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GetMAD

Final Report

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ABSTRACT

GetMAD is an acronym for Get Me A Drink. It is a prototype vending machine robot that operates on Radio Frequency Identification (RFID) commands. This project had two prime purposes. The first purpose of this robot is to provide some entertainment while waiting on the traditionally boring process of receiving your drink from a vending machine. The second purpose is to showcase some of the new generation technologies such as RFID.

EXECUTIVE SUMMARY

GetMAD's task is to receive a signal that contains information about the drink to vend. Once the signal is received, GetMAD navigates to the correct vending tower using simple line tracking. At the station, it triggers the vending mechanism, which vends the drink from the tower to the drop-off bin on GetMAD. Once the drink is received, GetMAD follows the line back to its source for delivery.

A unique 64-bit RFID card that is read by an onboard RFID reader provides the signal used for determining which vending tower to approach. The 64-bit value that represents each drink/tower is hard-coded into the code.

Line Tracking is performed by a series of single channel reflectance infrared sensors. These sensors provide a digital signal high when the sensor is over reflective (white) surfaces and low when it is over darker, less reflective surfaces. These results prove to be optimal when tracking a black line over a white surface.

Additionally, there is a sonar sensor present on the front of the robot to avoid collisions. The sonar stops the robot each time there is a collision detected.

A mechanical arm on the front of the robot performs the vending of the drink. The mechanical arm pushes the door on the vend tower that vends the drink into the tray on the robot.

Once a drink is delivered into the tray on the robot, a bump switch under the tray is activated because of the change of weight. This triggers GetMAD's software to return it to the start/end point and deliver the drink.

GetMAD once again performs line tracking using the reflectance sensors to return to home base and deliver the drink. As soon as the drink is delivered, GetMAD waits again until it receives another RFID signal.

INTRODUCTION

Waiting for a vending machine to vend your drink is fairly boring. All you hear is mechanics behind a closed door. After a couple seconds, BAM! A can or bottle of your favorite drink violently drops into a tray ready for you to pick up. But, you cannot open in instantly because due to the violent movements, the gas molecules in your drink are active and will explode/fizz as soon as you open it.

Coming to the rescue to a vending machine near you is GetMAD. GetMAD is a prototype vending machine robot that navigates the vending machine to pick up your drink and deliver it to you.

The mechanics on GetMAD and it's vending towers are very smooth and minimal, therefore reducing the violent movements and drops caused by traditional machines. As a bonus, GetMAD is left open, or optionally covered by transparent material (such as a plastic or glass dome), so that you can enjoy viewing the entire venting process.

To select your drink, simply wave a unique RFID card consisting of your drink identification. Once the system registers your request, it follows black lines (tracks) to find the appropriate drink tower and bring back your drink.

On it's way, it will also perform obstacle avoidance by waiting for potential obstacles to move out its way. It uses a sonar sensor to detect if there is an obstacle in its path.

GetMAD is build on a simple chassis purchased online. Different components are mounted on it using balsa wood, screws and bolts, and glue. The top of it contains a wooden tray to receive the drink.

INTEGRATED SYSTEMS

An Atmel Atmega128 microcontroller board with I/O ports and pins will act as the controller for the robot. The programming is all done using C. The PVR board, which is a microcontroller board that is based on the ATMEL Atmega128 microcontroller is used as the main hub. The board is equipped with multiple PWM ports, I/O ports, serial ports and an Analog to Digital conversion. I used the serial port (RS 232) to communicate with the RFID sensor. I also used two PWMs to control my servos and the ADC port to read in the sonar. The infrareds are accessed using the digital I/O ports and so are the LEDs and bump switches. An LCD is connected to the provided LCD port (port K).

The combination of these sensors as well as the software written for them are used to operate GetMAD.

MOBILE PLATFORM

A chassis is used as the primary body of GetMAD. It is a circular disk with various holes pre-cut to enable quick plug-ins. Plenty of wood is also used to create different add-on modules, like the tray for drink delivery, the servo mount bars and the line tracker mount bar.

I learned that working with wood is a very difficult process. Although wood can be mounted pretty fast, it is significantly difficult to make modifications to it though. Another problem with wood is that the type of wood I used (balsa wood) is very fragile and as a result, mounting mechanisms, such as nails and glue easily came off when introduced to heavy weights (like a can of coke). Custom fiberglass or metal frame would be a better alternative.

ACTUATION

For actuation, GetMAD utilizes two “modified” servos that are directly connected to corresponding left and right wheels. The servos are modified to provide a full 360° of rotation. The modification was done by removing the potentiometer and replacing it with a 100Ohm resistor, and by trimming the mechanical stop installed on the primary gear.

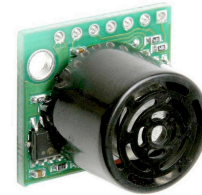
The servos are plugged into the PWM ports on the PVR board and controlled using the `Servo[port name][port#](int angle)` (i.e. `ServoD0(40)`) command. After modifying the servo, the angle variable becomes the speed variable. This means that the greater the integer, the faster the servo will move. Also, if a negative number is provided, the servo would go in reverse mode.

It is important to note that since one servo is plugged in the opposite way to match the other servo, when one servo's forward speed is 40, the other one's speed has to be -40 to match the direction. Additionally, there is a caster installed in the center rear of GetMAD to maintain balance.

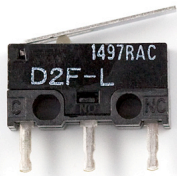
SENSORS

Sonar

A sonar is used for obstacle avoidance. This sonar is placed in the front of the robot. The sonar returns a signal value through the Analog to Digital conversion port. If the signal reduces below the threshold, the robot stops until the object in path is removed.



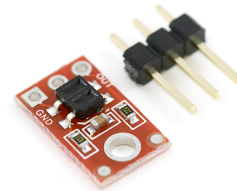
Bump Switches



A bump switch is placed under the drink tray as a weight sensor. If the tray has a drink, it will push down on the button and trigger the weight sensor. This tells GetMAD that it has a drink in its payload that needs to be delivered. Also, when the drink is removed, this sensor goes off and GetMAD knows to return to standby mode.

Infrared

Five single channel digital reflectance sensors are used for line tracking. The sensors connect to the digital I/O port (Port J) on the PVR board. To operate the sensor as a line tracker, the port is set to output with a high signal. After 10-11us it is set to low and switched to input. After a 1ms wait, the value is read. This method basically charges the capacitor and then reads the signal strength off of it.



If the sensor is over a white/reflective surface, the signal will be high and if it is over a black/dark surface, it will be low. After receiving this signal, the simple case statement is used to determine the next set of movements.

RFID



The Radio Frequency Identification (RFID) sensor is used to receive commands. When GetMAD starts, it waits to receive an RFID signal for initialization. Once initialized, a unique RFID that is linked to the corresponding drink is waved. As soon as the system recognizes the RFID (or drink choice) it navigates to vend the drink. At every intersection, identified by the line tracker sensor, the RFID is interrupted again to read a course-mounted RFID that also corresponds to the drink of choice. If the course-mounted RFID matches the drink to vend, then GetMAD makes a turn at that intersection, otherwise, it keeps moving.

BEHAVIORS

The robot has four behaviors: Obstacle Avoidance, Line Tracking, Command Receiving, and vending.

For obstacle avoidance, GetMAD uses a front mounted sonar. The sonar is calibrated on first use to determine stopping distance and other environmental noise. Then, once an obstacle is found, GetMAD simply makes a 360° turn and goes the other way.

The line tracking behavior utilizes a series of 5 Infrareads that are placed at the front bottom. These infrareads should read a binary value of 10001, which essentially means that the center 3 IRs are over the line and the outside two are not. This helps keep the robot centered on the track at all times. The system steers itself back on course if those values change in either direction.

The command receiving is done predominantly by the RFID. As mentioned in the sensors section, the RFID sensor receives signals from various unique RFID cards and acts on those accordingly.

Finally the vending process is done by a mechanical arm and un-modified servo. The servo arm basically pushes down on a door that vends the drink and then pushes it back up to ready state.

EXPERIMENTAL LAYOUT AND RESULTS

For the RFID, I simply read the strings to the LCD and then noted them down. With the unique strings at hand, I was able to hard code them into the system for use. As for the other sensors, namely sonar and IR, the robot goes into calibrate mode as soon as it is powered up. During this state, a threshold value is set for each one of the sensors. This allows GetMAD to be adopted in various environments.

CONCLUSION

GetMAD is a robot that navigates a set plane in search of a soft drink tower that was commanded to it by an RFID signal. It is capable of avoiding obstacles, following lines, vending drinks and carrying the drink back to the home base. Due to technical difficulties, like hardware failures, GetMAD was only able to implement RFID reading, Obstacle Avoidance and the weight sensor. The line tracking system was extremely buggy and did not function adequately. Also the mechanics on the vending tower were not good enough to smoothly vend the soft drinks. However, I intend to further develop GetMAD over the winter break and spring semester, and hope to have those two essential features working as well.

GetMAD is an exiting and fun approach at a vending machine system. It also serves as a showcase of new technologies, such as RFID, on the market.

APENDICES

Special thanks to Sid Garth and Yan Santos for helping me out with a lot of hardware related issues.

Code is provided online at <http://GetMAD.sarfarazsuleman.com>