Quarterly Report

Team #4

Micromouse

Sonja Abbey, Bill Dixon, Patrick Dowell, Eric Rico

EE 495: Senior Design

Professor Maarten Uijt de Haag

June 4, 2010
Abstract

This report details the past, present, and future of the Micromouse project. The project is first viewed from a “big picture” perspective; overarching goals and the purpose of the project are described. Goals and accomplishments (if appropriate) are summarized with respect to fall, winter, and spring quarters. A summary of program management is also included.

A more detailed look at the project is included as well. This encompasses a description of hardware, software, and interfaces in their current states. An analysis of constraints, impacts, and support engineering then appears. Appendices hold any information deemed too detailed to be included in the main body of this report.
1. Introduction

1.1. Overview

The project being discussed in this paper is the Micromouse project. This project consists of a team of four senior design students who are responsible for the design and assembly of a competition robot. The competition was held by IEEE Region 2 at Temple University on April 17, 2010.

1.2. System Need

The customer need is defined by our faculty project leads Maarten Uijt de Haag and Wouter Pelgrum and the purpose of this project is to bring positive attention to the college and its efforts while providing an educational senior design project to its students. The way this has been accomplished is our Micromouse’s to win first place in the IEEE Region 2 competition.

1.3. System Description

The system is a self-contained autonomous robot. The robot is controlled by an onboard microcontroller with software that lets it explore the maze, find a route to the center, and then calculate the shortest possible route to the center. The maze is mapped using a trio of infrared sensors for that detect the presence (and distance) of walls. Locomotion is achieved with brushed DC motors driven by a high-current driver chip.

1.4. Competition Rules

The system for competition must be self-contained and autonomous. The robot’s length and width must be equal to or less than 25 centimeters with no restriction on height. The robot must not fly, jump, or climb over the walls of the maze. The robot also may not burn down, mark, destroy or in any way damage the maze. The maze is composed of 256 (16x16) unit squares which each measure 18cm x 18cm. The floor of the maze is black, the sides of the walls are white and the tops of the walls are red.
2. Goals and Accomplishments by Quarter

2.1. Fall Quarter Goals and Accomplishments

Our goals for fall quarter were to complete the requirement writing and trade studies on sensor types and batteries. Another goal was to develop a preliminary design for the construction of the maze. Additionally, we needed to pick a template design from two baseline robots and order the robots themselves. All of these goals were accomplished with the trade study on long-range sensor types excepted – it was delayed until winter quarter. We successfully gave preliminary design requirements presentation.

2.2. Winter Quarter Goals and Accomplishments

Our goals for winter quarter were to finalize the design for the maze and complete the construction of the maze. Our objectives also included completing the trade study for long-range sensor types, selecting and ordering long-range sensors for the robots, and analyzing the software and hardware of the baseline robots so that they could be improved upon. All goals were accomplished with the maze completion being delayed until the end of spring quarter. A portion of the maze was constructed that is sufficiently large for testing the baseline (and any future improvements of those) robots.

2.3. Spring Quarter Goals and Accomplishments

Spring goals included determining which of the two robots are to be used, modification of that robot to meet our performance requirements, competing in the IEEE Region 2 Micromouse competition (winning 1st place), completing the maze for next year’s team and creating a user manual including tips for improvement for future groups.

3. Reference Documentation

The rules for the April 2010 competition can be found on Temple University’s website at:
4. Program Management

Statement of Work

A. The tasks performed by the micromouse included:
   1. Being designed within the restrictions of the competition rules and regulations.
   2. Capable of navigating to the center of the maze.
   3. Able to do all this in the shortest amount of time reasonably possible.

B. The deliverables that will be provided will be a writeup for the next group in the case that OU participates in the competition next year. As part of this we will provide a summary of hardware and software modifications made to the base platform and will discuss the aspects of the design that need improvement.

Work Breakdown Structure

The following is shown in the Gantt chart in the Table of Figures section, figure 4.2.

Concept of Operations

Purpose for Implementing the System

The micromouse navigates a maze from the outer corner to the center in the shortest amount of time possible to compete in the region II competition bringing home first place.

Highlight Major Objectives and Goals

To make a robot with the artificial intelligence needed to reach the center of the maze, also to make a robot within the parameters of the competition rules, and to make a robot that is as fast as reasonably possible.

Identify the Intended Audience
The intended audience included the IEEE Region II judges as well as competing schools and the members of the design team. Also in our final presentation our audience was the senior design students and the senior design faculty including our faculty project leaders.

**Set Boundaries on the Scope of the System**

The micromouse shall be a self-contained battery powered system. The external inputs shall be a USB port for communication to the programming device, a laptop.

**Describe an Overarching Vision for the System**

The micromouse will be a robot with sensory equipment and programming capable of navigating a maze. The end purpose of this robot was to compete in the Region II completion and win 1st place, which has been accomplished.

**Risk Management**

Few risks are relevant to this project but necessary to address. Of these risks some would have higher impact and some lower each varying in the likeliness of occurrence. Construction of the maze had a medium impact because testing relies on completion of the maze. At this point, the maze is just over 60% complete, sufficient enough for testing done of the micromouse. A problem which is somewhat out of our control is computer failure. This had a low chance of occurrence but would have a drastic impact as the computer is what we need to program and run the micromouse. To be safe we used an up-to-date computer and minimize the use of the selected computer outside the project. No issues arose due to computer failure. Damage to hardware would have a varied impact on our project depending primarily on what happens to it and when. If something were damaged too close to our deadline and we couldn't order the necessary parts the effect would be drastic as it could prevent us from competing in the competition. Before the competition we ordered spare parts to prevent this issue from occurring and had no problems with broken or failed hardware.

**Schedule**
Generally we remained on schedule, although we changed our priorities throughout the project. To prevent problems with meeting the competition deadline the team increased man hours on the project during the weeks before the competition. Also we developed a system of tracking the amount of time our team has invested into the micromouse as a way of encouraging each other to devote more time to the completion of our project. This method would have been more successful if the hours had been shared with the group to get an idea of who was spending time on what part and if some members had maintained a better sense of integrity in logging their hours.

Budget

Our team is fortunate enough to receive two types of funding. The first is our class fund of five hundred dollars which we recently exhausted. This budget was used primarily for the construction of the maze and various sensors and batteries. The next budget provided to us was from our customers whom which provided us a large helping hand by providing us enough to purchase two robots, the Airat II and the PICone, which allows us to pursue our two platform design approach. The final amount of budget provided by the customers was 1,060.

5. External Interfaces

The PICOne robot, the baseline model selected at the beginning of spring quarter, is built around a PICAXE 28X2 microcontroller. This processor will be described later. The processor is programmable in-place using a 3.5 mm jack (common in audio applications) that functions as a serial I/O port for interfacing with a computer.

The PICAXE takes input from several different sensors, gathering data such as distance and presence of maze walls and distance travelled. It outputs motor speed as well as diagnostic information shown through 5 board-mounted LEDs. The PICAXE is also capable of outputting the maze configuration that it currently has stored in memory to a computer with the appropriate software – the computer can then display a graphical representation of the maze layout.

6. Hardware
This section describes the system hardware in its final state.

6.1 Power Supply
The PICOOne robot in its original state did not have sufficient running time to meet our performance requirement of 30 minutes. To solve this, the team ordered 5 lithium-ion batteries with a nominal terminal voltage of 3.7 V and a rating of 1800 mAh. Two of these batteries in series form a pack, of which there are two, with one spare battery left over. These 7.4 V, 1800 mAh packs are able to replace the original 9 V battery source due to the presence of a 5 V regulator that supplies almost all sub-circuits on the robot’s mainboard – thus, the transition was almost trivial with respect to required work.

6.2 Processor
The PICOOne robot originally used two microcontrollers, a PICAXE 28X1 and a PICAXE 18X. The 28X1 was programmed only with control code and the ability to communicate bi-directionally via RS-232 with the 18X. The 18X was programmed with maze-solving code.

The PICAXE microcontroller is simply a PICmicro with bootstrap code that allows it to be programmed in BASIC instead of assembly. This adds ease to programming without sacrificing too much efficiency.

In order to reduce the time it takes the PICOOne to stop and solve the maze before making its next move (straight, turn left, turn right), the team replaced both original chips with a PICAXE 28X2 and a 10 MHz resonator that allows operation at 40 MHz (originally 8 MHz). The software from each chip was combined (not a trivial task) and programmed into the 28X2. In addition to a speed improvement, this allows more programmable I/O and additional program and data memory.

6.3 Motors and Drive System
The PICOOne design uses two brushed DC motors with a nominal operating voltage range of 2.5 – 3.3 VDC. These motors are commonly used in consumer CD and DVD players. The motors are driven by a 2-channel MOSFET driver chip rated for 3 A continuous current. This chip is controlled by PWM output from the PICAXE. The control loop is closed by an encoder on the driveshaft of each motor, the outputs of which connect to the PICAXE.
6.4 Sensors

The wall-sensing mechanism on the original PICOne robot was not modified from its original state. A 905 nm infrared LED pulses on in each direction; IR-sensitive phototransistors then produce a transient response to any incoming light; since these are AC-coupled to the PICAXE input, any DC component (usually ambient light) is rejected. The input of the PICAXE in this case is configured as an ADC – so the measurement is treated as a distance-to-wall.

7. Software

Overview

The software from the 28x1 and 18x1 was transferred over to the new PICAXE 28x2 chip. Within this code there is no serial communication anymore so some of the variables were changed in order for the 2 programs to work together in the one chip. Also an upgraded version of the compiler was downloaded to work with the new chip.

Executive

Within the software there are many subroutines included. These include setting the correct clock speed with the new frequency of 40MHz, initial values originally set when calibrating the robots, motor control loops to keep the micromouse centered between the walls in the maze, sensor readings to see if walls are present in order to navigate properly, and a maze solving algorithm to successfully reach the center of the maze.

Power-on sequence

This sequence consists of holding down the ‘A’ button on the micromouse when flipping the ‘Start’ switch. This resets any previous data in the micromouse and allows for the mapping process to start/

Debug Program

This program is used in order to get the initial values of the micromouse to be properly calibrated
Motor Control Loop

This loop is used in order to keep the micromouse centered in each portion of the maze between the walls. It does not require that the use needs to have two walls present to stay centered. Also it does this by slowing down one of the motors in order to straighten the micromouse.

Maze Solving Algorithm

The maze solving algorithm is used to save the position and orientation of the micromouse in a matrix that consists of the exact specifications of the competition maze. It has many portions of the algorithm where it makes decisions based on certain circumstances in the maze. After it maps the whole maze it then tries to find an alternate route to determine if the route is faster, then executes it.

8. Constraints, Impacts, and Support Engineering

Economic

Not applicable

Societal

In the ideal outcome of the micromouse robot it would be able to navigate and make decisions in any environment without any previous knowledge of the area. If this was the case, the micromouse would be able to save and map any area it traveled in and be able to get back to where it started. From this many data from an unknown area can be mapped without anyone having to physically enter the area.

Political

Not applicable

Ethical

Not applicable

Health and Safety
The micromouse is a very safe system. The worst case scenario is a possibly discharge of the lithium ion batteries which most likely would not cause any injury. Also as long as instructions for implementing every portion of the micromouse, no injury will occur.

Reliability

Numerous test runs in various maze layouts proves the reliability of the system.

Manufacturability

Multiple battery packs reduce downtime in case of battery failure. Also the micromouse has many connector pins so a lot of the components can be removed and replaced making a quick and simple fix to any components not working.

Flexibility

After replacing the two processors with a single processor, it increased the amount of configurable input/output pins along with opening up more room to add switches or other various parts to the micromouse.

Summary

9. Conclusion

This report details the past, present, and future of the Micromouse project. The project is first viewed from a “big picture” perspective – overarching goals and the purpose of the project are described. Goals and accomplishments (if appropriate) were summarized with respect to fall, winter, and spring quarters.

A more detailed look at the project was included as well. This encompasses a breakdown of program management activities, a description of hardware, and an overview of software. An analysis of constraints, impacts, and “-ilities” was included last.
Appendix B – Software Flow Chart

Power-On -> Software Delay -> Placement

Roam Maze, Store Layout Data

In Center of Maze? -> No -> Already Mapped Maze? -> Yes

Yes -> Return to Start Space via Alternative Route While Mapping

No -> Select Optimal Route to Center

Robot Powered Off and Removed From Maze -> Execute Route as Quickly as Possible
Appendix C – Risk “Stoplight” Charts
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**Risk Description**

- **Damage to Hardware**
  - Impact: 5
  - Occurrence: X
  - Risk Mitigation:
    1) Hardware Precaution
    2) Highlight Systemic Weaknesses

- **Computer Failure**
  - Impact: 5
  - Occurrence: X
  - Risk Mitigation:
    1) Up-to-Date Computer
    2) Minimize Computer Usage

**Risk Description**

- **Personnel**
  - Impact: 5
  - Occurrence: X
  - Risk Mitigation:
    1) Scheduling in Advance
    2) Stay Healthy