Final Report

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B.L.a.R.R.

EEL 5666L – Intelligent Machine Design Laboratory

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Abstract

This report includes the technical details of the B.L.a.R.R. robotic platform. B.L.a.R.R., which is an acronym for Bomb Locating and Removal Robot, is an autonomous mobile robot capable of detecting and removing objects that are life endangering. When powered on, B.L.a.R.R. will proceed to randomly search for objects it perceives as bombs while avoiding obstacles. When an object is found, it will slowly approach it and apprehend it using its mechanical arm. After the bomb is procured, it will then search for the bomb tube and place the bomb into it thereby neutralizing the threat.

Executive Summary

The B.L.a.R.R. robotic platform has two main behaviors, to locate and pick up bombs and to dispose of them in the bomb disposal area, all while avoiding obstacles. To accomplish this task, several electronic and mechanical components are used.

The main component of B.L.a.R.R. is the Pridgen Vermeer Robotics (PVR) board which features an Atmel Xmega128a microcontroller. This board/microcontroller contains all the necessary input and output options that B.L.a.R.R. requires to operate. It supports serial communication, analog to digital (A/D) conversion, digital I/O, and pulse width modulation (PWM). Connected to the board are all of the electrical sensors and parts of B.L.a.R.R. An LCD, as well as several LEDs and speakers allow for real time feedback during the robot's different operations.

The sensors used to accomplish the task of bomb removal are Sharp GP2D12 short range infrared (IR) sensors and a Carnegie Mellon University camera 1 (CMUcam1). Positioned on the front of the robot, these sensors act as the eyes of B.L.a.R.R. The camera, which operates with the PVR board via RS-232 serial communication, can differentiate between brightly colored objects and is used to locate the bombs, as well as the disposal area. The IR sensors utilize the A/D conversion ports and are used to detect when the objects are at the correct range for B.L.a.R.R. to interact with. The IR sensors are also used for collision avoidance when the robot is searching for the bombs.

For locomotion, two Merkle-Korff Industries gear reduction motors are used. These are controlled by Toshiba TB6612FNG motor drivers. A ball wheel located at the rear of the platform is used to allow zero-radius turning. The motor drivers are also used to manipulate the robotic arm which picks up and drops off the bombs. The robotic arm is part of the EDGE kit sold by OWI Robots.

Introduction

With the modern technology available, endangering human life is unnecessary. Inspired by other bomb robots such as the Andros F6A, B.L.a.R.R. (pictured below in **Figure 1**), is a robotic platform which was created to handle the dangerous task of bomb removal. Unlike other bomb robots, B.L.a.R.R. is capable of operating entirely autonomously. It will serve as the first line of defense in the event of a bomb threat. With the ability to act autonomously, it will remove the element of human error caused by the nervousness of extreme situations.

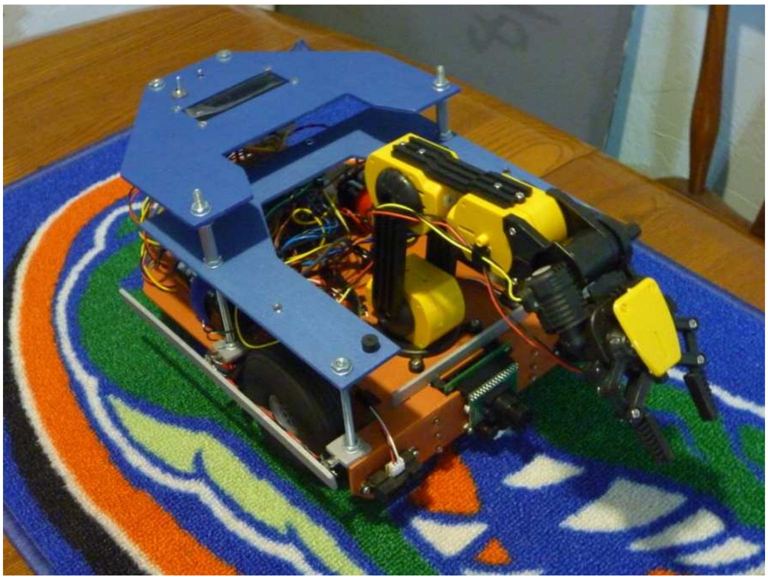

Figure 1. B.L.a.R.R. robotic platform.

By using various sensors and mechanical parts, B.L.A.R.R. is capable of locating and removing dangerous or suspicious objects.

The following will explain the details of the integrated systems used in the B.L.A.R.R robot as well as the specifics of the mobile platform, actuation, and sensor usage. Designed behaviors will also be explained. Also, some sample code will be given in the appendix.

Integrated Systems

At the heart of the system is Xmega128 board from Pridgen Vermeer Robotics (PVR). This board uses an Atmega128a microprocessor. Other various devices interact with the board to allow B.L.a.R.R. to complete its task. The complete system consists of the following components:

1. PVR microcontroller board
2. 3 x Sharp GP2D12 Infrared Sensors
3. CMUcam1
4. An LCD Screen
5. 3 blue LEDs
6. 6 white LEDs
7. 2 x Speakers
8. 2 x Contact Switches
9. 3 x Toshiba TB6612FNG DC motor driver boards
10. 6 x gearmotors
11. 2 x 7.2V rechargeable battery packs (6 x AA each)

The system configuration showing how several of these devices interact with each other is outlined below in **Figure 2**.

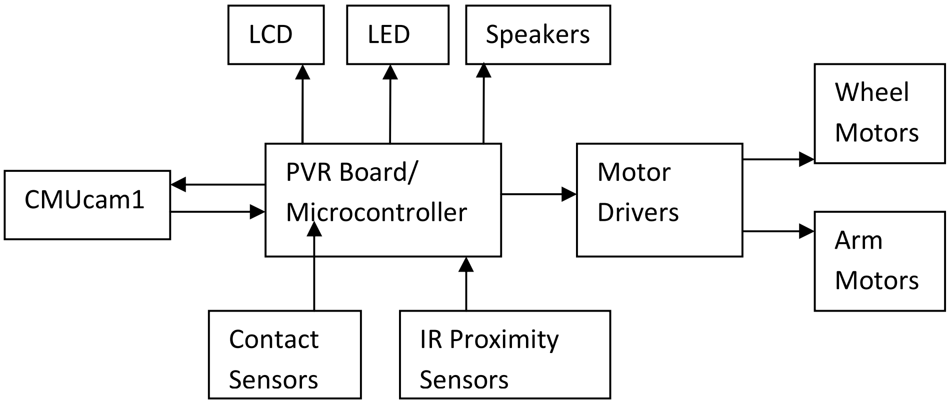

Figure 2. B.L.a.R.R. system diagram.

Two battery packs are used to power system. One for the drive motors, camera, and arm and one for the rest of the system which includes the board and other components. This prevents voltage drops in the system in the event the motors draw too much current. It also prolongs operation periods between recharging.

The infrared sensors positioned on the front bumper (**Figure 3**) are used for collision avoidance. When a large object is detected by the sensors as being "too close", B.L.a.R.R. will attempt to avoid the object by rotating and moving in an alternate direction. The center infrared sensor located below the CMUcam1 aids in determining the position of the desired objects and the goal.

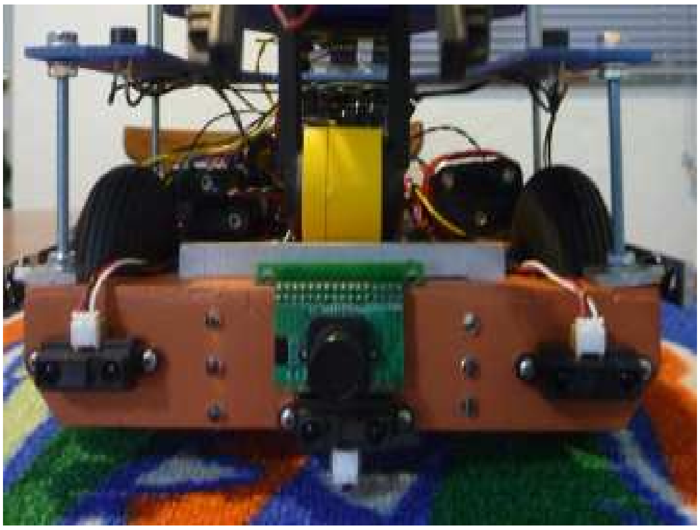

Figure 3. IR sensors and CMUcam located on the sensor bumper.

Figure 3 also shows the CMUcam1. The function of this camera is to detect colored objects, which are the bombs and the disposal area.

For feedback, an LCD screen, several LEDs, and two speakers are used (**Figure 4**). The LCD screen displays B.L.a.R.R.'s current behavior. There are three blue LEDs located on B.L.a.R.R. One serves as an "on" light to show that power is being supplied to the board. The other two are used to inform when the bomb is being picked up. Two speakers act as an alarm during the lifting and dropping operations.

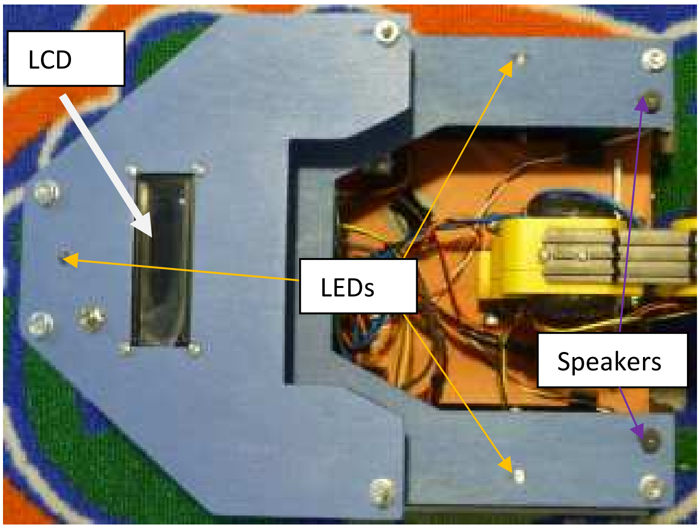

Figure 4. Top view of B.L.a.R.R. showing the LCD,LEDs, and speakers.

Mobile Platform

B.L.a.R.R.'s main platform was designed using Solidworks. It is constructed mostly of wood and was cut out from the T-Tech machine. It consists of three layers. The bottom holds most of the components including, the PVR board, battery packs, motor drivers, mechanical arm, and all sensors. The middle layer has the speakers as well as 2 feedback LEDs. The top layer has the LCD screen and the power switch and power LED. The components were placed carefully in order to have even weight distribution.

For movement on the ground, B.L.a.R.R. has three wheels. Two model airplane wheels were situated in the front and one ball wheel in the back. This allows for zero radius turns.

Actuation

The movement of B.L.a.R.R. is controlled by 6 gear reduction dc motors. Two motors are used for locomotion and the remaining 4 are used to manipulate the mechanical arm. All motors are controlled by the PVR board in conjunction with Toshiba TB6612FNG DC motor driver boards (**Figure 5**). To prevent large current draws on the PVR board, a separate 7.2V battery pack was used for actuation power.

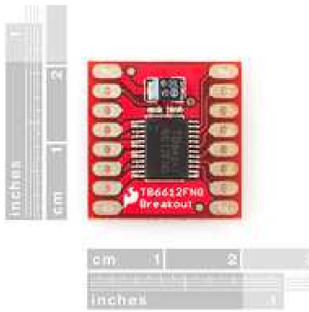

Figure 5. Toshiba TB6612FNG motor driver breakout board.

To control the motors, Toshiba TB661FNG DC motor drivers were used. Each driver is capable of controlling 2 motors independently. Since B.L.a.R.R. uses 6 motors, 3 motor driver boards were required in its design. Each board needs three inputs to control each motor: A pulse-width modulation signal (PWM) and two digital inputs. The PWM signal controls the speed at which the motor operates and the two digital inputs are used to select its four operations: clockwise, counter-clockwise, stop, and short-brake. It can supply a constant current of up to 1.2A for a single motor.

The motors used for locomotion are 2 S1627B gear reduction motors by Merkle-Korff Industries (**Figure 6**). At 12Vdc it will operate at approximately 240RPM and at 6Vdc it will operate at approximately 120RPM. With no load, one draws about 250mA. (Enter signal used)

Figure 6. S1627B gear reduction motor by Merkle-Korff Industries.

The arm, which was purchased off-shelf, uses 4 dc motors with gear reduction (**Figure 7**). One motor is used at each of the three revolute joints, and one is used to control the end effecter. (Enter signals used for each motor). The complete code used for controlling the motors used in locomotion and arm movements can be found in the appendix.

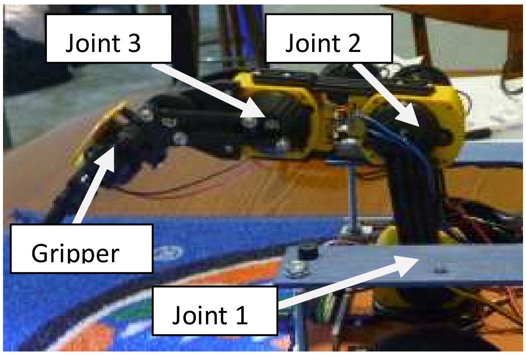

Figure 7. Mechanical arm with joints and end effecter, or gipper, pointed out.

A very important lesson was learned when installing a motor driver early on. Patience and caution was not taken and the connector for signal power was installed in reverse. Though it was connected incorrectly for only several seconds, it was enough time to render the motor driver board useless. From this point on, I took great care in connecting components properly.

Sensors

The B.L.A.R.R robot utilizes the following sensors in order to accomplish its task:

- 3 x Sharp Infrared GP2D12
- CMUcam1
- Bump

The IR sensors made by Sharp, pictured below (**Figure 8**), are used for collision avoidance as well as to determine the distance of the objects B.L.a.R.R. will seek.

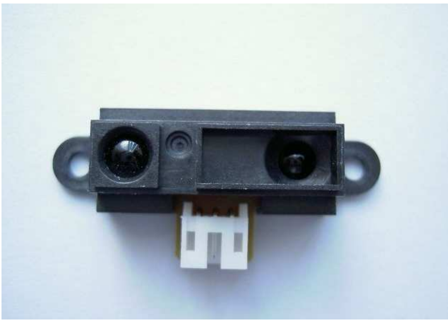

Figure 8. Sharp GP2D12 infrared sensor.

The CMUcam1 is used to identify the objects and the goal. It will inform B.L.a.R.R. where the objects are in order to position itself in order to pick up and drop off the bombs. To determine the necessary color values for the objects, software included in the camera package was used. **Figure 9** below shows the GUI of the camera with the goal in view.

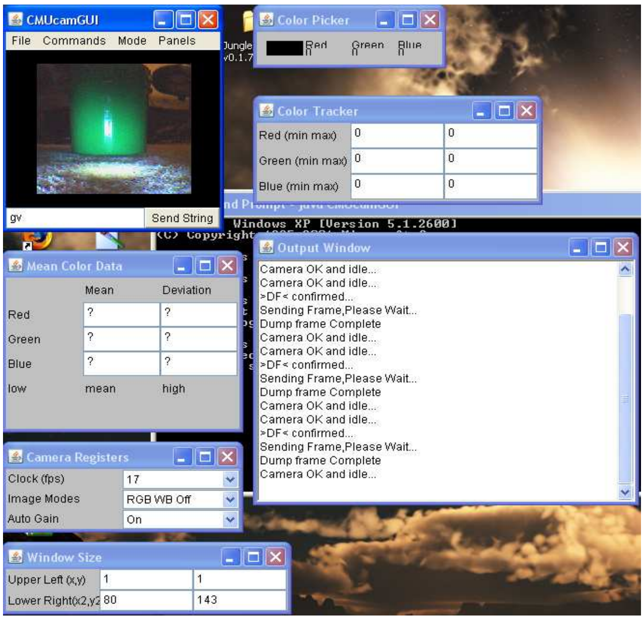

Figure 9. CMUcam GUI with goal in view as it would be seen by B.La.R.R.

Bump sensors are used as limit switches for the robotic arm. This was necessary to determine when the arm was at its top position and bottom position. When hit, the limit switches tell the board to stop moving the arm.

Behaviors

Upon powering up, B.L.a.R.R. will randomly search the area for a bomb. Immediately after a bomb is found, B.L.a.R.R. will sound an alarm. It will then proceed to approach the bomb and orient itself in a position so that its mechanical arm can grasp and pick it up. During this behavior, the alarm will sound continuously and several LEDs will light up. The object it will perceive as a bomb can be seen in the figure below (**Figure 10**).

Figure 10. Bomb that B.L.a.R.R. will be searching for and retrieving.

The bright red LED and vivid red paint allow the camera to easily identify the bomb and differentiate it from any red that could be present in the surrounding area.

After the bomb is procured, B.L.a.R.R. will then begin its search for the safety tube. When the safety tube is found, B.L.a.R.R. will approach it and dispose of the bomb. The safety tube in which the bombs will be disposed of is brilliant colored green bucket. The tube can be seen in **Figure 11** below.

Figure 11. Bomb disposal tube.

While B.L.a.R.R. is continuing his search bombs, it will practice collision avoidance. When object is detected as being too close, B.L.a.R.R. will turn until its forward facing path is clear. If an object is too near on the left side, B.L.a.R.R. will take a right. If an object is too near on the right side, a left will be taken.

Conclusion

I would deem the final stage of B.L.a.R.R. reached in this class as a success. During the final demonstration, B.L.a.R.R. was fully capable of completing its task of autonomously locating the bombs, retrieving them, and disposing of them nearly every time without any human intervention. Areas that have room for improvement are collision avoidance and programming. Collision avoidance sensors were originally planned to be located all around the platform, but had to be removed due to inadequate sensors. The code could also use some changes to help B.L.a.R.R. complete its task more efficiently. Since I had very little programming knowledge prior to taking this class, this was by far the most difficult part for me and without the help of classmates, would have been impossible.

If the project could be started over, I may have considered slight modifications to the platform to allow better implementation of more collision avoidance sensors, as well as better efforts to conceal the wiring and hardware. Future modifications may include alterations to the current design to allow for these changes. I would also like to fine tune the programming to smooth out he pick up and drop off sequences.

Finally, I would like to thank Jason Monsorno, Diego Mesa, and Alan Hamlet for their help in programming. I would also like to thank Dr. Arroyo and Dr. Schwartz for their advice. Thanks also to the rest of the IMDL class of spring 2010.

Appendix

Due to its large size, code has not been placed in this report. All code which was used can be found at B.L.a.R.R.'s website: http://plaza.ufl.edu/jbuttice/Index.htm.