# Intelligent Guide Robot (I-GUIDE)

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## ABSTRACT

*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. This project utilizes a Pioneer 3 Robot as a working platform for the Intelligent Guide Robot (I-GUIDE). Microsoft Visual Studio and ARIA MobileSim software packages are used to program and simulate the Pioneer 3 in C++. I-GUIDE employs a basic wall-following and path planning algorithm with obstacle avoidance and unique landmark detection. The wall-following and obstacle avoidance algorithms utilize arrays of infrared and sonar sensors. Unique landmark detection is provided by ultra-violet sensitive barcodes placed on the ceiling, which are read by an extended range barcode scanner. Path planning is accomplished using an internal topological decomposition map, where each node corresponds to a unique landmark. A user interface consisting of a keypad, "kiosk" liquid crystal display monitor, and computer speakers is used to interact with ECE Department visitors.*

## Keywords

topological decomposition, autonomous mobile robotics, informational tours

## 1. INTRODUCTION

Many professors at Bradley University's ECE Department spend time giving tours of the facilities, laboratories, and classrooms to prospective students and their families. During the course of these tours, the professors invariably end up in the Senior Laboratories to show examples of the Senior Capstone Project. I-GUIDE serves the dual purpose of providing an example of a Capstone Project as well as alleviating the professors of giving tours. To serve in these functions, 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 is not completely autonomous and some user assistance is required.
- Perform obstacle detection and autonomously navigate around obstacles.
- Autonomously locate predefined points of interest 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.

## 1.1 Topological Decomposition

Since I-GUIDE is primarily built for a known environment, a mapping technique known as topological decomposition is implemented.

This technique identifies key nodes in an environment and the connectivity between them. The connectivity also contains the angle for each arch between nodes. **Error! Reference source not found.** shows an example modeling of an environment.

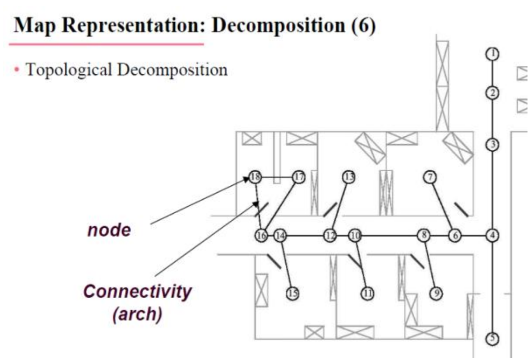


**Figure 1 - Example Topological Composition Map [1]**

## 2. PHYSICAL SYSTEM

The high-level diagram in **Error! Reference source not found.** shows the overall system hardware. The human keypad, 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. The infrared (IR) sensors produce an analog signal that is read by an Analog to Digital Converter to USB (ADC-USB), which in turn is read by the laptop. The laptop provides power to the barcode scanner and the scanner is triggered by a digital output on the ADC-USB.

Lastly, because the sonar sensors are already built into the

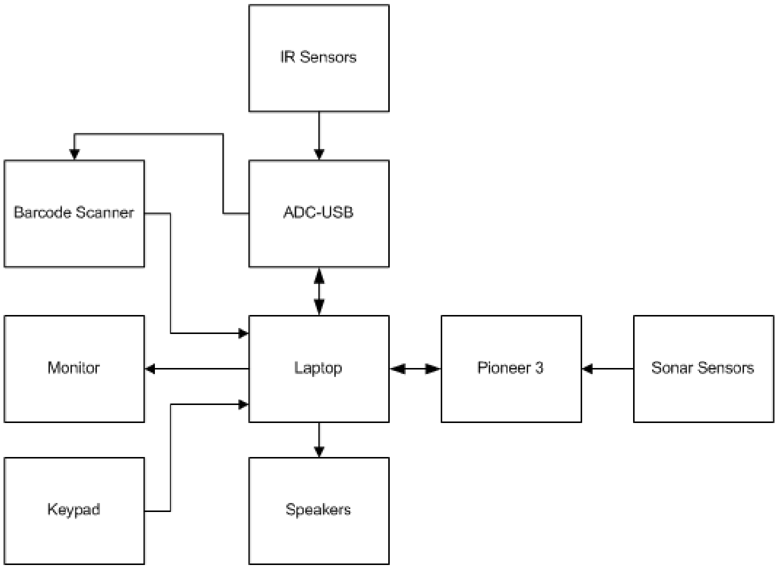


**Figure 2 - Overall System Block Diagram**

Pioneer, their outputs are read from the Pioneer to the laptop.

## 2. SOFTWARE COMPONENTS

I-GUIDE's software consists of three major components: Wall-Follow, Obstacle Detection & Avoidance, and Path Planning & Localization.

### 2.1 Wall-Follow Algorithm

The wall-follow algorithm employs a front bank of IR sensors, three on each side, to detect the distance from the sensor and the wall.

The algorithm begins by attempting to keep the robot in the "threshold" of the hallway, which is a thin corridor down the center of the hallway. Whenever the robot detects that it is outside of the threshold, it rotates back towards the center. To reduce oscillation, the rate and speed of the rotation is determined by the distance outside of the threshold. Lastly, the speed of rotation is rate limited to maintain a smooth return to the center of the hallway.

A sample simulation is shown in **Error! Reference source not found.**, with the simulation robot being picked up and placed next to a wall three times, and with both walls. The double blue lines illustrate the threshold.

### 2.2 Obstacle Detection & Avoidance

Using a combination of sonar and IR sensors, a means of detecting static and dynamic obstacles is implemented. The IR sensors are capable of producing very accurate measurements of distances greater than 750mm. The sonar sensors react poorly in I-GUIDE's operating environment for long range distance determination but work very well in close proximity.

#### *2.2.1 IR Sensors*

As the IR sensors have high precision and greater distances than the sonar sensors, the IR sensors are used to detect obstacles that enter the robot's field of vision at some distance out. This greater distance allows I-GUIDE to compensate its path to move around the obstacle without losing speed. Since when reversing, speed is not crucial, the IR sensors are also employed.

#### *2.2.2 Sonar Sensors*

The sonar sensors, which are built into the Pioneer 3, are subject to a lot of noise due to the reflective surfaces in the ECE Department. However, the sonar sensors are reliable in much higher proximity than the IR sensors. For this reason, the sonar sensors are used to determine if an obstacle is, or has become, too close to I-GUIDE. The robot then compensates by slowing down drastically, stopping, reversing a little, turning towards the center of the wall and the obstacle, determining clearance, and then slowly driving till the obstacle is cleared.

### 2.3 Path Planning & Localization

#### *2.3.1 Localization*

Localization is achieved by detecting unique landmarks within the operating environment. These landmarks are made up of ultra-violet (UV) sensitive ink barcodes placed on the ceiling [2]. I-GUIDE is equipped with an extended range (9ft.) barcode scanner to read the barcodes. Each barcode is encoded with the floor number and numerical value, under the UPC-E barcode scheme.

#### *2.3.2 Path Planning*

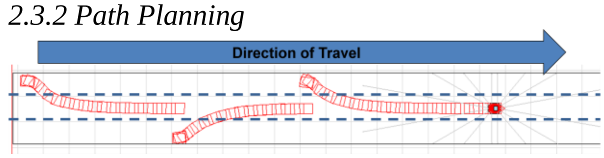


**Figure 3 - Wall Follow Simulation**

The path in which I-GUIDE must take is determined by the current position and the final position necessary for the robot. The landmarks are encoded in ascending order, which allows a difference equation to determine the direction of travel necessary. Once direction of travel is achieved, and proper orientation is set, the robot simply continues until it reaches the next landmark and checks if it is the final destination. The internal topological decomposition map contains instructions on which direction to turn when a certain node is reached.

### *2.3.3 Current Orientation*

To determine if the robot is facing the correct direction to reach the next logical landmark, the difference between the current location and the previous location gives the bearing.

## 3. CONCLUSION

I-GUIDE provides not only a working demonstration of the Senior Capstone project but also an autonomous tour guide to relieve professors, as well as a stronger platform to build future projects. With the integrated IR sensors, barcodes scanner, monitor, additional channels on the ADC-USB, and a means in which to navigate the ECE Department accurately, additional projects can focus on the more advance applications of robotics and not the low-level hardware aspects.


## 4. ACKNOWLEGMENTS

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## 5. REFERENCES


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[2] J. Huh, W. S. Chung, S. Y. Nam, and W. K. Chung, "Mobile robot exploration in indoor environment using topological structure with invisible barcodes," *ETRI Journal*, vol. 29, no. 2, pp. 189-200, 2007.