INTELLIGENT GUIDE ROBOT

FUNCTIONAL DESCRIPTION
&
COMPLETE SYSTEM BLOCK DIAGRAM

By:

Joe Buckner

Nir Chezrony

Project Advisors:

Dr. Joel Schipper

Dr. James Irwin

Date:

November 11, 2008

INTRODUCTION & SYSTEM GOALS

The objective of this project is to design an autonomous robot that acts as a tour guide for visitors of the Electrical and Computer Engineering (ECE) Department at Bradley University. To meet this objective the Intelligent Guide Robot (I-GUIDE) must meet the following goals:

- Successfully navigate the ECE Department
- Identify key points during a tour
- Provide accurate information to the user
- Provide a means for user input

FUNCTIONAL DESCRIPTION

This project utilizes a Pioneer 3 Robot as the working platform for I-GUIDE. ARIA MobileSim Software and Microsoft Visual Studio software packages are used to simulate and program the Pioneer. The foundation and basic platform programming for the Pioneer were developed in C++ during Dr. Malinowski's Autonomous Mobile Agents [1] class (EE410). Thus, I-GUIDE is programmed in C++. Other hardware, discussed in detail later, is implemented to aid in the functionality of the robot.

The necessary goals for this tour robot are defined below. I-GUIDE must:

- Autonomously navigate the second and third floors of the ECE Department utilizing the elevator as a means of transportation between floors. Due to the complexity of the elevator problem, navigation may not be completely autonomous and some user assistance may be required.
- Perform obstacle detection and autonomously navigate around obstacles.
- Autonomously locate predefined locations throughout the ECE Department and provide audio and visual feedback while facing the user.
- Detect when the battery is low and autonomously locate the Pioneer docking station.
- If time permits, further objectives include the construction of a complete system docking station, navigation of the first floor, and fully autonomous operation of the elevator.

SYSTEM BLOCK DIAGRAM

The high-level diagram shown in Figure 1 shows the overall system hardware. The human interface device, speakers, and monitor are connected to the laptop via their standard interface; i.e. USB port, 3.5mm stereo jack, and VGA port, respectively. The laptop is connected to the Pioneer using the serial port. After selecting and obtaining localization sensors, they are connected directly to the laptop. Lastly, because the sonar sensors are already built into the Pioneer, their outputs are read from the Pioneer to the laptop.

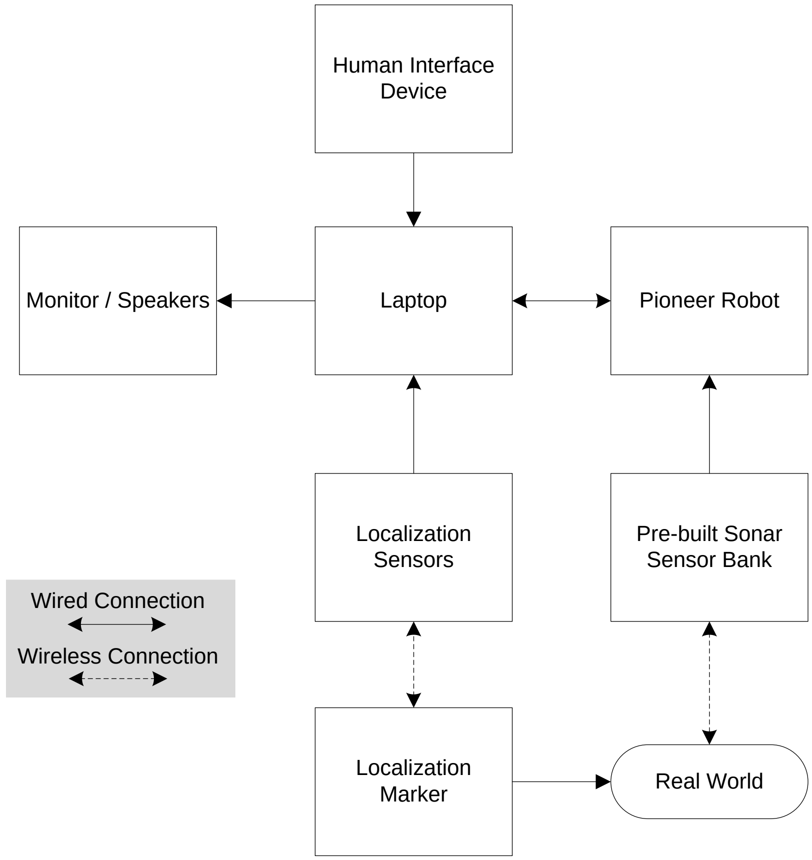

Figure 1 - High-Level Block Diagram

HUMAN INTERFACE DEVICE

Allowing the user to select a destination is a crucial part of I-GUIDE. This requires some type of human interface device (HID) that allows the user to communicate to I-GUIDE. The following is a list of devices that may be implemented. Only one device is necessary.

Possible Devices:

- Touch screen
- Joystick
- Keyboard
- Mouse with a Graphical User Interface
- Button Array

MONITOR / SPEAKERS

To provide the user with information in an intuitive manner, I-GUIDE requires a means of displaying pictures and video, as well as playing accompanying audio.

PIONEER ROBOT

The Pioneer 3 provides a base from which to build all peripherals, both physically and figuratively. The laptop, additional sensors, monitor, speakers, and HID will all rest on top of the Pioneer. As the robot is pre-built with sonar sensors, a means of locomotion, and a battery, this project interfaces the rest of the software and hardware to the Pioneer.

LOCALIZATION SENSORS / MARKERS

Using solely the Pioneer's sonar sensors, it is possible to navigate any standard indoor environment. However, it would be difficult and time consuming to determine I-GUIDE's exact location in relation to its presumed position. The error between the presumed position and the exact location is generally due to wheel slippage. To compensate for this error, and to provide an easier and faster means of determining the robot's exact location, another set of sensors are implemented. Some of these sensors may require special markers placed in the operating environment.

Several methods have been proposed and some investigation is required to determine which is the most reliable, affordable, technologically feasible, and least obtrusive to the operating environment. The following is a list of sensors or localization methods followed by a brief description. One or more will be implemented.

Possible Sensors / Methods:

- IR Transmitter / Receiver – I-GUIDE would be equipped with an IR receiver that would decode unique flashes as a particular location. An IR LED would be placed at each location that would flash its unique code periodically.
- Digital Compass – Equipping the system with a digital compass would allow the system to determine which way it was facing, thus allowing it to determine its next, and possibly fastest, route.
- Barcode Reader – By placing unique barcodes at predefined locations, I-GUIDE could read these barcodes and determine its exact position.
- RFID Transmitter / Receiver – The system would transmit a frequency which would power a small Radio Frequency Identification tag, which in turn would transmit a unique signal back to the system.

- Environment Counting – Implementing a camera on the robot would allow for some type of counting scheme to determine location as movement occurs. This includes counting floor tiles, wall bricks, and ceiling lights.

SOFTWARE BLOCK DIAGRAM

The high-level software block diagram seen in Figure 2 shows the overall setup of the software. This project is programmed in C++ because a large amount of the base programming used for the Pioneer is written in C++. Also, the ARIA MobileSim software simulation package is utilized for simulation of various algorithms for the Pioneer.

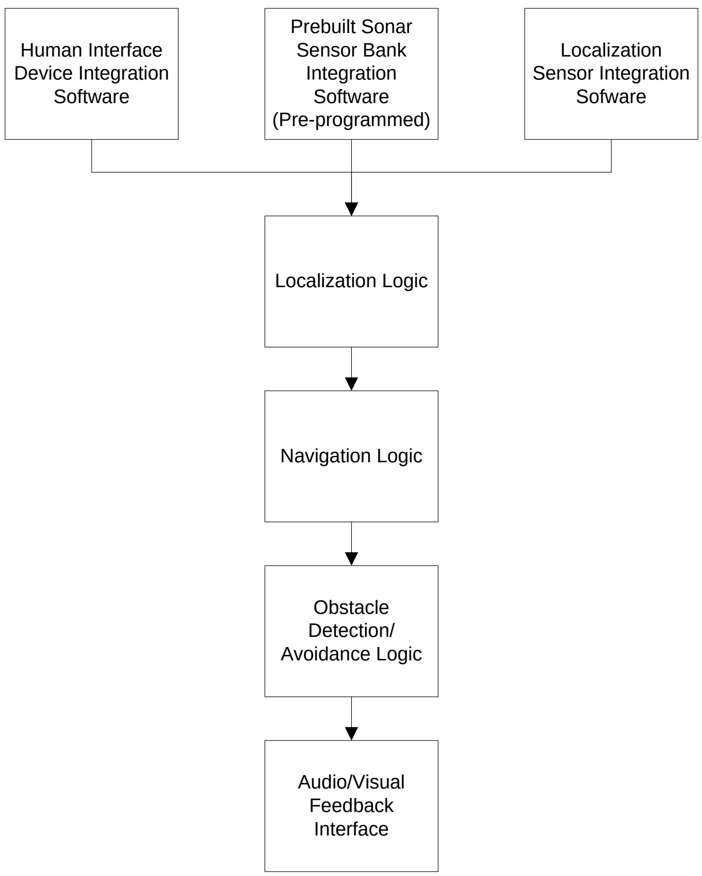

Figure 2 - High-Level Software Block Diagram

INPUT INTEGRATION SOFTWARE

There are three basic inputs to the software that must be integrated. The pre-built sonar sensor bank integration software is provided by Dr. Malinowski and the ARIA MobileSim software package. The integration of the HID and the localization sensors will be determined after the hardware for these components have been chosen.

LOCALIZATION LOGIC

The localization logic answers the question, “Where am I?” This logic utilizes the localization sensor and the pre-built sonar sensor bank inputs to determine where the robot is located.

NAVIGATION LOGIC

The navigation logic answers the question, “Where am I going?” This logic utilizes the localization logic and the HID input to determine what is the next course of action. This logic governs most of I-GUIDE’s actions.

AUDIO/VISUAL FEEDBACK INTERFACE

This is the logic that provides the user feedback based upon I-GUIDE’s current location. This logic is responsible for providing whatever predefined audio and visual feedback is required at key points during the tour.

OBSTACLE DETECTION/AVOIDANCE LOGIC

The obstacle detection/avoidance logic answers the question, “Is there anything in my way?” This logic utilizes the localization and navigation logic sets as well as sensor inputs to detect and navigate around any obstacles. The first challenge with this logic is obstacle detection. The next challenge comes after an obstacle has been detected. The challenge now becomes how to get around this obstacle.

CONCLUSION

Implementation of I-GUIDE requires the investigation of several different devices and techniques as well as designing algorithms to optimize localization, navigation, and obstacle avoidance/detection. However, the backbone of simple navigation has been already coded, which provides a good starting point.

REFRENCES

[1] R. Siegwart and I. Nourbakhsh, Introduction to Autonomous Mobile Robots, Cambridge, MA: The MIT Press, 2004.