Autonomous Vehicle Navigation Using Stereoscopic Imaging

Senior Capstone Project
Final Presentation

Department of Electrical and Computer Engineering
Bradley University

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Presentation Outline

- Project Summary
- Previous Work
- Stereoscopic Imaging Overview
- Detailed Description
  - System Block Diagram
  - Subsystems
  - Modes of Operation
- Results
- Suggestions for Future Work

Project Overview

- The objective of this project is to develop a vehicle that can navigate autonomously through a terrain of obstacles.
- Utilizes Stereoscopic Imaging
- Two Modes of Operation
  - Calibration Mode
  - Navigation Mode

Previous Work

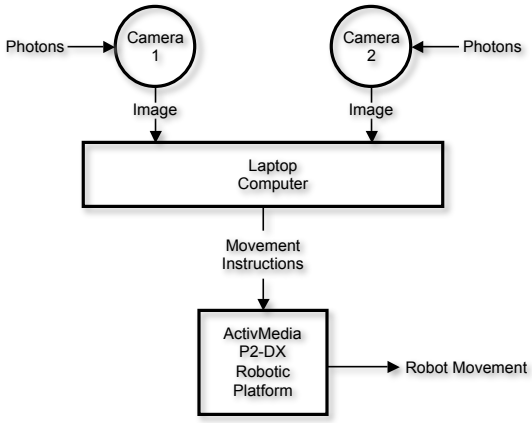
- Stereoscopic Imaging
  - Bradley Rover (Steve Goggins, Rob Scherbinski, and Pete Lange, 2005)
  - T-bird (Arik Brooks and Nick Patrick, 2004)
  - BirdTrak (Brian Crombie and Matt Zivney, 2003)
- ActivMedia P2-DX Robotic Platform
  - MapBot (Stephanie Luft, 2006)
  - GuideBot (Dan Leach and John Hathaway, 2005)

Stereoscopic Imaging

- Two cameras a known distance apart
  - Side by side
  - One on top of the other
- Allows 3-D information to be extracted
- Currently being used on the Mars rovers Spirit and Opportunity

Detailed Description

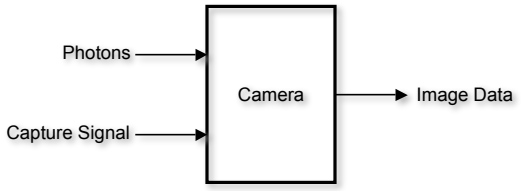
System Block Diagram



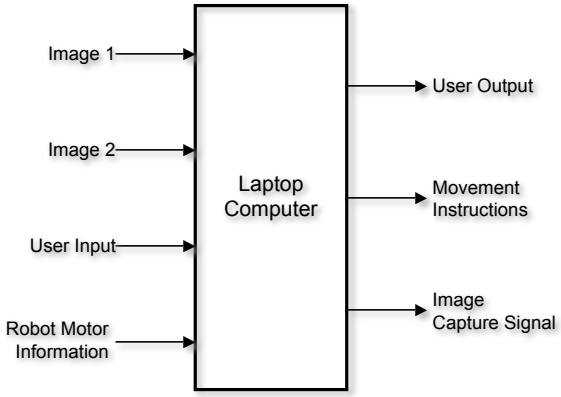
Subsystems

- Cameras
- Laptop and Software
- Robotic Platform

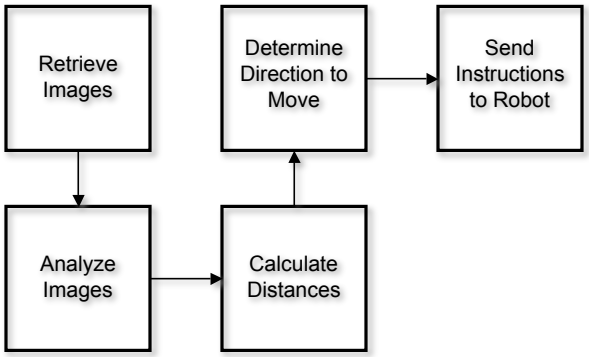
Cameras



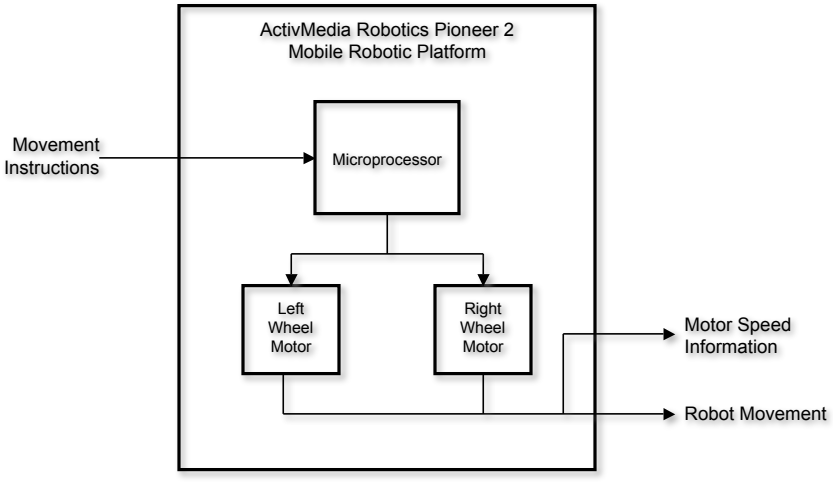
Laptop



Software



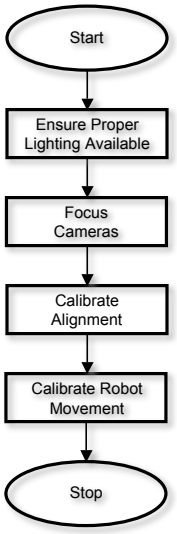
Robotic Platform



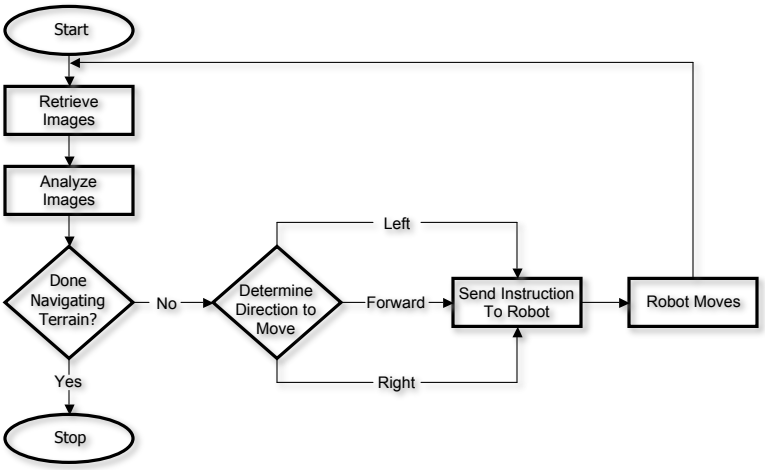
Modes of Operation

- Calibration Mode
  - Used to calibrate cameras and robot movement
- Navigation Mode
  - Main mode of operation where terrain navigation takes place

Calibration Mode



Navigation Mode

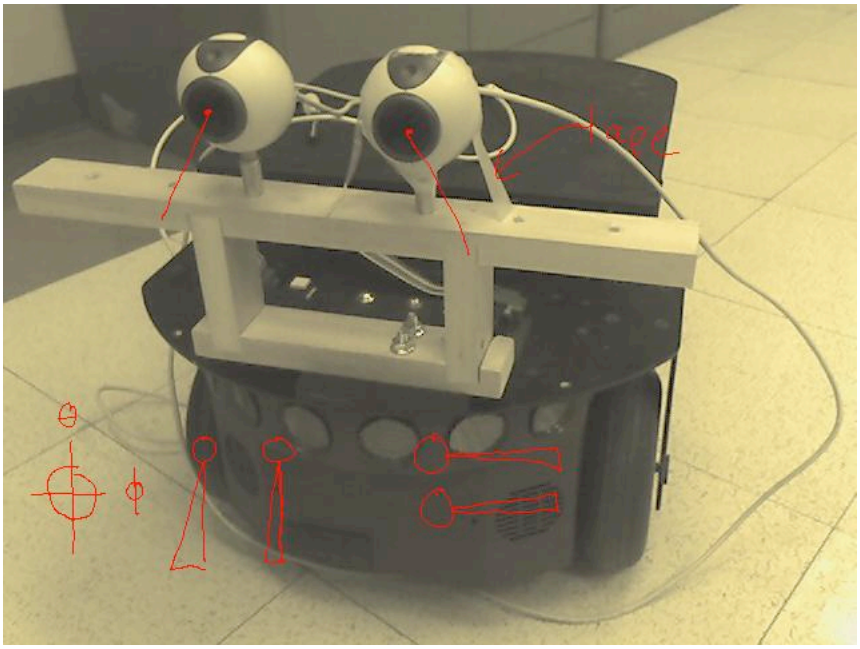


Results

Camera Lighting Testing

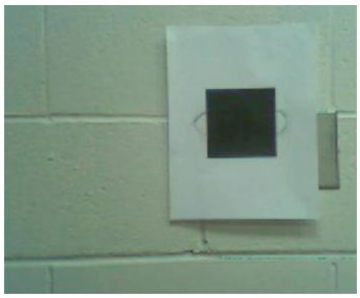
Dorgem

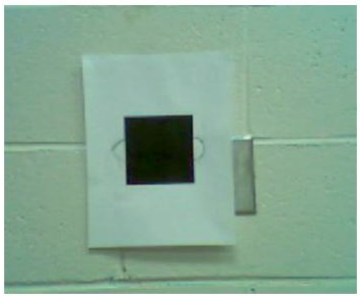
- Dr. Malinowski introduced us to Dorgem
- Runs a web server
- Allows greater control than Matlab



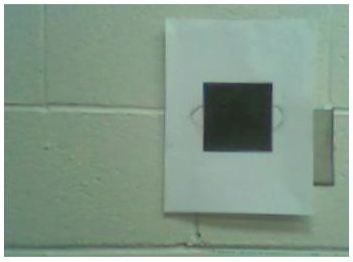
Camera Mount Testing

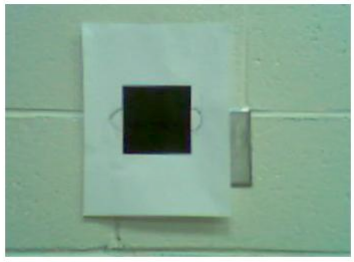
Camera Mount Testing



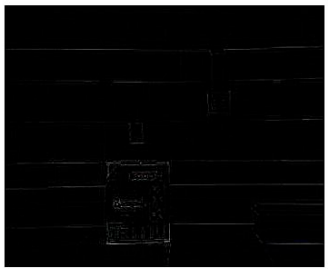


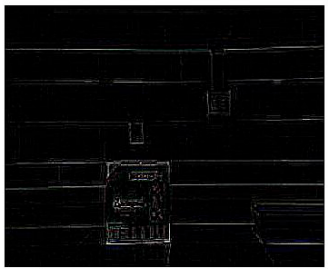
Camera Mount Testing





Basic Edge Detection

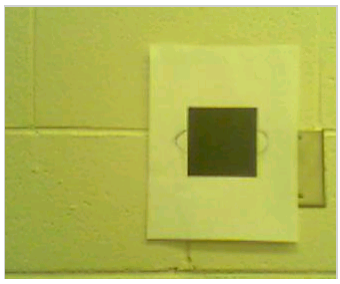


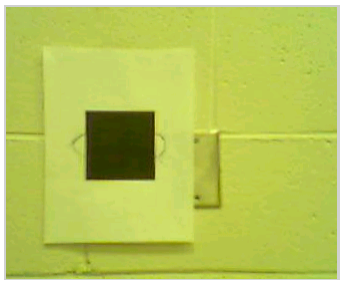


0 1 0
1 -4 1
0 1 0

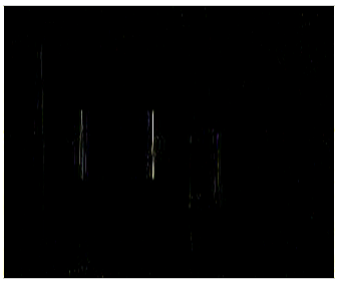
1 1 1
1 -8 1
1 1 1

Advanced Edge Detection



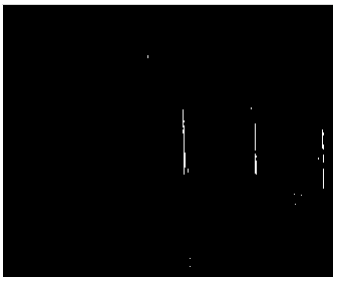


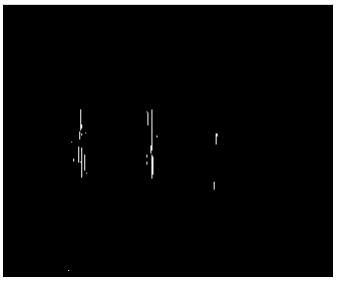
Advanced Edge Detection



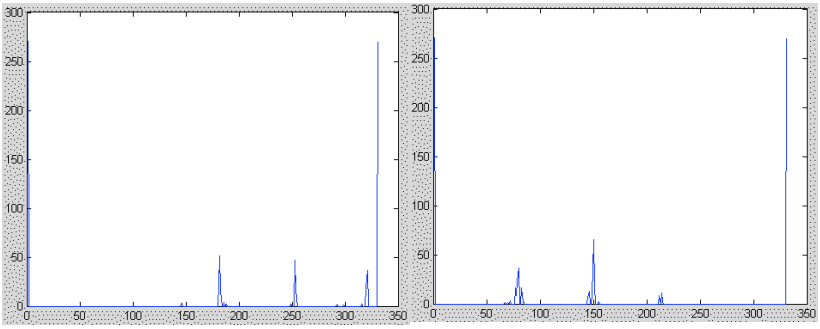
-1 2 -1
-1 2 -1
-1 2 -1

Advanced Edge Detection



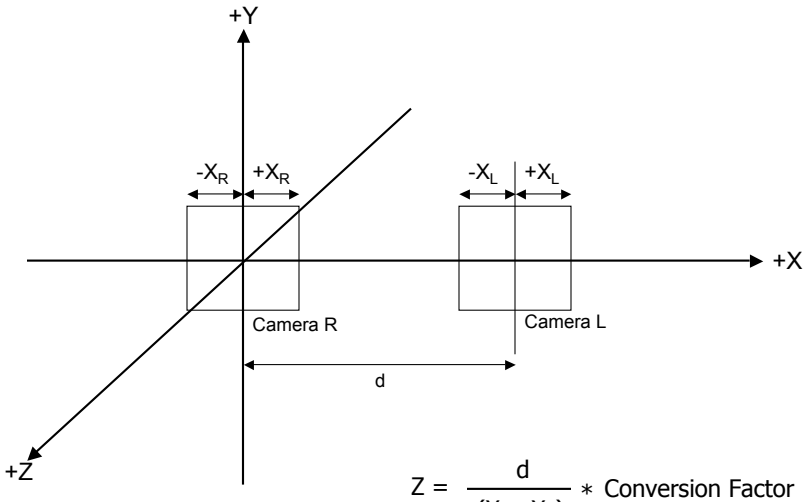


Advanced Edge Detection



Distance Calculations

Pinhole Model

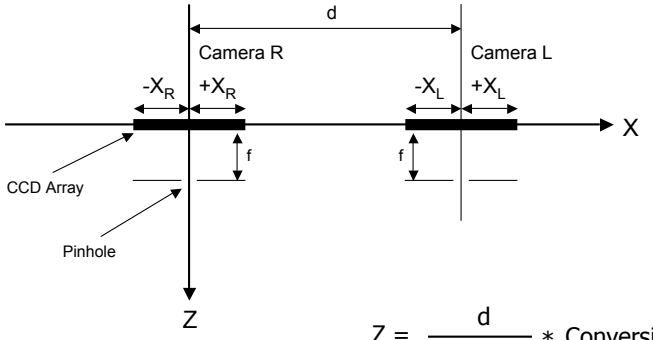


$$Z = \frac{d}{(X_L - X_R)} * \text{Conversion Factor}$$

Distance Calculations

Pinhole Model

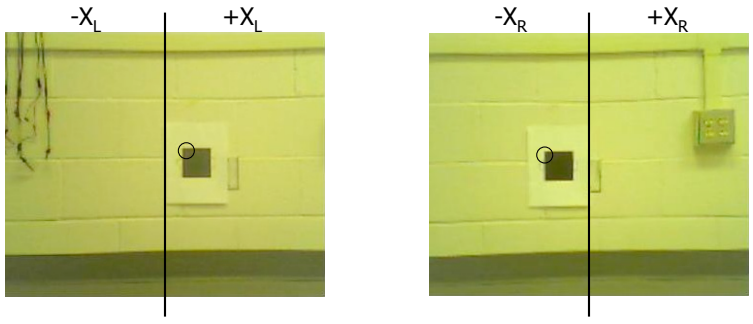
Bird's Eye View



$$Z = \frac{d}{(X_L - X_R)} * \text{Conversion Factor}$$

Distance Calculations

Conversion Factor Experiment



Z = 2.0 m
d = 0.10 m
X_L = 21 and X_R = -43

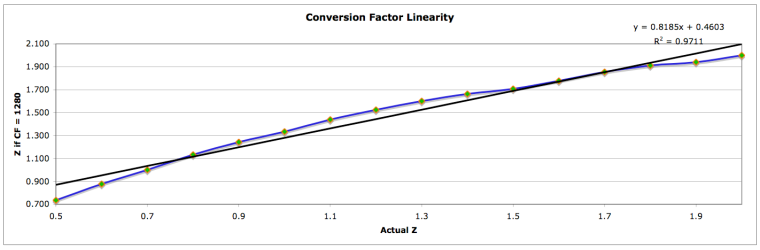
Distance Calculations

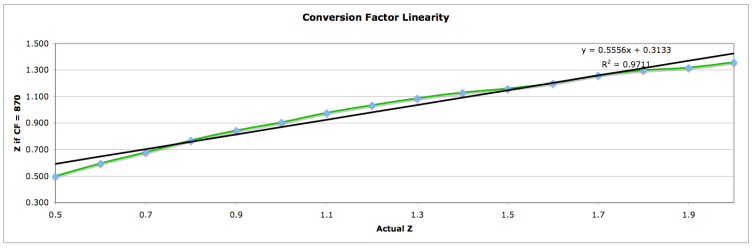
Conversion Factor Experiment

Distance From Robot (m)	Xleft (pixels)	Xright (pixels)	XL (pixels)	XR (pixels)	XL - XR (pixels)	d (m)	Conversion Factor (pixels)
2.0	186	122	21	-43	64	0.10	**1280**
1.9	171	105	6	-60	66	0.10	**1254**
1.8	190	123	25	-42	67	0.10	**1206**
1.7	188	119	23	-46	69	0.10	**1173**
1.6	181	109	16	-56	72	0.10	**1152**
1.5	169	94	4	-71	75	0.10	**1125**
1.4	179	102	14	-63	77	0.10	**1078**
1.3	182	102	17	-63	80	0.10	**1040**
1.2	178	94	13	-71	84	0.10	**1008**
1.1	182	93	17	-72	89	0.10	**979**
1.0	179	83	14	-82	96	0.10	**960**
0.9	184	81	19	-84	103	0.10	**927**
0.8	183	70	18	-95	113	0.10	**904**
0.7	188	60	23	-105	128	0.10	**896**
0.6	188	42	23	-123	146	0.10	**876**
0.5	184	10	19	-155	174	0.10	**870**

Distance Calculations

Conversion Factor Experiment



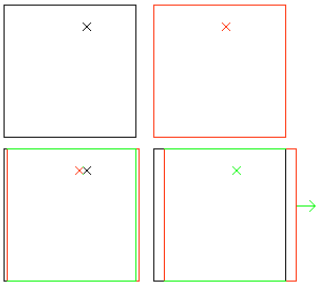


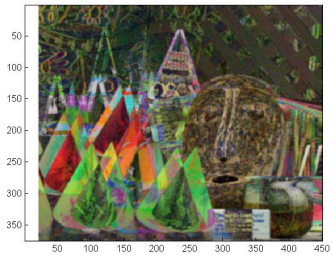
Distance Calculations

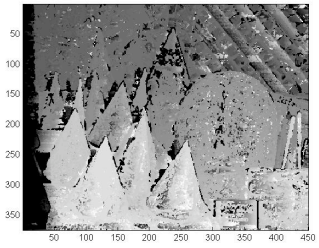
Conversion Factor Experiment

Z (m) Actual	Z (m) CF = 1	Z (m) CF = 870	Z (m) CF = 1280	Z (m) CF = 1000
2.0	0.00156	1.359	2.000	1.563
1.9	0.00152	1.318	1.939	1.515
1.8	0.00149	1.299	1.910	1.493
1.7	0.00145	1.261	1.855	1.449
1.6	0.00139	1.201	1.778	1.389
1.5	0.00133	1.160	1.707	1.333
1.4	0.00130	1.130	1.662	1.299
1.3	0.00125	1.088	1.600	1.250
1.2	0.00119	1.036	1.524	1.190
1.1	0.00112	0.978	1.438	1.124
1.0	0.00104	0.906	1.333	1.042
0.9	0.00097	0.845	1.243	0.971
0.8	0.00088	0.770	1.133	0.885
0.7	0.00078	0.680	1.000	0.781
0.6	0.00068	0.596	0.877	0.685
0.5	0.00057	0.500	0.736	0.575
Range	**0.00099**	**0.85938**	**1.26437**	**0.988**

Color Correlation







Suggestions For Future Work

- Obtain and implement high end cameras
- Develop object location software
- Develop calibration GUI
- Integrate software with robot movement

Questions

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