

# Self-Navigation Robot Using 360° Sensor Array

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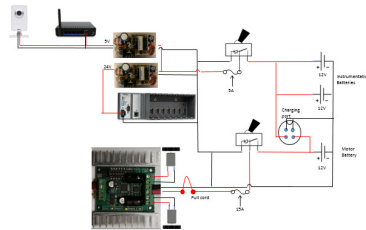
## INTRODUCTION

This Self-Navigation robot utilizes a variety of sensors, mechanical parts, and LabVIEW code which allows it to navigate through an environment with precision and accuracy. This project is a culmination of three generations worth of work that involved myriad hours of building, troubleshooting, and learning.

## PURPOSE

The goal of this project was to develop a robot that can navigate through an environment with many obstacles using a sensor array that provides a 360 degree view of its surroundings. The sensor array consists of infrared and ultrasonic distance sensors. Four sensor arrays are swept in an angular pattern to provide a complete view of the robots surroundings. The data from the two sensors must be combined using a mathematical calibration algorithm to take advantage of each sensor's specific characteristics. The unique aspects of this project are the navigation program and the sensor calibration algorithm.

## DESIGN



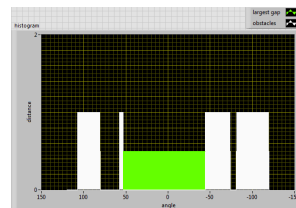
Circuit Diagram

A Sharp infrared and MaxBotix ultrasonic sensors are used to gather depth data. The IR sensor is rated for accurately detecting objects between 0.2m to 1.5m with an inverse voltage to distance relationship. However the IR sensor gave varying values for different colored and textured objects at the same distance. The ultrasonic sensors were rated for a range of 0.15m to 6.45m with a linear voltage to distance relationship. The ultrasonic sensor gave accurate readings for all surfaces further than 0.3m. The sensors were used in conjunction to detect objects at all distances, surfaces, and angles.

## THE ALGORITHM

### VECTOR-FIELD HISTOGRAM (VFH)

In order to navigate through a space, we need to develop a depth map of obstacles in the robot's surroundings by linking infrared and ultrasonic distance data with the objects' relative locations. This is done with a vector field histogram algorithm. The sensor servo sweeps back and forth through its field of view, taking depth data at every angle, and then sends that to the VFH. A set of four VFH's are created in the program to detect objects at various distance thresholds, allowing it to assign more significance to closer objects than those that are further away.



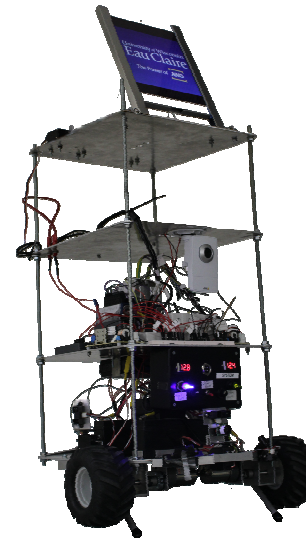
Sample Vector Field Histogram

### NAVIGATION ALGORITHM

Using the data from the VFH, areas where the sensors detect objects are avoided by the robot's control algorithm as it navigates through its environment. Its speed is calculated relative to the nearest object its sensors detect, allowing it to traverse tight spaces carefully, and open spaces quickly. If an object is detected within 20cm of it, it will back up and turn away from that object before proceeding. In the event that direct control is desired, the user can take over manual control of the robot via a joystick controller.

## ROBOT SPECIFICATIONS

### PHYSICAL DESIGN



- Compact RIO 9073
  - 9263 Analog Output module
  - 9205 Analog Input module
  - 9401 Digital I/O module
- Compact DAQ 9174
- Sabertooth 2x12 Motor Controller
- GP2Y0A02YK and GP2Y0A21YK0F Sharp Infrared and MB 1040 LV-MaxSonar-EZ4 Ultrasonic distance sensors
- Three 12V batteries
- Two power supply units
  - 12V to 5V converter
  - 12V to 24V converter
- Axis M1011 IP Camera
- Dlink DIR-601 Wireless Router
- Parallax Standard Servo Motor

## THIRD GENERATION ROBOT REDESIGN

Improvements made to the robot include three additional sets of sensors located on the sides and back of the robot that sweep back and forth to provide a 360 degree view of its environment, also added were two sensors in the front and the back angled to the floor to determine a drop off, we also updated the wiring for more stable connections,

## CONCLUSION

The control algorithm functioned rather superbly. The robot is able to navigate through a wide variety of environments. It could always be improved by the implementation of more sensors to collect data in more directions and heights, however, the current setup yields promising results. Three of these robots have been constructed by our team, with two more in the works for the future.

### FUTURE GOALS

- Two way audio/video communication
- Second video camera for a wider field-of-view
- Wheel encoders to improve the navigation algorithm
- Addition of a Gyroscope/Accelerometer
- Long-range network control
- Path-Planning algorithm
- Communication between multiple robots for more complex tasks