Autonomous Vehicle Navigation Using Stereoscopic Imaging

Senior Capstone Project
Progress Report

Department of Electrical and Computer Engineering
Bradley University

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Advisors: Dr. Huggins, Dr. Stewart

March 1st, 2007

Presentation Outline

- Review of Proposed Project
- Adam's Overall progress
  - Camera lighting testing
  - Dorgem
  - Camera mount testing
  - Basic 'edge' detection
- Nick's Overall progress
  - Camera Mount Design
  - Nick Patrick's Work
  - Distance Calculation Software
- Remaining Tasks
- Revised Schedule

Project Overview

- The objective of this project is to develop a vehicle that can navigate autonomously through a terrain of obstacles.
- The primary theory behind NavBot is stereoscopic imaging.

Original Proposed Schedule

Week of	Task	Assigned To
1/21	Adjust Pinhole Equations for Horizontal Cameras Begin Development of 3D Map Software	Nick Adam
1/28	Begin Distance Calculation Software Continue 3D Map Software	Nick Adam
2/4	Continue Distance Calculation Software Continue 3D Map Software	Nick Adam
2/11	Continue Distance Calculation Software Continue 3D Map Software	Nick Adam
2/18	Begin Edge Detection Algorithms Begin Interfacing Robot Platform with PC/Matlab	Nick Adam
2/25	Continue Edge Detection Algorithms Continue Interfacing Robot Platform	Nick Adam
3/4	Continue Edge Detection Algorithms Continue Interfacing Robot Platform	Nick Adam

Original Proposed Schedule

Week of	Task	Assigned To
3/11	Continue Edge Detection Algorithms Continue Interfacing Robot Platform	Nick Adam
3/18	Spring Break!	Both
3/25	Begin Direction Decision Algorithms Begin Implementing Max Time	Nick Adam
4/8	Continue Direction Decision Algorithms Continue Implementing Max Time	Nick Adam
4/15	Continue Direction Decision Algorithms “Close the Loop” with Motor Speed Feedback	Nick Adam
4/22	Continue Direction Decision Algorithms “Close the Loop” with Motor Speed Feedback	Nick Adam
4/29	Continue Direction Decision Algorithms “Close the Loop” with Motor Speed Feedback	Nick Adam

Tasks Completed

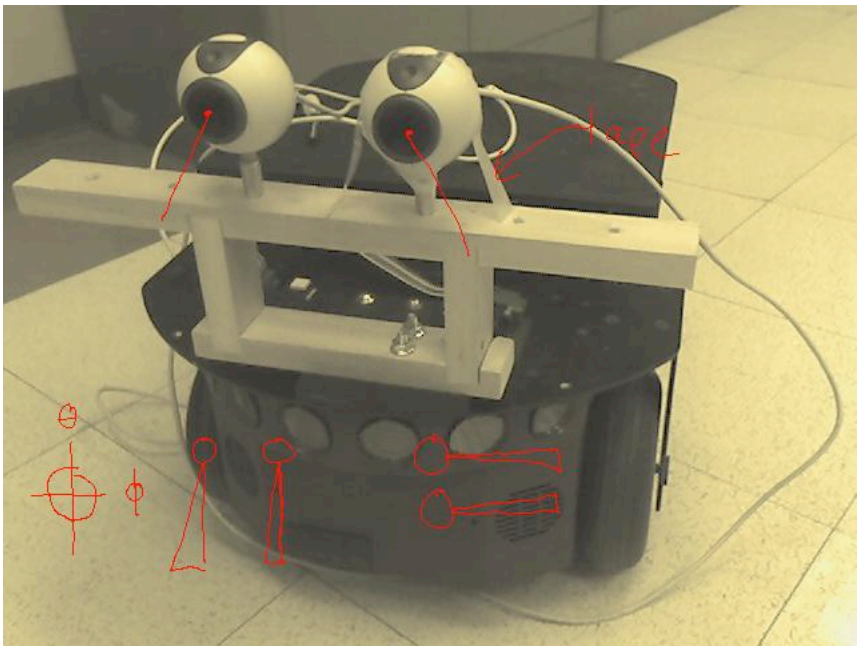
Adam's Outline

- Overall progress
  - Camera lighting testing
  - Dorgem
  - Camera mount testing
  - Basic 'edge' detection

Camera Lighting Testing

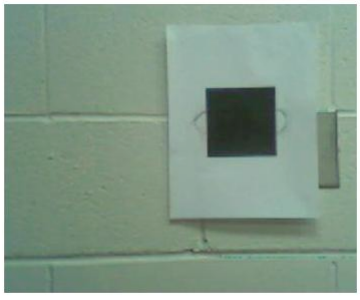
Dorgem

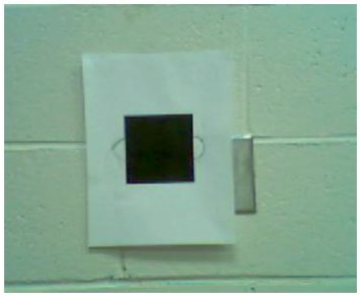
- Dr. Malinowski introduced us to Dorgem
- Runs a web server
- Allows greater control than Matlab



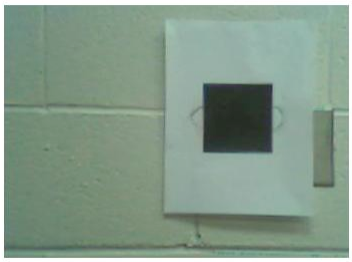
Camera Mount Testing

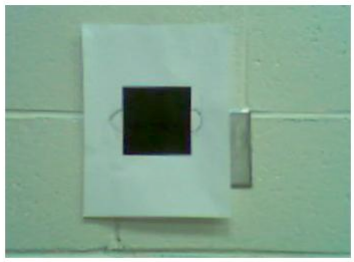
Camera Mount Testing



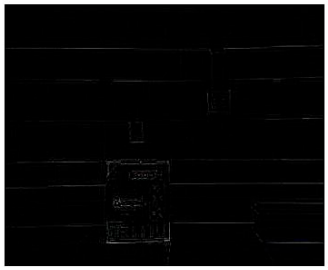


Camera Mount Testing

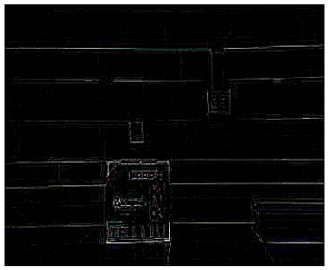




Basic Edge Detection



0 1 0
1 -4 1
0 1 0

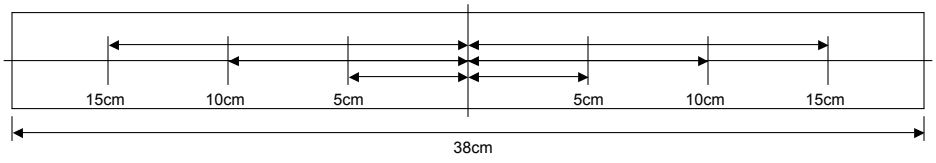


1 1 1
1 -8 1
1 1 1

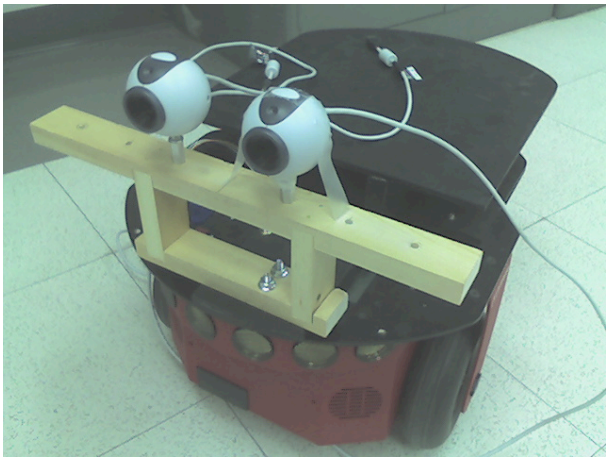
Nick's Outline

- Overall progress
  - Cameral Mount Design
  - Nick Patrick's Work
  - Distance Calculation Software

Camera Mount



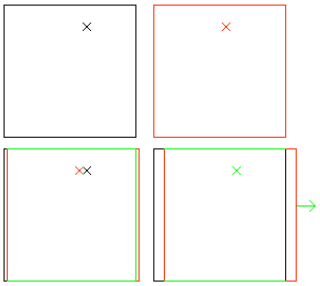
Camera Mount

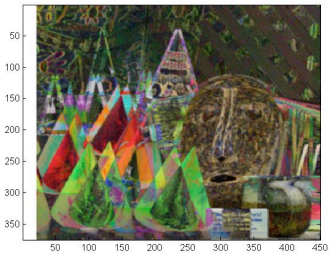


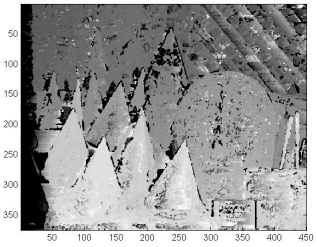
Nick Patrick's Work

- Slide right image horizontally over the left image one column at a time
- Calculate disparity for each slide
- Determine maximum correlation

Nick Patrick's Work

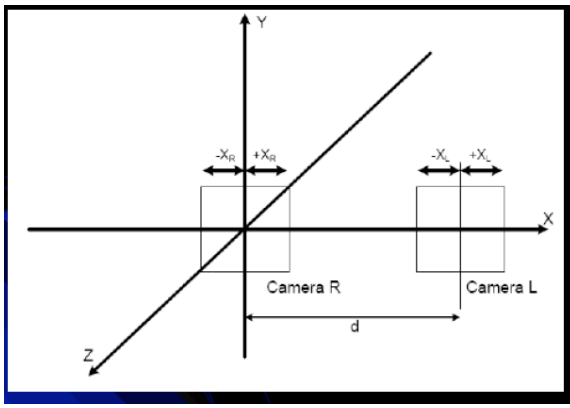






Images from *Stereoscopic Imaging* by Nick Patrick

Distance Calculations



$$X = \frac{X_L * d}{X_L - X_R}$$

$$Y = \frac{Y_L * d}{X_L - X_R}$$

$$Z = \frac{f * d}{X_L - X_R}$$

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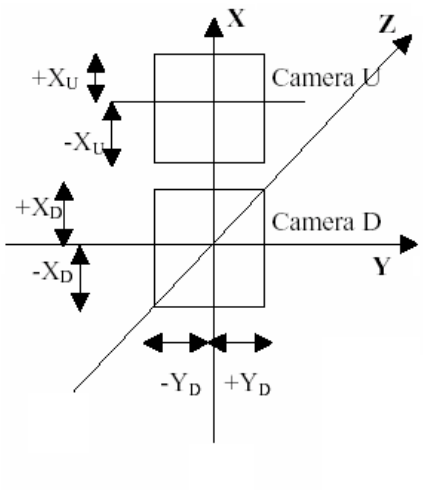
Distance Calculations



Z location = distance from the XY plane containing the cameras to the XY plane containing the object

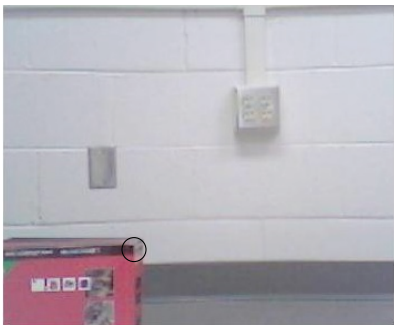
$$Z = \frac{d \times f}{(X_D - X_U) \times conversion\left[\frac{meters}{pixel}\right]}$$

where: d = distance between cameras (meters)
f = focal length (meters) = 0.008

$$conversion = \frac{0.0036 \cdot [meters]}{imageHeight \cdot [pixels]}$$

Images from Arik Brooks and Nick Patrick

Distance Calculations



Z = 3 ft = 0.9114 m
d = 30 cm = 0.30 m
X_L = 58 and X_R = 130
Conversion = Unknown
Focal Length = Unknown

Distance Calculations

- 1 equation and 2 unknowns
- Assumed conversion factor is the same
- Calculated focal length to be 3mm
  - T-Bird camera's f = 8mm
  - Similar webcam specified to have f = 40cm

Project Priorities

- Develop Distance Calculation Software
- Develop 3-D Mapping Software
- Perfect the Image Capturing
- Integrate Software with Robot Movement

Revised Schedule

Week of	Task	Assigned To
21-Jan	Continue Camera Implementation Testing Continue Camera Implementation Testing	Nick Adam
28-Jan	Design Camera Mount for Robotic Platform Test and Implement Dorgem	Nick Adam
4-Feb	Adjust Pinhole Equations for Horizontal Cameras Begin Development of 3D Map Software	Adam Nick
11-Feb	Adjust Camera Alignment Continue 3D Map Software	Adam Nick
18-Feb	Continue Distance Calculation Software Continue 3D Map Software	Adam Nick
25-Feb	Continue Distance Calculation Software Continue 3D Map Software	Adam Nick
4-Mar	Begin Edge Detection Algorithms Begin Interfacing Robot Platform with PC/Matlab	Nick Adam
11-Mar	Continue Edge Detection Algorithms Continue Interfacing Robot Platform	Nick Adam
18-Mar	Spring Break!	Both
25-Mar	Continue Edge Detection Algorithms Continue Interfacing Robot Platform	Nick Adam
8-Apr	Begin Direction Decision Algorithms Begin Implementing Max Time	Nick Adam
15-Apr	Continue Direction Decision Algorithms Continue Implementing Max Time	Nick Adam
22-Apr	Continue Direction Decision Algorithms “Close the Loop” with Motor Speed Feedback	Nick Adam
29-Apr	Continue Direction Decision Algorithms “Close the Loop” with Motor Speed Feedback	Nick Adam

Questions

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