Computer Vision with Linear Light

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Introduction

Our goal is to build a navigation structure based on a vision system which detects obstacles using a linear structured light array to guide a mobile robot. This project integrates the concepts of image processing, computer vision and obstacle location detection; and mobile robotics via robot interface and motion control.

Motivation

Autonomous navigation is a significant area of computer vision research where obstacle detection in structural environments is one of the basic requirements for implementation. Vision systems may be used in obstacle detection, trajectory tracking, and non-stationary object tracking. Due to the speed requirements for robot response, effective algorithms have been developed.

Hardware

- 650 nm red light sources.
- 650 nm pass band filter:
  - Blocks white light and allows red light to pass
- Bullet camera
- DE2 -70 FPGA Altera Board:
  - Image acquisition & processing, obstacle detection
- Arduino Microcontroller:
  - Robot control
- iRobot Create:
  - Autonomous navigation system.

Implementation

Image Processing

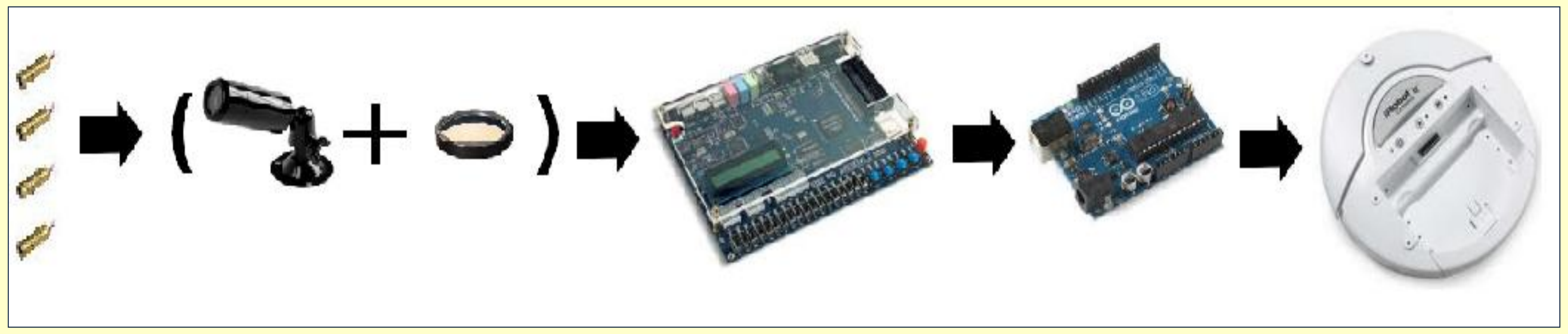
Video is sent from the camera to the FPGA, proceeding to extract an image frame. A corresponding histogram is built to register the quantity of pixels in each grayscale intensity bin. Using probabilistic distribution, the threshold for grayscale to binary image conversion is determined. The binary image is then passed through a coordinate generation module to find the coordinates of the line segments that correspond to the linear structured lights.

Obstacle Detection

The endpoint coordinates of each filtered line segment are passed into the obstacle detection module on the FPGA. This module detects the existence of light deformations on each distinct line based on length and approximate distance to others. The module outputs a one bit answer that either confirms or invalidates the presence of an obstacle.

iRobot Interface

Robot movement is controlled through a finite state machine module. The FSM outputs obstacle detection results to the Arduino through FPGA GPIO pins. The operational codes are then sent from the Arduino microcontroller to the robot via the iRobot cargo bay port. Thus the state module determines direction and forward motion based on obstacle detection module outputs. Upon obstruction detection, the FSM halts movement and redirects the iRobot.



Future Work

The current system is capable of detecting stationary, rectangular obstacles based on image processing. To expand upon the MRVS concept, the obstacle detection module may be modified to accommodate more realistic obstacle shapes and traveling obstacles. The algorithms may calculate the distance between the robot and obstacle and approximate its width. Based on this information, the robot will contain a wider range of evasive action, such as turn at specific angles and backing up to a certain distance.

Figure 1

Standard, clear path environment, presented in binary image.

Figure 2

Line deformations indicate immediate forward obstacle, presented in grayscale image.

Figure 3

Light deformation and obstacle presence, exhibited in binary image.

Contact Information

For more information regarding the Mobile Robot Vision System, each group member may be reached via eecs.452.computer.vision.project@umich.edu.

Acknowledgements

The MRVS team would like to extend our gratitude to Professor Alfred Hero, Dr. Kurt Metzger, Chao Yuan, and Charlie Yan for extended project support and assistance.