Multi Robot Navigation and Mapping for Combat Environment

Senior Project Proposal

By:

Nick Halabi

&

Scott Tipton

Project Advisor:

Dr. Aleksander Malinowski

Date:

December 10, 2009

Project Summary

The Multi Robot Navigation and Mapping for Combat Environment project will safely enable a robot to navigate through an indoor or outdoor urban combat environment. The first robot, which would be inexpensive or expandable, will be in charge of mapping the environment and any obstacles or dangers. The second robot, which represents supply caravans or troops, will then use the map generated by the first robot and use a path finding algorithm to determine the best path through the environment that avoids all obstacles and threats. The overall goal of this project is to guide autonomous supply caravans or troops safely through a combat zone.

Detailed Description

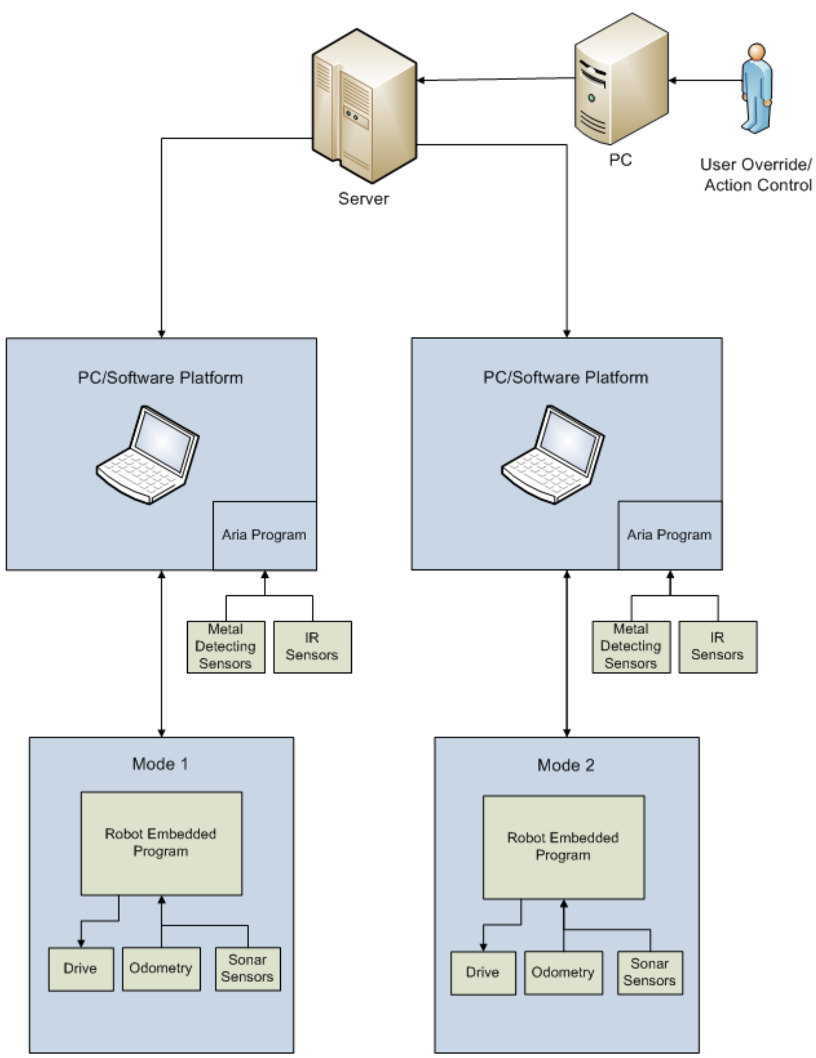
The robots that will be used for this project are the Pioneer 3D-X series robots. The 3D-X model has 8 sonar sensors in the front and sides that can get readings from + 90 degrees to -90 degrees. It has two wheels up front that allow the robot to move in any direction and an additional wheel in the back for stability. Each robot is connected to a laptop via a USB port. The laptop runs the actual C++ program (created in Visual Studio) that will control the robot. A program called ARIA then interfaces the C++ program with the robot. Our program is divided into two modes, one for each robot. Mode 1 is responsible for mapping the unknown/combat environment and relaying that map to the server via a laptop with a wireless network connection. Mode 2 is responsible for retrieving the map through a wireless laptop connection, and safely navigating through the environment. Another PC is connected to the server in case manual override would ever be required. Additional sensors (IR and metal detection) will be added later and connected to a Silicon labs 8051 microcontroller, which will then send the information to the ARIA program.

Current Project Goals

- Robot Navigating
    - Find and travel to closest wall/object
    - Position robot in a specific position to wall(s)/object(s)
    - Left/right wall following
    - Determine if sensors more accurate than sonar sensors will be necessary. If so, integrate the sensors into ARIA if possible.
    - Identify appropriate sensors for combat-like environment.
    - Acquire and integrate sensors for simulated combat-alike environment (metal detector?)
    - Develop communication framework, allowing server/central command to override local control algorithms and remote control robot
- Environment Mapping
    - Research and develop algorithms to map an unknown environment
    - Research available ARIA or Pioneer robot compatible software for mapping

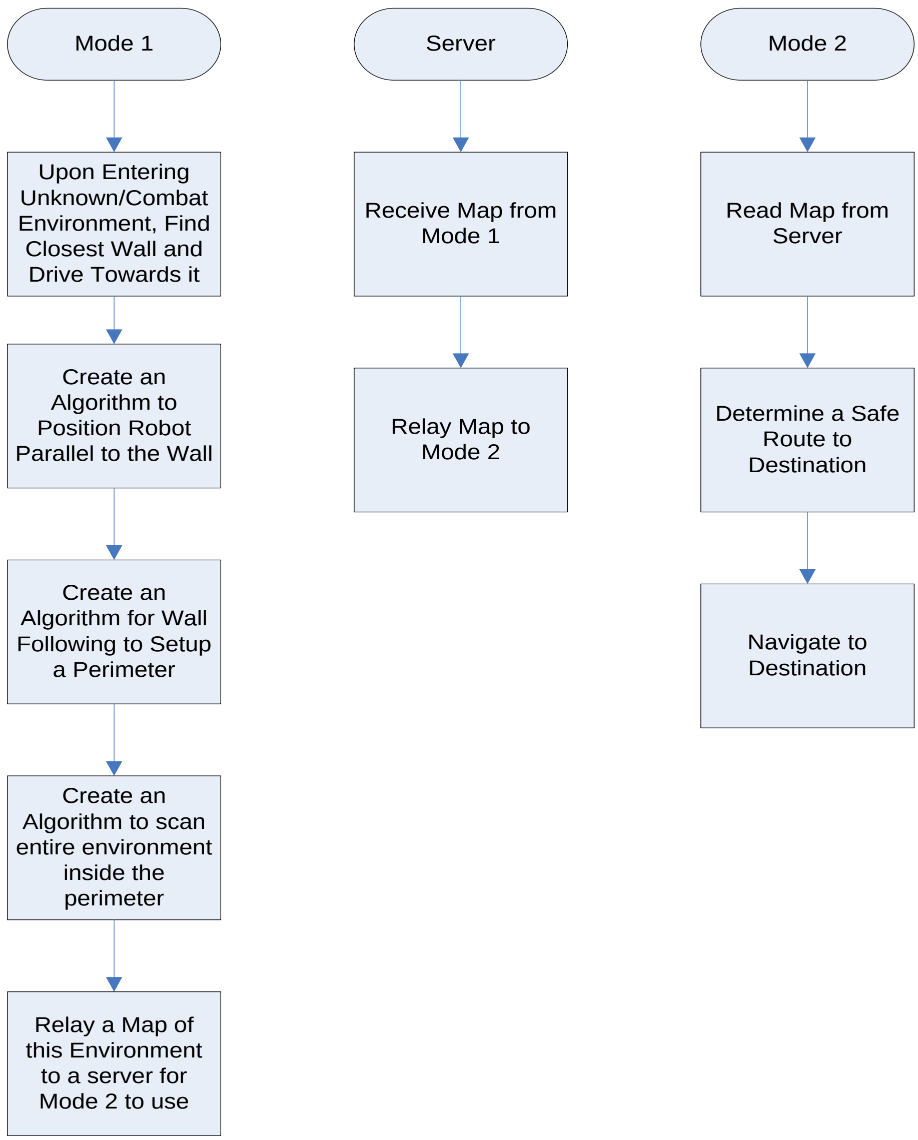
    - Develop framework to contribute maps to server/central command and update maps from the server
    - Research and develop algorithms to locate robot by matching its current map with the global map available on the server/central command
- Other Tasks
    - Create digital maps of the real-life-alike environments for computer simulation
    - Setup the infrastructure server for multiple robot cooperation/coordination
    - Weekly website update on project progress

Figure 1: High Level System Block Diagram



The high level system block diagram is divided into three main subsystems: mode 1, server, and mode 2. The first subsystem is the mode 1 subsystem. This subsystem's prime responsibility is to map an unknown/combat environment and send the map to a central server for storage. The second subsystem is the server subsystem which receives and stores the map from mode 1. When the map is completed, the server then sends that information to mode 2. The last subsystem is the mode 2 subsystem, which reads the map sent from the server. Based on the map received, mode 2 determines a safe route to the destination and then navigates through the environment. These three subsystems are all explained in better detail in Figure 2.

Figure 2: Subsystem Block Diagrams



Functional Requirements

Below are the functional requirements identified for the Multi Robot Navigation and Mapping for Combat Environment project. The quantitative values of the requirements are subject to change through experimentation and research.

Navigation Requirements:

- The Pioneer shall maintain a minimum distance of 250 millimeters from its edge to all walls/obstacles. This will allow for safe navigation throughout the environments in which the Pioneer 3-DX will be used.

- The robot shall be able to navigate through the space of a standard hall doorway (810 millimeters in the US).

- The speed of the robot shall not go above 300 millimeters per second to ensure accurate sensor readings and mapping.

- The software shall localize itself on a grid of 0.3 m x 0.3 m squares. This is slightly larger than the robot (0.22 x 0.38 m) and provides enough resolution when making a map.

- Infrared lasers shall be implemented if the sonar sensors do not provide enough accurate readings for proper navigation and mapping.

- A metal detector accuracy specification will be determined via research of different sensors. Tradeoffs between cost and accuracy will influence which sensors are used.

- The robot using mode 1 shall detect any metallic substance at least 76.2 meters (3 inches) from its surface. For this project, the metal would represent some type of threat such as mines.

- The robot’s path finding technique (mode 2) shall find the shortest route possible while avoiding all obstacles and potential threats.

Server/Wi-Fi Requirements

The robots must maintain a constant connection with the server to store and receive the map file using 802.11g wireless. In an actual battlefield, peer-to-peer with re-broadcasting, or deployed access points and robots with external Wi-Fi antennas would be used with encrypted transmission. Our method will be more of a proof of concept rather than a battlefield simulation.

Schedule

	Nick Halabi	Scott Tipton
12/17/2009 - 1/20/2010	Obtain 3 more metal detector kits	Improve wall following algorithm
	Solder all metal detector kits	Develop potential field path planning
	Perform necessary adjustments on detectors for 12 volts	Start server setup
1/21/2010 - 2/11/2010	Come up with a design for a robot extension for detectors	Setup server infrastructure
	Begin integrating metal detectors to 8051 board	Investigate how to receive the inputs from the 8051 board to Aria
	Begin integrating IR sensors to 8051 board	Begin integrating metal detectors and IR sensors into program
2/18/2010 - 3/11/2010	Find and build environments for testing	Work with Mike Firman on 3D imaging
	Finish integrating metal detectors to 8051 board	Implement force feedback joysticks
	Finish integrating IR sensors to 8051 board	Localization if time permits
	Start testing	Start testing
3/13/2010 - 3/22/2010	Continue Testing and troubleshooting	Continue Testing and troubleshooting
	Begin working on final presentation	Begin working on final presentation
	Begin working on conference paper	Begin working on conference paper

Bibliography

[1] Siegwart, Roland, and Illah R. Nourbakhsh. *Introduction to Autonomous Mobile Robots (Intelligent Robotics and Autonomous Agents)*. New York: The MIT, 2004. Print.

Equipment List

- Pioneer 3D-X
- Metal detector – Electronics123.com Product # Velleman K7102
- IR sensors - Sharp GP2Y0A02YK0F
- Force Feedback Joystick
- Silicon Labs 80C51F120 + UART/USB adaptor
- Space in Jobst as testing environment