

# Robot Navigation Using LabVIEW Vector Field Histogram Algorithm

Erik J. Olson, Dr. Kim Pierson,  
Department of Physics & Astronomy UW-Eau Claire

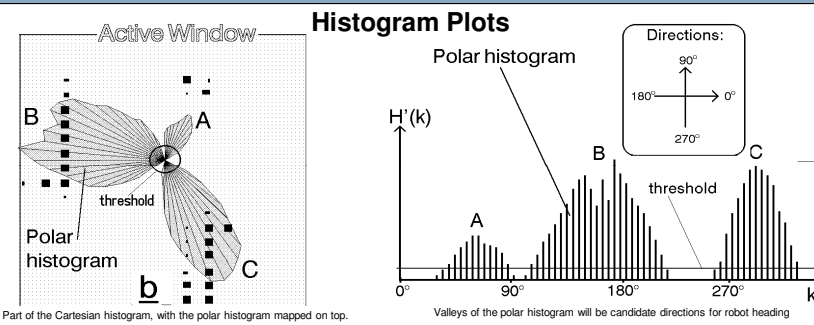


## Project Purpose

For autonomous robots, navigating through a building to a specific spot selected within the building can be very difficult. If this could be accomplished, a myriad of menial tasks could be performed more efficiently than by a human. The specific purpose of this project was to design a program for the National Instruments Single-Board RIO robot that could navigate in a building, given only start and end points, using the Vector Field Histogram as an obstacle avoidance and path finding algorithm.

## Vector Field Histogram (VFH)

The Vector Field Histogram is a method of autonomous navigation. This method works by storing probabilities of obstacles in two different histograms. One is a large Cartesian histogram that contains data for the whole area the robot might occupy, shown on the left below. A smaller polar histogram keeps track of the local surroundings. Using the polar histogram, the best immediate direction of travel can be chosen while the Cartesian map provides path planning. The sensors on the robot are used to update the Cartesian map in real time.

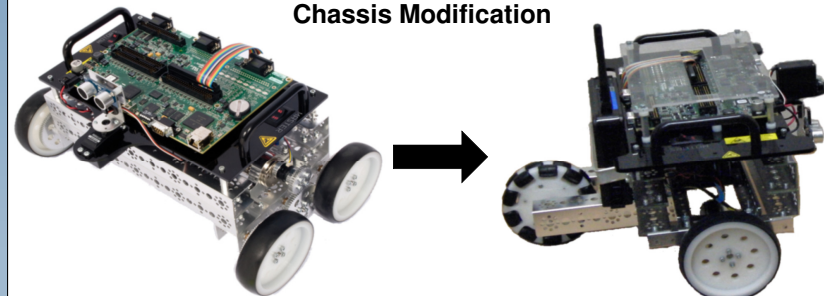


Borenstein, J.; Koren, Y.; "The vector field histogram-fast obstacle avoidance for mobile robots." Robotics and Automation, IEEE Transactions on, vol.7, no.3, pp.278-288, Jun 1991  
doi: 10.1109/70.88137  
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&number=88137&number=2880>

## Problem with Original Robot Design

In order to successfully navigate between two points, keeping track of the robot's position and heading is extremely important. If this is calculated incorrectly, the robot will quickly get off target, and never reach the goal. The stock LabVIEW robot was driven by four wheels and two gears, which would slide uncontrollably when turning. We changed the design to only be driven by two wheels, with a third passive wheel in the back for stability that allows for more accurate movement.

## Chassis Modification



On the left is the original robot from National Instruments. On the right is our modified robot with three wheels

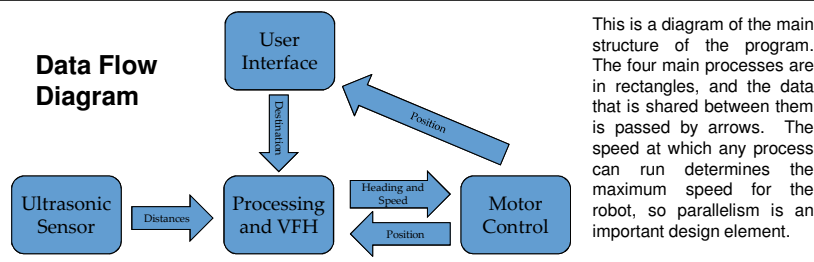
"NI Robotics Starter Kit: List of Parts." Zone.ni.com. National Instruments, 15 Jan. 2010. Web. 8 Apr. 2012

## VFH in LabVIEW

The LabVIEW Robotics software package has many common algorithms already programmed for designers, including VFH. However, the LabVIEW implementation of VFH only uses the local polar histogram, and not the Cartesian, so path planning around a number of obstacles is not possible. To get around this limitation the robot is equipped with encoders connected to its wheels so that distance and direction information can be recorded. This allows the robot to navigate between two points.

## Navigation Program Design

The program is split into three independent parts: sensing, thinking, and moving. To get information about its surroundings, our robot has one ultrasonic sensor that spins around on a servomotor. Data is sent into the "thinking" loop, where LabVIEW's VFH method is used to choose the heading and speed of the robot. This is passed into the motor control loop that keeps track of the robot's position in space.



## Analysis of Navigation Program Capabilities

The robot is able to navigate between start and end points successfully in many environments, but some specific scenarios pose difficulties. Most difficulties stem from the limitation that the robot cannot plan a path from its current location to the end goal without additional data. One example of this a dead end: in its current implementation, the robot will get stuck in sufficiently large dead ends forever because the robot doesn't recognize that progress is not being made and go in circles. Obstacles like stairs are also impassable because the robot can not sense the drop-off at a step.

## Future Improvements

Adding additional sensors can solve some of the current issues. To prevent the robot from going down stairs, or generally any dangerously steep terrain, downward pointing sensors will be added to the front of the robot to detect the distance between the bottom of the robot and the floor. Adding another rotating distance sensor pointing behind the robot would allow the robot to avoid things or people that were approaching from behind it. A camera could possibly be used to help with the robot's navigation. If the robot knew several landmarks, then it could use the cameras to update its positional data when they are recognized. With multiple cameras, it may be possible to implement parallax vision processing where the difference in two images can be used to create depth perception, like in the vision of humans.

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