 7400 (see below) into the UAV computer system.

2.2.3.1.3 Diamond Systems Corporation Quartz-MM Counter/Timer and Digital I/O The Quartz-MM is a PC/104 format counter/timer and digital I/O module. It provides 10 16-bit counter/timers, 8 bits of TTL input, 8 bits of TTL output, and software controlled interrupt capability.

The Quartz-MM is used to read and write PWM signals. PWM signals are read from the radio receiver on board the Bergen Industrial Helicopter when an actuator is being controlled by a human pilot and PWM signals are generated when a actuator is being controlled by the on-board flight control software. The Quartz-MM digital I/O is used as a sensor interface to the CSC 4 Speed Regulator, the 6500 Series Ultrasonic Ranging System, and the C-100 Fluxgate Compass.

2.2.3.1.4 Diamond Systems Corporation Opal-MM Optoisolated and Relay I/O The Opal-MM is a PC/104 format digital I/O module that isolates the computer and the external signals it is monitoring and/or controlling. The Opal-MM has 8 optoisolated digital inputs and 8 relay outputs. The 8 relay outputs are SPDT format. Each relay has 3 contacts: Common, Normally Open, and Normally Closed. The relays have long lifetime (10,000,000 operations) and quick actuation time (5ms max operate and release).

The Opal-MM is used to increase the fault-tolerance of the UAV system. Control inputs from both a human pilot and the on-board control software are input into the Opal-MM. During normal operation, the on-board control software inputs are sent from the Opal-MM to the five actuators on the Industrial Helicopter. During times of emergency, such as during sensor failure, the human pilot inputs can be sent to the helicopter actuators instead, allowing the pilot to assert control over the UAV. In the event of main power failure, the relays will default to their no-power state which routes human pilot control inputs to the actuators. Battery backup-power is supplied to the servos and radio receiver in the event of main power failure.

2.2.3.1.5 Diamond Systems Corporation Emerald-MM Quad RS-232 Serial Port The Emerald-MM is a PC/104 format module that provides 4 RS-232 serial ports operating at speeds up to 115kbps.

The Emerald-MM is used to interface the computer system to the C-

MIGITS II, which has 2 serial ports.

2.2.3.1.6 Ajeco ANDI-FG Color Video Frame Grabber The ANDI-FG is a PC/104 compatible video acquisition and image processing card with a digital signal processor (DSP). This multistandard card can be used with NTSC, PAL and SECAM color video signals.

The ANDI-FG is used to interface to the V-1205 CCD Camera.

2.2.3.2 Software

2.2.3.2.1 QNX Realtime Operating System (RTOS) QNX is a realtime, extensible POSIX OS with a small microkernel making it ideal for embedded systems. The microkernel handles process creation, memory management, and timer control. The microkernel also includes POSIX.1 (certified) and many POSIX.1b realtime services.

QNX shall be used as the RTOS on both CoreModule/4DXi's.

2.2.3.2.2 Flight Software The flight software encompasses all remaining software running on the on-board computer system. This currently includes, but is not limited to:

- low-level software drivers for interfacing with sensors and actuators
- UAV flight control software for guidance, navigation, and control
- autonomous operation and on-line learning software
- RW and UV communication software
- self test software including, power-on built in test (BIT), commanded BIT, and health checks software
- vision processing software running on the ANDI-FG DSP

All software shall be written primarily in C/C++. Assembly shall be used if required for speed of execution purposes. A structured software development and documentation methodology shall be followed with design, code, test, and integration followed at the individual software unit level all the way to the complete software/hardware UAV system. This methodology is currently being tailored for the UAV development effort based upon a variety of sources, including DoD-STD-2167A and MIL-STD-498.

2.2.4 two-way wireless communication link

2.2.4.1 Proxim RangeLAN2 PC (PCMCIA) Card 7400 Wireless LAN

The RangeLAN2 PC Card 7400 is a long range, high performance, wireless LAN PC card. The RangeLAN2 PC Card 7400 plugs into the Mini-Module/PCMCIA described earlier and is part of the computer system on board the UAV. The RangeLAN2 PC Card 7400 operates in the 2.4 GHz frequency band, employs frequency hopping spread spectrum technology, has a 1.6 Mbps data rate per channel with 15 independent channels and a range of up to 1000 feet in open space in outdoor environments.

The RangeLAN2 PC Card 7400 provides a two-way wireless link between the UAV and RWs and other UVs.

2.2.5 one-way wireless communication link

TBD.

2.2.6 one-way wireless video link

TBD.

2.2.7 adequate power for on-board electronics

TBD.

2.2.8 off-board computing capabilities

2.2.8.1 Toshiba Tecra 500CDT Laptop and Docking Station

The Tecra 500CDT is a laptop PC based upon a 120MHz Pentium CPU. It has 16M bytes RAM, a 1.26G bytes removable hard drive, a 12.1 inch high-res color monitor, a CD-ROM, and a Kingston Technology EtheRx PC Card. Both Windows 95 and QNX 4.23A operating systems are installed as well as the Watcom 10.6 C/C++ compiler. The Docking Station expands the capabilities of the Tecra 500CDT by providing two full-length expansion slots for standard ISA and 32-bit PC Expansion Cards and one half-length 32-bit PC expansion slot. It also has a selectable bay for installing additional hardware such as CD-ROM drives or floppy drives. A 1.44M byte floppy drive has been installed in the slot.

The Tecra 500CDT is used during the UAV system development, integration, test, and maintenance phases of the project. It has multiple functions.

First, the Tecra 500CDT provides a software development environment through the use of the QNX 4.23A operating system and the Watcom 10.6 C/C++ Compiler. Using this environment, code shall be developed and tested. Also, through the use of RCS, a QNX software version control utility, software configuration management shall be implemented.

Second, it functions as a wireless operator interface to the UAV by using the EtheRx PC Card to provide a 10Base-T Ethernet link between the Tecra 500CDT and the RangeLAN2 Ethernet AP-II (see below).

Third, the 1.2G byte hard drive provides long-term storage capability for flight test data.

2.2.8.2 Proxim RangeLAN2 Ethernet AP-II Wireless LAN

The RangeLAN2 Ethernet AP-II is a long range, high performance, wireless Ethernet LAN. The AP-II operates in the 2.4 GHz frequency band, employs frequency hopping spread spectrum technology, has a 1.6 Mbps data rate per channel with 15 independent channels and a range of up to 1000 feet in open space in outdoor environments.

The AP-II provides a two-way wireless link between the Tecra 500CDT laptop and the RangeLAN2 PC Card 7400 on board the UAV.

Chapter 3

UGV System Requirements and Preliminary Design

3.1 UGV System Requirements

The Unmanned Ground Vehicle (UGV) system requirements are driven by the mission scenario. Each UGV must have the capability to autonomously execute a mission in a dynamic environment as well as be able to coordinate with other UGVs and UAVs in the mission. Each UGV must also be able to provide the warfighter with telemetry and other information about the immediate environment of the UGV. Further, each UGV must be equipped with a teleoperation mode where it can be driven by the warfighter if necessary. Since the UGVs will be required to re-task themselves on command as well as autonomously (if necessary), it is believed that a homogeneous group of vehicles is sufficient. The basic requirements of each UGV system are as follows

3.1.1 mobility

- traverse nominally flat terrain
- minimum speed 5 mph
- payload (e.g., sensors and computers) 10 pounds
- minimum battery life 30 minutes (preferably between 1-2 hrs)

3.1.2 sensors

- for control
  - nominally flat terrain traversal
  - localization to within 10 feet in x,y position on the ground
  - realtime obstacle avoidance
- for gathering situation information

3.1.3 on-board computing capabilities

- processes sensor data
- provides UGV navigation and localization control
- provides autonomous operation and on-line learning

3.1.4 two-way wireless communication link

- re-tasking commands from Warfighters to UGV
- system telemetry and situation information from UGV to RWs and other UVs
- range [minimum range: 300 feet]
- bandwidth [minimum bandwidth: To Be Determined (TBD)]

3.1.5 one-way wireless video link

- live video feed from UGV to RWs
- range [minimum range: 300 feet]
- bandwidth [minimum bandwidth: 10 frames/sec, video frame rate preferable]

3.1.6 adequate power for on-board electronics

- battery power for long-term (nominal mission) operation [minimum time: 30 minutes]

3.1.7 off-board computing capabilities

- used during system development, integration, test, and maintenance
- provides software development environment
- provides wireless operator test interface
- provides long-term storage for localization and sensor fusion test data

3.2 UGV Preliminary Design

In this section, we provide details of a COTS system available from ActiveMedia Inc. which satisfies all the requirements listed above. We also include a sensor suite which meets the requirements listed above. It should be noted that other platforms (such as the tracked systems available from IS Robotics for example) are also under consideration. The final decision on which platform to use will also depend on a combination of several criteria including but not limited to

1. Capabilities
2. Cost
3. Delivery Schedule
4. Maintanence/Customer Service

3.2.1 mobility

A version of the Pioneer 1 mobile robot from RWI is currently the best candidate for the UGV platform. The platform currently available meets the requirements of this contract, however for a modest increase in cost a better version is likely to be available soon. Here we list the details of the currently available system, indicating in some places what the next version will improve.

The Pioneer I is a 2-wheel differential drive chassis with a onboard MC68HC11 based controller. Two independent DC drive motors with encoders are used. It comes standard with a sonar ring for obstacle avoidance. The next version will be a 4-wheel differential drive chassis with the same controller thereby providing better low end torque and higher stability.

3.2.2 sensors

The Pioneer I comes standard with some sensors and is amenable to sensor enhancements rather easily.

3.2.2.1 GPS System

Reliable localization for the UGV systems need a global positioning system. Dead-reckoning alone is unlikely to suffice. The exact system to buy is undecided (TBD).

3.2.2.2 Polaroid 6500 Series Ultrasonic Ranging System

The 6500 Series provides measurement of proximity to objects, used for take-off, landing and obstacle avoidance. Seven of these come standard with the robot.

3.2.2.3 KVH Industries C-100 Fluxgate Compass

The C-100 provides heading information and is used for dead-reckoning or other localization techniques. The compass has a serial interface suitable for the onboard 6811

3.2.2.4 Newton Lab's Fast Track Cognachrome Vision System

- Manual-tilt, forward-facing color camera on the robot's console
- Special rear panel with video/communication ports and power
- Serial communications for control and frame grabbed images

- Saphira(tm) software support for offboard client vision processing

This system is not standard on the Pioneer but is available as an add-on.

3.2.3 on-board computing capabilities

The on-board computing capabilities requirement is met through a combination of hardware and software. The main processor is the MC6811 which is standard on every Pioneer. The vision system processing is handled by a Motorola 68332 microcontroller. Pioneer Applications Interface (PAI) libraries allow all robot sensor, motor and accessory functionalities to be easily available from C programs.

3.2.3.0.1 Control Software The control software encompasses all remaining software running on the on-board computer system. This includes, but is not limited to:

- low-level software drivers for interfacing with sensors and actuators
- UGV control software for guidance, navigation, and control
- autonomous operation and on-line learning software
- RW and UV communication software
- self test software including, power-on built in test (BIT), commanded BIT, and health checks software
- vision processing software running on the Cognachrome system

All software shall be written primarily in C/C++. Assembly shall be used if required for speed of execution purposes. As with the UAV development a structured software development and documentation methodology shall be followed with design, code, test, and integration followed at the individual software unit level all the way to the complete software/hardware UGV system. This methodology is currently being tailored for the UGV development effort.

3.2.4 two-way wireless communication link

TBD

3.2.5 one-way wireless video link

2.4 GHz Audio/Video transmitter/receiver is available as an accessory. It is a rear mounted unit on Pioneer with a range of approximately 300 ft. This unit satisfies the system requirements.

3.2.6 adequate power for on-board electronics

On board batteries provide upto 5 hours of continuous operation thereby easily meeting the extended mission requirements for this contract.

3.2.7 off-board computing capabilities

3.2.7.1 PC based Linux workstation

PC's running a UNIX variant called Linux are available as a basestation and development platform from the same vendor.

3.2.7.2 Comrad Radio Modems

- For tetherless serial communications between robot server and basestation client
- Two RS-232 spread-spectrum radio modems with antennas (may have up to 10 independent pairs)
- One external power supply and 9-to-9-pin cable; 9-to-25-pin adapter
- 900 MHz operating frequency
- 1.2 to 38.4 Kbps data rates
- Up to 250' indoor operating range

Chapter 4

A Survey of Multi-robot Simulators

This chapter presents a survey of existing simulation packages for multiple robot research. During the course of this contract it will be necessary to test tasking algorithms in simulation before implementing them onboard the robots. This Chapter presents the results of a major survey of existing simulators which we undertook before deciding whether to use/modify an existing simulator or to design and build a new system.

4.1 Introduction

Given that computer simulation of multi robot systems provide a strong testbed, especially for the Artificial Intelligence (AI) aspects of such cooperative tasks, our first attempt was to summarize currently available simulation tools for similar systems.

In this report we compare and contrast several simulation packages developed to study multiple robot systems. The interdisciplinary nature of this research area has led to a variety of software tools as well as abstraction levels, ranging from populations of cellular-automata-alike entities to highly distributed, realistic simulation environments. This relatively broad range is due to the interaction among the fields of Multi-Agent Systems, Artificial

Life (Gutowitz 1995), Distributed AI and Autonomous Mobile Robotics.

In doing this survey, our main goal has been to identify different design approaches followed by the research community so far, besides software issues such as portability and extendibility.

4.2 Descriptions

4.2.1 ModSAF - Distributed Interactive Simulation (DIS)

ModSAF (Modular Semi-Automated Forces) is a large-scale simulation environment developed with DARPA support (Calder, Smith, Courtemanche, Mar & Ceranowicz 1993). Originally conceived as an extension of the Simulation Network (SIMNET) program, ModSAF allows multiple simulators to share a virtual environment and interact. As a long-term goal, the U.S. Military plans to bring together various tactical simulators using the DIS protocol (*The Battle Labs Brochure, U.S. Army Training and Doctrine Command* 1996), which is also available as an IEEE Standard (IEEE 1995*a*), (IEEE 1995*b*) since 1994.

The Intelligent Forces (IFOR) research program lead by Rosenbloom at USC Information Sciences Institute (ISI) (Rosenbloom, Johnson, Jones, Koss, Laird, Lehman, Rubinoff, Schwamb & Tambe n.d.), (Tambe, Johnson, Jones, Koss, Laird, Rosenbloom & Schwamb 1995) and the University of Michigan's Unmanned Ground Vehicle project lead by Durfee (Durfee, Kenny & Kluge 1997) are among DARPA funded research initiatives using ModSAF as a realistic simulation tool. In view of the fact that such a large scale simulation with the associated expertise is available at ISI we are exploring the possibility of collaborating with the IFOR team to develop a simulation tailored to the needs of this contract.

In DIS, information exchange is accomplished using Protocol Data Units (PDU's), which are pre-defined for a number of interaction types. The principle PDU type is the Entity State PDU, encapsulating the position, linear and angular velocities as well as accelerations of an entity at a given time. In addition, message-PDU's provide a powerful means of extending the current set of PDU's.

Besides the U.S. Military and research universities, a number of private technology companies such as Carmel Applied Technologies, TASC-Primark and Distributed Simulation Technology have also been using the DIS approach. Brutzman's work (Brutzman 1994) on Autonomous Underwater Vehicle (AUV) simulations is one of the well-documented DIS implementations.

WWW sites : http://www.modsaf.org/, http://siso.sc.ist.ucf.edu/dis/index.htm and http://dis.pica.army.mil/

4.2.2 Mission Lab

MissionLab is a set of software tools developed by Prof. Arkin's research group at Georgia Tech under a DARPA contract, with the aim of designing and testing behaviors for single robots and robot teams (MacKenzie, Arkin & Cameron n.d.), (MacKenzie, Ali & Balch 1997). Supporting both 2D-simulated and real robots (built by Denning Mobile Robotics and Nomadic Technologies), MissionLab also encompasses a command language interpreter which is capable of translating high-level mission statements into a series of commands for individual robots of a team. These robots, in turn, embody behavior-based control architectures.

Contact person : Prof. Ronald Arkin (arkin@cc.gatech.edu)
WWW site : http://www.cc.gatech.edu/ai/robot-lab/research/MissionLab/

4.2.3 Swarm

Swarm is a simulation package for multi-agent systems, developed at the Santa Fe Institute. The basic unit of simulation is the swarm, a collection of agents executing a schedule of actions and interacting via discrete events.

Contact person : Chris Langton (cgl@santafe.edu)
WWW site : http://www.santafe.edu/projects/swarm/

4.2.4 Khepera Simulator

Khepera Simulator is a freeware package developed by Olivier Michel, allowing to develop controllers for the mobile robot Khepera. It includes an environment editor and a graphical user interface.

Contact person : Olivier Michel (Olivier.Michel@di.epfl.ch)
WWW site : http://diwww.epfl.ch/lami/team/michel/khep-sim/

4.2.5 VirtualRobots Simulator

VirtualRobots software package was developed as a tool in the research of mobile robots at the Department of Computer Science, University of Essex, England. It is basically a 2D simulation of a mobile robot environment.

Contact person : John Standeven (stanj@essex.ac.uk)

4.2.6 SIEME

SIEME has been developed by Magnin Laurent, a former graduate student at the LAFORIA Lab in France. This simulation platform allows the user to create, test and modify the behaviors of the robots in an environment defined using the Sieme syntax. It has been mainly used to study team behavior for soccer playing robots (Magnin 1996).

Contact person : Magnin Laurent (Laurent.Magnin@laforia.ibp.fr)
WWW site : http://www-laforia.ibp.fr/ magnin/these/sieme.html

4.3 Requirements

Table 4.1 shows the software requirements of the various systems.

Simulator	*Platform*	*Prog. Lang.*	*Library*	*Documentation*
MissionLab	Solaris 1.x/RedHat Linux 4.0	C	IPT, CThreads	User Manual
Swarm	Solaris and Linux	Objective C	-	Web site
Khepera	UNIX	C	X11	User Manual
SIEME	PC	Smalltalk80	-	-
VirtualRobots	UNIX	C	PVM	-

Table 4.1: Software Requirements of the Simulators

4.4 Features

Table 4.2 shows various features of the surveyed systems.

Simulator	*Domain*	*World model*	*Dynamics*	*Communications*
MissionLab	military	2D	none	yes
Swarm	multi-agent	mostly grid 2D	implementable	yes
Khepera	mobile robots	2D	none	-
SIEME	soccer	2D	-	-
VirtualRobots	mobile robots	2D	none	-

Table 4.2: Features of the Simulators

4.5 Conclusion

As a result of this survey, we believe that none of the currently available simulation tools are well suited to our purposes. Since our project involves both aerial and ground-based robots, a considerable amount of dynamics have to be integrated into the simulations to achieve realistic physical behaviors.

However, this study is in progress and other simulation environments are under investigation. If no appropriate simulation is found a possible approach seems to develop a new 2D simulator, encompassing reasonable robot dynamics together with sensor and noise models. For inter-robot communications, UNIX-based socket programming could be chosen.

Chapter 5

Preliminary User Interface Design

This chapter presents a preliminary design for a hand-held portable user interface for the remote warfighter. The basic constraints that the design has to satisfy are as follows:

1. Portability
2. Simple to use in noisy environment and easy to learn
3. Birds-eye view of field of operation
4. Egocentric view from any particular robot (enable the warfighter to see what the robot is seeing).
5. Control group level activity
6. Teleoperate single robot

The current design is a touch sensitive hand-held palmtop computer which will show a display much like Figure 5.1. Each requirement above will be met as follows:

1. Portability - use a Palmtop computer
2. Simplicity - Touch sensitive interface (by tapping on the screen)

3. Use robot telemetry to create the birds-eye view

4. Egocentric view will be a live video feed at no less than 10 frames/sec.

5. Control group activity by tapping on action icons

6. Control single robot activity by tapping on individual robot icon

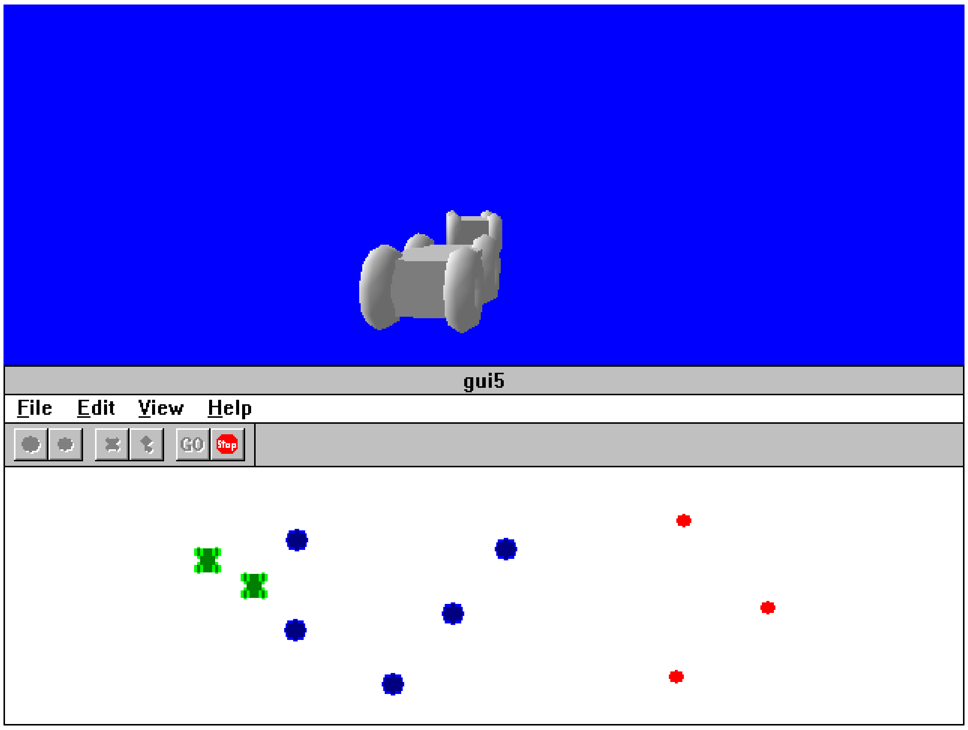


Figure 5.1: A Prototype User Interface: the blue icons are obstacles, the red icons are sensors that mark a perimeter and the articulated icons are the robots

Several vendors manufacture hand-held palmtops that run Windows CE. The choice of vendor has not yet been made. The interface software will be developed using World Toolkit. A brief description of the prototype interface shown in Figure 5.1 is as follows.

The screen is divided into two parts. The bottom part shows a birds-eye view (a plan view) of the mission arena. The blue icons are obstacles, the red icons are the boundary of the secure area and the articulated icons are the robots. The upper half of the screen shows two robots as seen from the point of view of an observer standing near one of the obstacles. This view is chosen by tapping on the lower screen at the desired viewpoint.

The buttons on the toolbar in the central part of the screen are the command and control buttons. These are used to direct the colony to perform a specific task or to teleoperate a particular robot.

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