Fully-Autonomous LabVIEW-Controlled Robot

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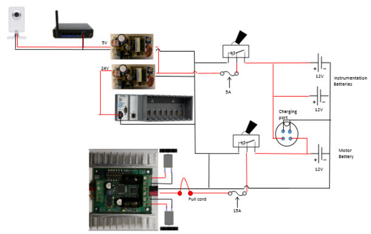
Introduction

The goal of this project was to develop a self-navigating robot, using multiple types of sensors, capable of traversing any environment it is placed in. Programmed with National Instruments LabVIEW graphical programming language, these robots are capable of interfacing with a large variety of hardware devices utilized by this project. It can be controlled using a network connection, making it portable and convenient.

Purpose

The purpose of this project was to design and build a fleet of 5 robots that can be used in Dr. Pierson's LabVIEW courses. The robot is equipped with National Instruments cDAQ and cRIO devices with NI Analog Input, Analog output and Digital I/O modules. Students are able to gain experience communicating and programming with both of these devices using them to learn about the systems of this robot and to design there own self-navigation program.

Design



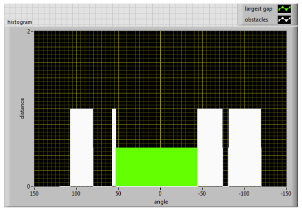
Circuit Diagram

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 fourth 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.

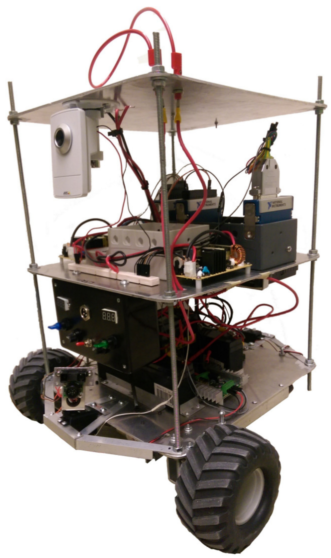


Sample Vector Field Histogram

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 an Xbox 360 wireless controller.

Robot Specifications



Physical Design

- Compact RIO 9073
  - 9263 Analog Output module
  - 9205 Analog Input module
  - 9401 Digital I/O module
- Compact DAQ 9174
- Sabretooth 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

Robot Redesign

Improvements made to the robot include a drive train redesigned by Turner, a better caster wheel placed on the back for smoother driving, kickstands were added to pick the drive wheels off the ground for troubleshooting the robot and power supplies were rearranged and rewired to give sensitive systems a stable voltage.

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
- Additional sensors, including floor/stair detectors
- 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
- Creation of outside casing for the chassis
- Communication between multiple robots for more complex tasks

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