Self-Navigating Field Programmable Gate Array Robot

MARISSA ZALESKI AND REBECCA TOLLAKSON

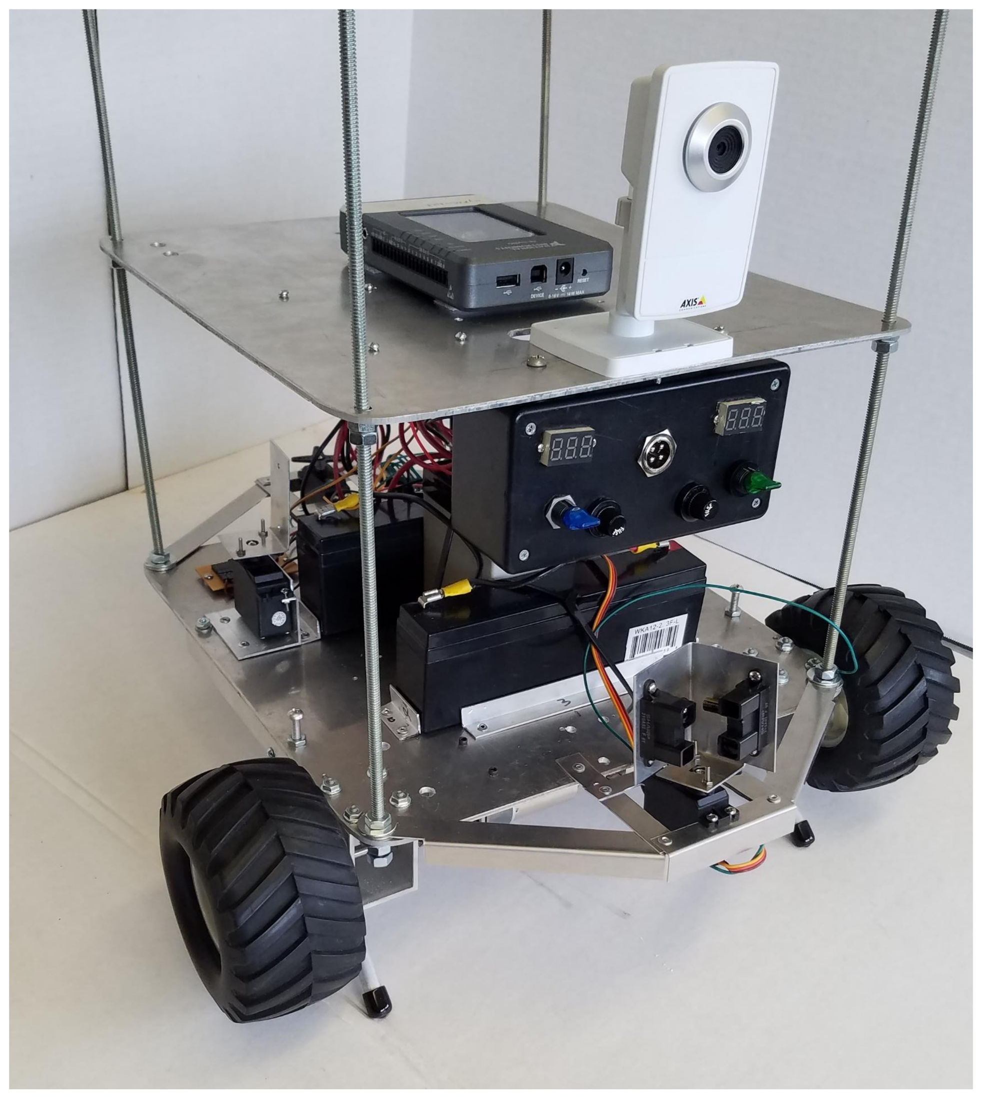
Mentors: Dr. Kim Pierson and Turner Howard | Department of Physics and Astronomy

INTRODUCTION

The robot we designed uses multiple sensors, servos,and LabVIEW code implemented on a myRIO National Instruments device to navigate autonomously through varying environments. The project is currently on its fourth generation.

PURPOSE

The purpose of this research is to design a self-navigating robot that can perform at a higher speed than the previous configuration. We accomplished this by using a new kind of computer chip called a field programmable gate array (FPGA). The advantage of the FPGA is the ability to operate faster because the computer control code runs on hardware gates within the FPGA, rather than as lines of code on a central processing unit in a regular computer. In addition, the control algorithm can be designed to operate as a large number of parallel independent loops which further increase the speed of operation. We also incorporated a new distance sensor design, which allows the sensor to scan twice as fast as the previous configuration, enabling twice as much data to be processed, and more accurate decisions made. All these enhancements allow the robot to drive at maximum speed through an obstacle filled environment.



Our current design

HARDWARE

FIELD PROGRAMMABLE GATE ARRAY (FPGA)

An FPGA is an integrated circuit that is designed to be configured by the user to implement a computer program in 'hardware.' A large system of logic circuits and interfacing circuitry can be wired up to perform the functions of the program instead of running code on a computer central processing unit (CPU). An FPGA has three main advantages: the program runs much faster than software on a CPU; programming functions can be designed to run in parallel providing additional gains in processing speed; and the system can be reprogrammed many times to accommodate desired changes to functionality.

MyRio Control System

MYRIO

The myRIO is a 'real-time' embedded control board with WiFi that connects the FPGA to the rest of the robot. It is used to develop automatic control systems that utilize its onboard FPGA and microprocessor. The myRIO sends the data that is collected by the robot's sensors to the FPGA. The FPGA then interprets the data and sends information back through the myRIO to the motors via analog output. The myRIO acts as a translator between the FPGA commands and the devices used on the robot. It requires LabVIEW to program and it is geared toward providing students with engineering physics experience using cutting-edge hardware interface technology.

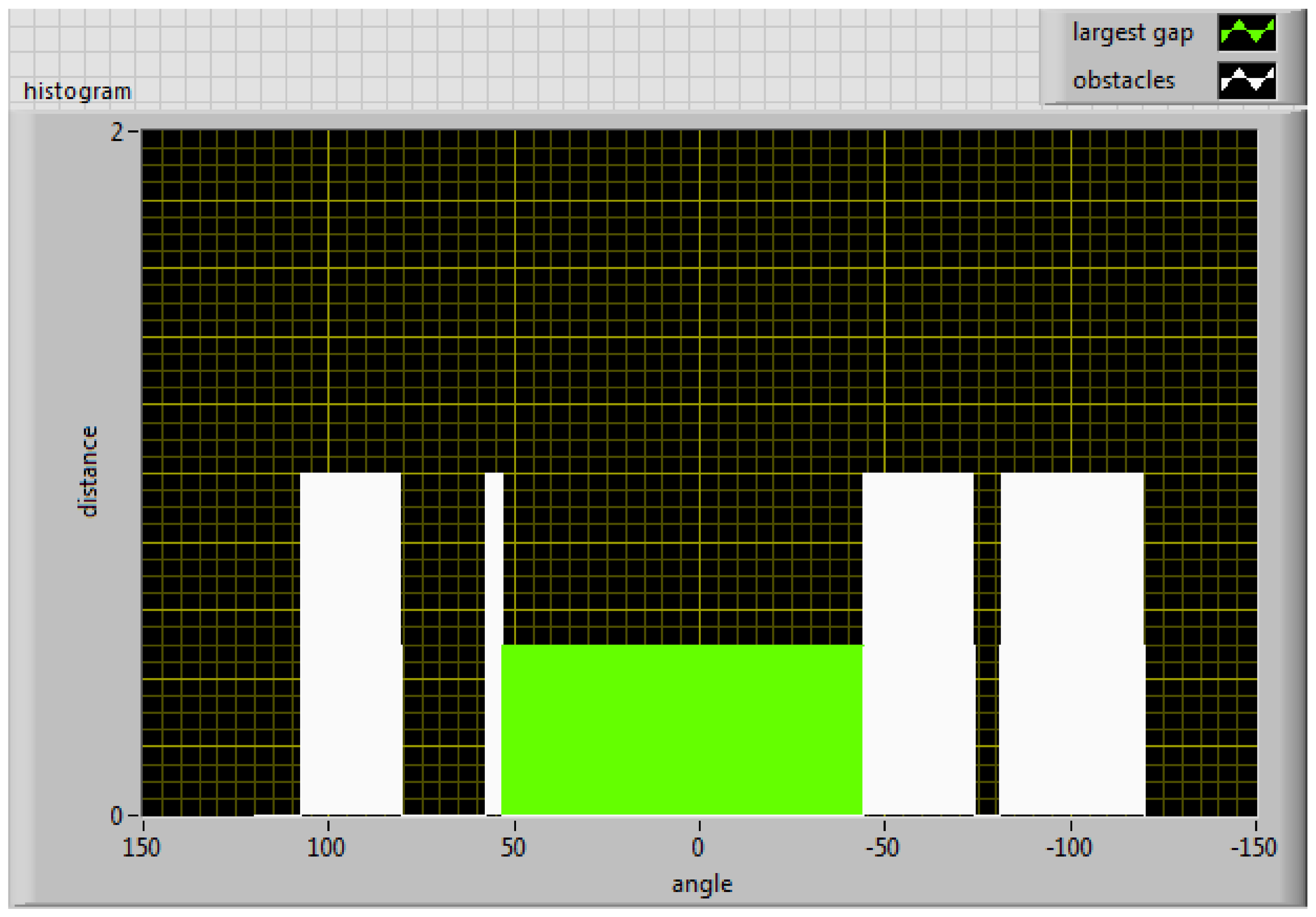
REDESIGN

All previous generations of this research project used a combination of a compact RIO (cRIO) and a single distance sensor to make similar robots self-navigating. These devices allowed the robots to navigate independently but limited the size of the area in which the robots could operate. Replacing the cRIO with the myRIO, we not only lessened the overall weight and power consumption, but were also able to connect the robot to the university WiFi, which vastly expanded the area in which the robot could be used. The dual forward-looking sensor arrangement doubles the speed at which objects can be recognized and avoided and thus allows the roaming speed of the robot to be doubled. Using the myRIO, our robot is also now more efficient and able to accelerate faster.

LABVIEW ALGORITHM

VECTOR FIELD HISTOGRAM (VFH)

In order to navigate autonomously, the robot must be able to read data from the sensors as a map of its surroundings. This is accomplished using a Vector Field Histogram (VFH) algorithm in LabVIEW. Infrared Sensors (IR sensors) are mounted on a servo motor that sweeps back-and-forth. The IR sensors indicate how far away obstacles are located. Data pairs consisting of distance and angle are fed into the VFH which then provides angles at which open spaces are located. The robot is programmed to turn toward those open spaces and continue driving forward. The servo sweeps about once per second, but because of the unique arrangement of dual sensors on the servo, the obstacle information is updated about twice per second. This allows the robot to navigate twice as fast as previous versions



Sample Vector Field Histogram

CONCLUSION

This newest version of a self-navigating robot can travel twice as fast as previous versions. Its WiFi capability also allows it to roam anywhere on campus. The myRIO is also easier to program than the previous system. More care was taken whilst routing wires which has resulted in fewer intermittent loose connections that had previously caused failures. The myRIO uses less power that the previous control system so that longer roaming times can be achieved.

THE FUTURE

- Two-way audio/video communication
- Incorporation of wheel encoders to allow more precise turns
- Path-Planning algorithm
- Additional IR sensors for a wider view of surroundings

ACKNOWLEDGEMENTS

This research was supported by the UW-Eau Claire Physics and Astronomy department and the UW-Eau Claire Blugold Fellowship Program which is jointly funded by Differential Tuition and The Foundation.

We thank the Office of Research and Sponsored Programs for supporting this research, and Learning & Technology Services for printing this poster.