Self-Mapping Mobile Robot (MapBot)

CAPSTONE PROJECT PROPOSAL

Submitted to

Dr. Aleksander Malinowski

Dr. Winfred Anakwa

by Stephanie Luft

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Project Summary

The objective of the Self-Mapping Mobile Robot senior capstone project is to develop a robot that can independently map an area of its environment, locate itself within the map, and navigate within the environment. This is primarily a software development project, although it will require several pieces of complex equipment to be interfaced with computers and the robot.

Detailed Description

System-Level Description

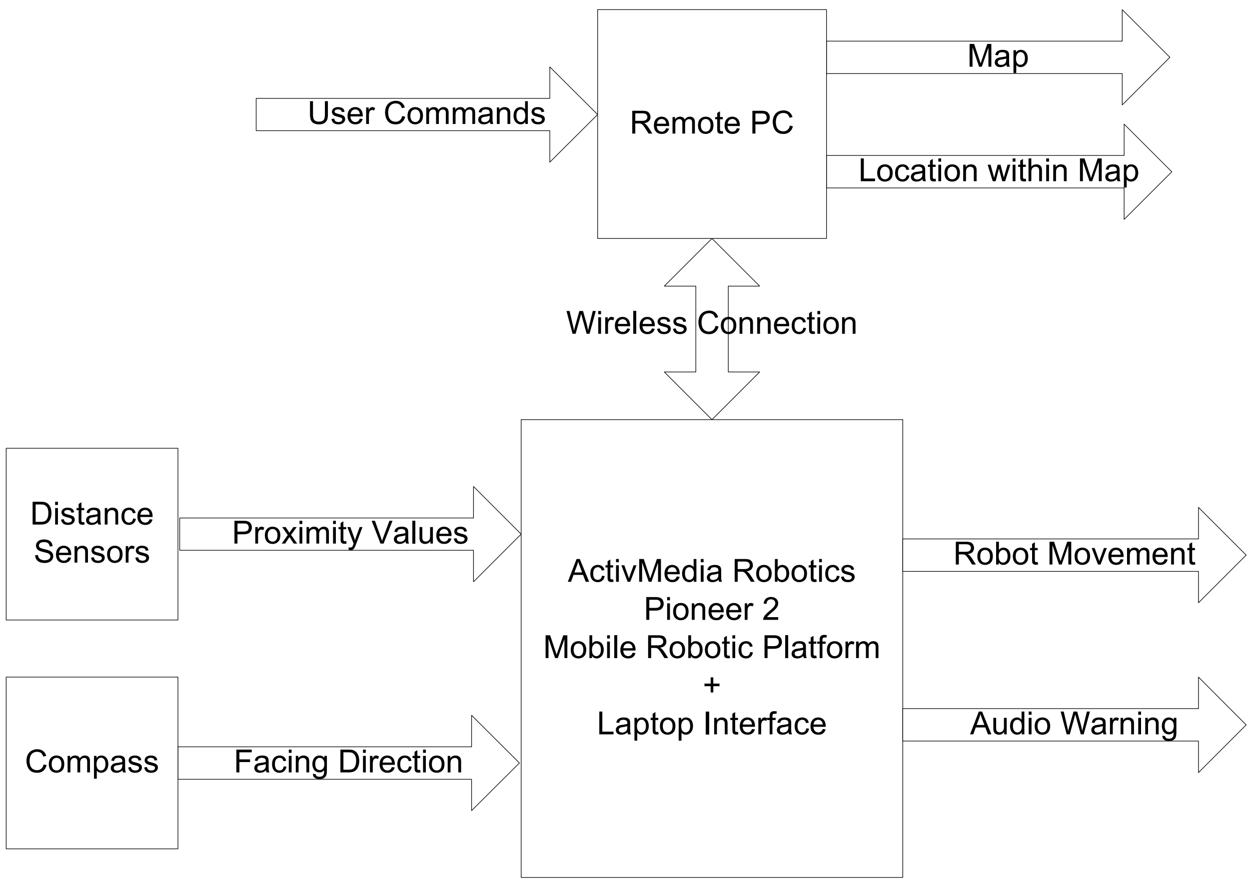

Figure 1: System block diagram for the MapBot

The primary components of the robot system, shown in Figure 1 on the previous page, will be the ActivMedia Pioneer 2 mobile robotic platform previously used in the GuideBot project and a Gateway laptop computer mounted on the mobile platform. One or more laser distance sensors will be used to measure the proximity of obstacles in the area, and a digital compass will provide directional information. A remote computer will communicate with the laptop through a wireless connection and will be used for the majority of the processing required.

The laser sensor will be mounted on a pan-tilt unit. This will allow the sensor to turn nearly 360 degrees as well as up and down. In this way, the robot will be able to detect stairs, avoid short obstacles, and look straight ahead while going down slopes.

The robot will move throughout its environment at the command of both the user at the remote computer and the "immediate response" software on the laptop. The robot will use data from the sensors and the compass to create a map of its environment and then locate itself on the map. The robot will be able to make a warning sound if it encounters a problem, for example if it finds itself in a small, closed-in space or if an obstacle approaches too quickly for the robot to avoid it.

Discussion of Laser Sensor Selection

Up to this point, the selection of the laser distance meter has required the most time and effort. The primary considerations are

- Cost: as low as possible and the best value for the project requirements.
- Accuracy: this is the primary reason for choosing a laser sensor as opposed to an ultrasonic model.
- Measurable distance: a 0.2 to 10 meter range as a minimum specification.
- Safety: lasers above class II may require inconvenient eye protection.
- Weight: The pan-tilt unit can support a limited mass, and additional weight slows the robot and more quickly drains the batteries.
- Ability to interface with the computer.
- Availability.

Several laser distance meters have been considered. The first models considered were very expensive industrial sensors with serial connections and proprietary software from several different vendors.

The option currently under consideration is a construction-type hand-held distance meter. These meters are much less expensive than the industrial type; however, they require a button to be pressed to initiate a measurement. Several have the option of connecting to the computer through a USB cable, and at least one model has a proprietary software program available that would allow a user to control the keypad through a GUI.

The problem with the less-expensive laser meters is that they require much more interfacing work. This will take time away from the completion of the actual project objective. It also opens the entire system to the potential for additional and time-consuming glitches.

A feasibility investigation is currently underway using a CST/Berger (Stanley FatMax) TLM 100 laser distance meter, the least expensive and most readily available model on the market at this time. This is essentially a trial run to determine if it is possible to run the meter by breaking open the casing and reading or driving the internal signals.

Software Description

The robot will have two main functional modes: Mapping and Maneuvering. Both modes will include obstacle avoidance features in the “immediate response” software on the laptop. The majority of the mapping and navigating processing will be done through the remote PC.

The Mapping mode will fulfill the project’s primary objective of plotting the robot’s environment and locating the robot in the map. It will include several functionalities needed to create the map, such as

- Distance sensing to read data from the distance sensor and compass
- “Immediate response” obstacle avoidance, including a warning signal
- Data transmission over the wireless connection
- Plotting the map to create the visual representation of the robot’s environment and showing its location
- Self-locating to determine the robot’s location within the environment and within the map
- Previous map identification to allow the robot to recognize a location that it has “seen” before
- Navigation and maneuvering using semi-random motion.

The Maneuvering mode will be similar to the mapping mode in several respects, but will allow the user to direct the robot’s movement. It will have many of the same functionalities, including

- Interfacing to allow the user to command the robot to map an area and to display the map to the user.
- Data transmission over the wireless connection
- “Immediate response” obstacle avoidance, including a warning signal
- Navigation and maneuvering
- Distance sensing to read data from the distance sensor and compass
- Self-locating to determine the robot’s location within the environment and within the map
- Plotting the robot’s location on the map.

The functionality described above will be implemented using C++ on the laptop computer and using C++ and/or MATLAB with Simulink on the remote computer. The flowchart for the initial software implementation is shown in Figure 2 on the following page.

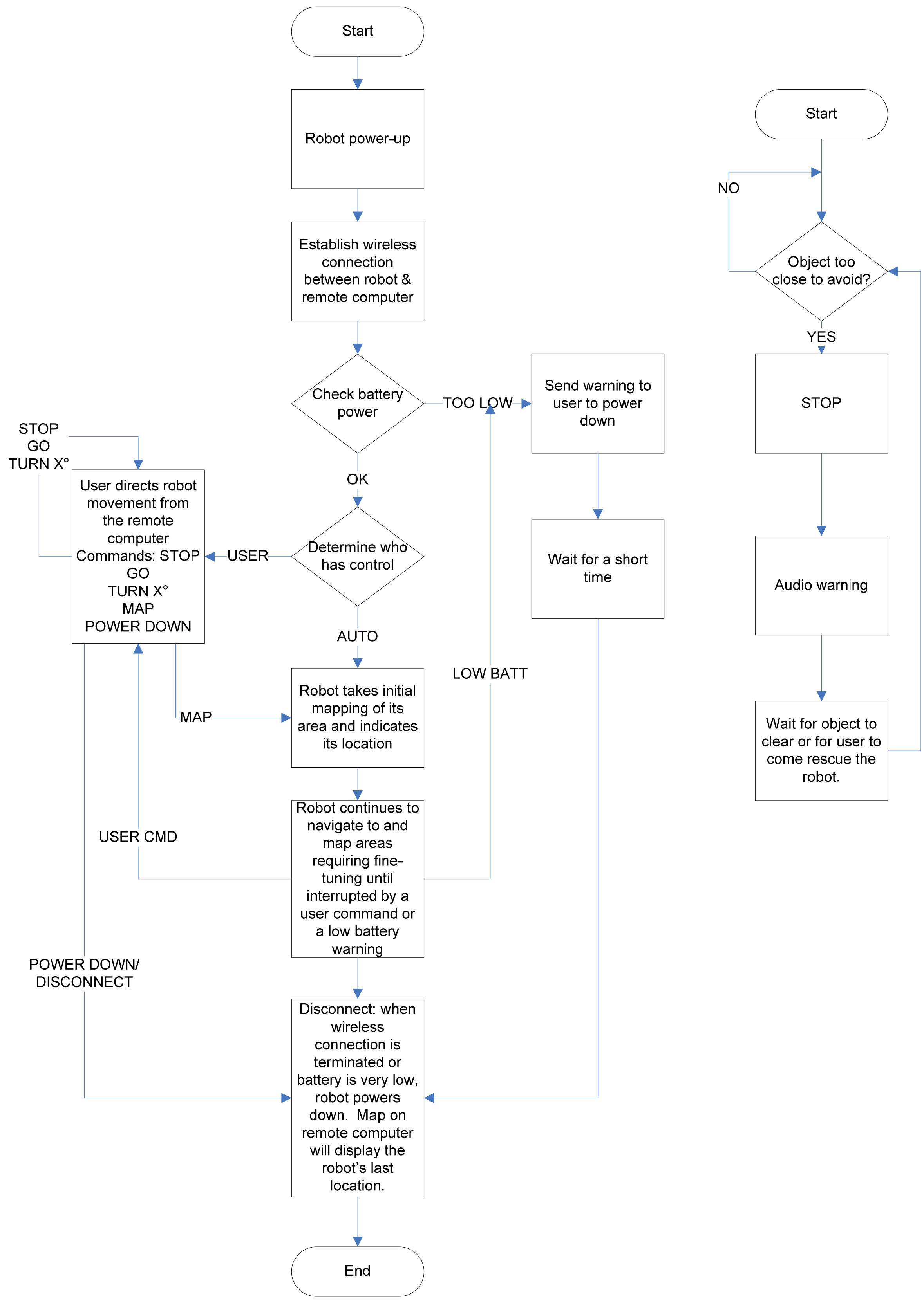

Figure 2: Initial Software Implementation Flowchart

Standards and Patents

Since the real design work for this project falls into the software realm, the number of applicable standards and patents is limited. There is a relatively new software initiative known as CMMI. It is a process improvement and integration method for the entire project cycle, and has been widely adopted in several industries.

Schedule

There will be approximately fourteen weeks available to complete the project in the coming semester. The proposed schedule is as follows:

Week of 22 Jan.	Research software methods and details of equipment functionality
29 Jan. – 11 Feb.	Connect hardware, develop functional understanding
12 Feb. – 25 Feb.	Software development
26 Feb. – 11 Mar.	Software simulation
12 Mar. – 15 Apr.	Software debug and test
16 Apr. – end of semester	Prepare for final report, presentation, and expo

Researched Works

The following works are useful in the research phase of the project:

- Duckett, Thomas D, *Concurrent Map Building and Self-Localization for Mobile Robot Navigation*. Thesis: Department of Computer Science, University of Manchester, United Kingdom. Oct. 2000.

- GuideBot Capstone Project 2005. John Hathway and Daniel Leach.
    - http://cegt201.bradley.edu/projects/proj2005/guidebot

- University of Illinois Mechatronics Laboratory Projects:
    - http://coecsl.ece.uiuc.edu/ge423/spring04/group7/group7.html
    - http://coescl.ece.uiuc.edu/ge423/spring04/group7/index.html

<u>Equipment List</u>

This project requires the following equipment:

- The ActivMedia Pioneer 2 mobile robotic platform
- A laptop computer with a wireless network connection
- A digital compass
- A remote PC with a network connection
- A laser distance meter
- A pan-tilt unit for mounting the laser distance meter
- Appropriate connectors for the listed equipment
- MATLAB, Visual Studio, and/or another type of software development system.