IMDL Final Report
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Steven Buss
Crab
Intelligent Machines Design Lab EEL 5666

Instructors:	Dr. Arroyo
	Dr. Schwartz
TAs:	Adam Barnett
	Sara Keen
	Mike Pridgen

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Abstract

Crab is an autonomous robot that uses a motion detection algorithm, written in MATLAB, to see moving objects and utilizes an omnidirectional drive train to move toward the objects it sees.

Executive Summary

Crab was originally conceived as a robot that catches a rolling ball and returns it to a person. This objective was not met due to lack of time - everything except a grabbing mechanism was completed. I did succeed in writing code to recognize moving objects in MATLAB, I am correcting for rotation using a gyroscope, and I have a successful Bluetooth link between Crab and my computer.

Crab contains several important subsystems: an interrupt-based sonar system, an interrupt-based gyroscope system, an interrupt-based UART over Bluetooth system, and a wireless video camera capture system.

Introduction

I wanted to provide a solution to tracking a moving object on a plane in front of a robot. This could be used for a basic follow-the-leader type system, or for robots that play games with each other or a human.

I will first cover my integrated systems and mobile platform, and then go into detail about each subsystem on Crab.

Integrated Systems

Crab integrates three sonar range finders, a gyrochip, TTL over Bluetooth, a wireless video camera, and four motors.

The wireless camera is constantly sending data to a capture card on a PC, which then feeds the video stream into MATLAB. MATLAB detects the moving objects in the field of vision and send commands back to the robot over Bluetooth, using a Sparkfun BlueSmirf to connect to the Mavric IIB. The Mavric IIB receives movement commands using an interrupt-driven UART library (written by Peter Fleury).

The sonar subsystem is also running on interrupts, constantly cycling through the available sonar modules attached to the Mavric IIB. The sonar library I wrote keeps track of the last distance each sonar detects, allowing the current distance measurements to be accessed at any time with no wait. The system is constantly checking the sonar measurements and will override any command that would cause a collision.

When movement data is received, it is transformed into PWM values and combines sonar information to plot an appropriate course.

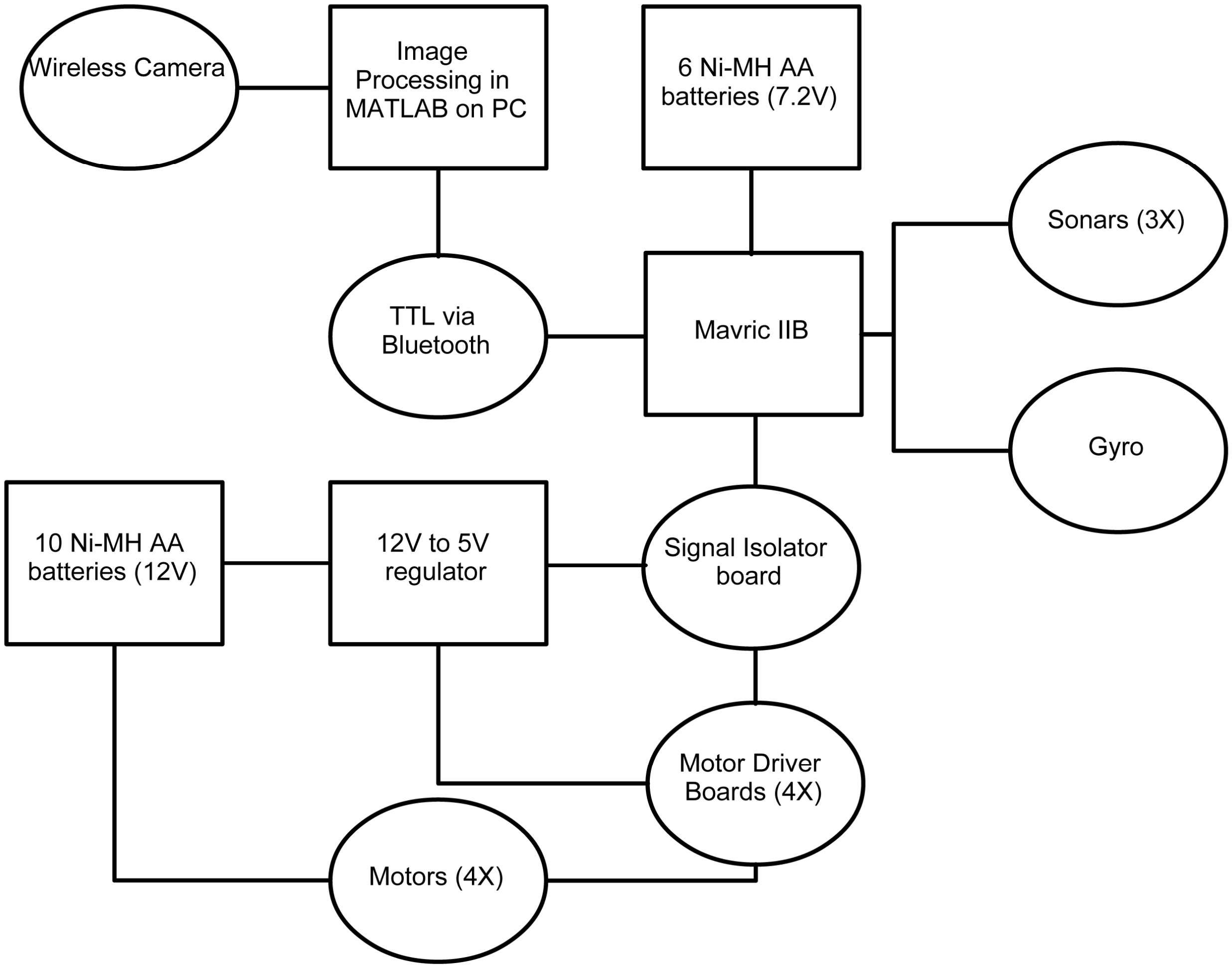

Figure 1 - Integrated System

Power to the main board is provided by a 6-pack of Ni-MH rechargeable AA batteries, and power to the motors is provided by 10 Ni-MH rechargeable AA batteries. Those 10 batteries also power the motor driver boards and isolator boards after passing through a 12V to 5V regulator.

Mobile Platform

Crab was built out of two circular pieces of aircraft balsa stacked on top of each other. This gave me plenty of space to place all of my components and was perfectly suited for the four wheel omnidirectional drive train. The motors and driver boards were on the underside of the bottom level. The grysocope and voltage regulator board were on the top of the bottom level. The three sonars were mounted on the underside of the top level, and the Mavric, battery packs, power switches, Bluetooth module, and wireless camera were all on the top of the upper level. This design allowed for easy routing of wires between levels and a compact robot.

Actuation

The only actuation done on crab is for the motors. The motors are Lynxmotion 200rpm (after a 30:1 reduction) gear head motors. They have a stall torque of 255 oz-in, at 4.84 Amps. These motors were chosen due to their low cost and good performance. All four motors are powered by 10 Ni-MH rechargeable AA batteries. They are interfaced with the Mavric IIB through Mike Franks' motor driver boards from summer 2007 IMDL.

Sensors

CRAB has a wireless camera, a gyrochip, and three sonar range finders.

The camera is fixed to the body and transmits a video stream wirelessly to a nearby PC. The amount of data that needed to be processed from the camera was too large to handle on the Mavric-IIB, so it was processed in MATLAB.

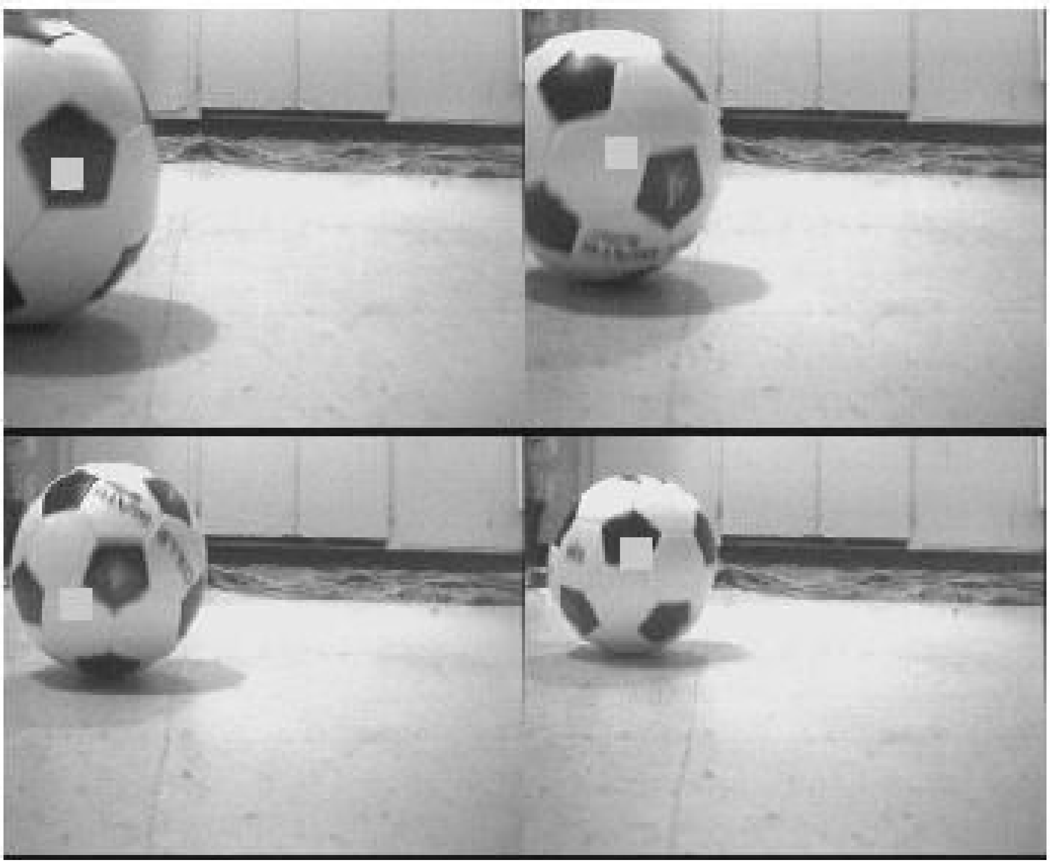

Figure 2 - Object tracking in MATLAB

I used an Analog Devices ADXRS300 evaluation board to calculate angular rate of rotation. The gyro is sampled at 900 Hz by reading the ADC when an OC interrupt fires. The gyrochip produces somewhat noisy data, so I implemented a simple averaging filter. The gyro is sampled eight times, and the average of those readings is used as the value for calculating angular rate of rotation. This value is then fed into a modified version of Kevin Watson's gyro library, typically used in the FIRST Robotics competition. I modified his library to work with the

Atmega128. (Please note, the modified library is not included in the code because I have not yet acquired permission to distribute his code with my changes. If I receive permission, the code will be available on my website, http://www.cise.ufl.edu/~sbuss/courses/eel5666/)

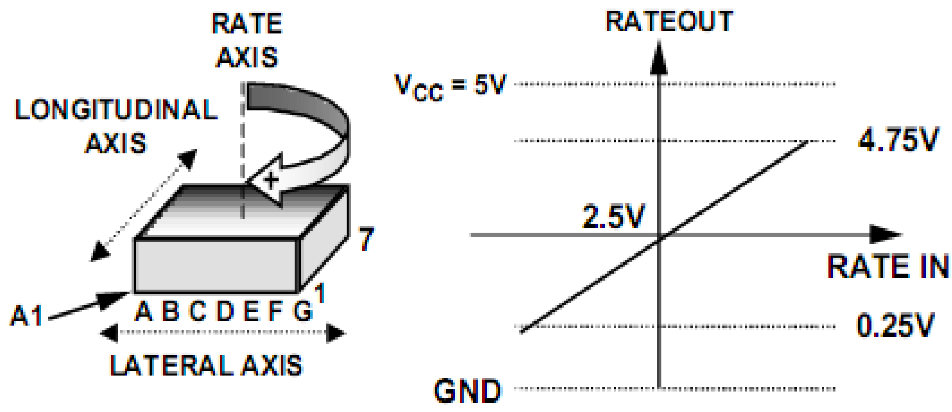

Figure 3 - RATEOUT signal increases with clockwise rotation

The gyrochip has a generally reliable null voltage of 2.4 volts. This fluctuates based on ambient temperature and other environmental factors such as high frequency vibrations caused by myriad other electronics. The bias in the clockwise direction causes all left turns to be under-reported, which is then corrected by scaling the data in one direction in software.

I used three Devantech SRF-05 ultrasonic range finders to avoid collisions with objects. The three SRF-05s are operating on a 57.6 KHz OC interrupt timer, firing sequentially to avoid interfering with each other. All processing is done in the interrupt to avoid halting program execution while the sonars wait for a reply. The time between a ping and a reply scales linearly with distance:

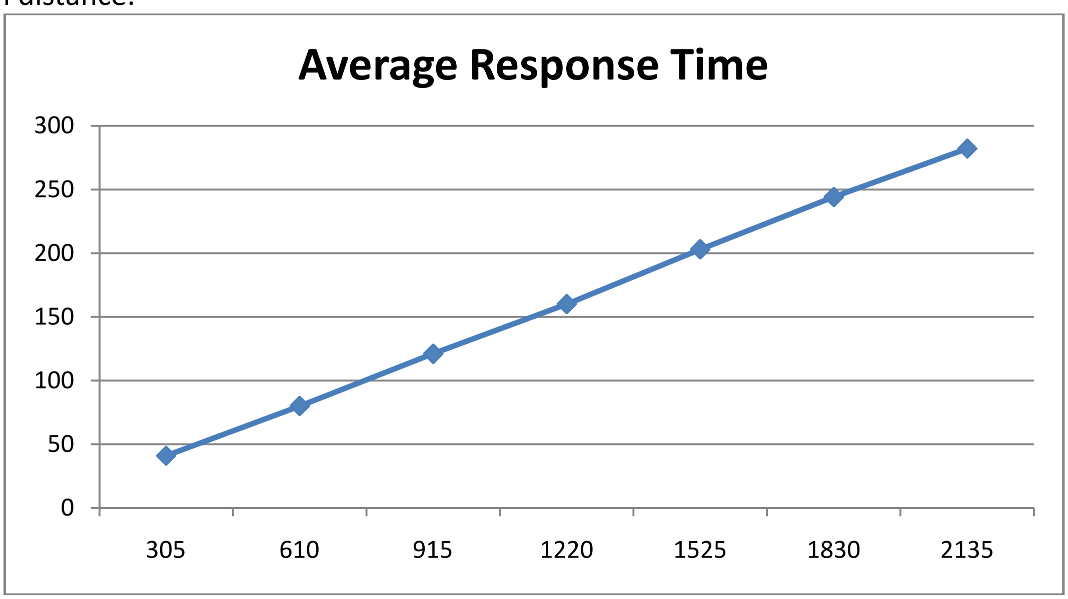

Figure 4 - Average sonar response time

Behaviors

Crab's main behavior is to move toward any moving objects. This is done by processing a video stream in MATLAB and sending commands back to the robot. Movement was then very easy, and only required sending different values to the motors based on the command given by MATLAB.

Experimental Layout and Results

The gyrochip was tested by mounting it to a breadboard and turning it a known number of degrees. The data returned from the gyro were then compared against expected values, and scaled until they matched my desired outcome. This proved to work very well and led to a very reliable detection of angular rate of rotation and current angle.

The SRF-05s were tested by mounting them to the robot body and placing it known distances away from a wall and recording the distance returned. No modification was done to this data, as it scaled linearly with distance.

The motor driver boards were tested in the Machine Intelligence Lab using an oscilloscope and a function generator. They initially did not work, and had to be modified with the help of Mike Franks. After replacing a dual bilateral switch with an and gate breakout board, the motor driver boards worked perfectly.

Conclusion

In the end, Crab didn't work as well as I had initially hoped, but I am by no means upset with its level of functionality. I was able to successfully build and program an autonomous robot that can detect movement and chase after it, while avoiding collisions with objects.

Intelligent Machine Design Lab has been a very rewarding class. I have learned very much about topics that I had little background in. I am a computer science major, so I normally do not get to work with hardware. I learned a lot about circuits and writing code for embedded systems. I dedicated so much time to this course, and got very little sleep during the last six weeks of the course. I spent all of my spring break on campus, and then nearly every day in the Machine Intelligence Lab working on the robot.

I was very grateful for the help of the TAs and from past IMDL students. In particular, Tom Feeney and Mike Franks were both very helpful.

Appendix

Please see http://www.cise.ufl.edu/~sbuss/courses/eel5666/ for the code used for Crab.