Senior Design Project

EE/CompE 490

Team NAVI

Micromouse Project

Submitted to: John Kennedy and Lal Tummala

Design Co. Ltd, San Diego, CA

Sponsored by San Diego State University

Landy Chan

Daniel Lapuz

Bruce Le

Justin Mateo

Victor Nguyen

Anthony Ortiz

Abstract

Each year, SDSU hosts a micromouse competition. The objective of the competition is to construct a robot that is able to navigate autonomously inside a 16 x 16 unit square maze as well as find the center in the shortest time possible. The robot must be constructed according to the official rules of IEEE, which includes a maximum price range, a restricted size of the robot, and that it may not touch a wall. The goal of this project is to simulate and construct our own self-contained robot that will traverse the maze and identify the center along with the quickest way to it. Our robot must accomplish this task without any control regulation beside the implemented code within the allocated 10 minutes.

Project Description

According to the IEEE California Micromouse competition, the objective for a team is to design and build an autonomous robotic mouse that can solve a maze as fast as possible. Requirements for the micromouse are the following: that it shall not be remote controlled, shall not use an energy source having any type of combustion process, it should not leave any part of its body behind while navigating and solving the maze, it shall not jump over, fly over, climb, scratch, cut, burn, mark, damage, or destroy the maze walls, it shall not be larger, in length or width, than 25 centimeters even if changing geometry (no restrictions on height of a Micromouse), and the project shall not cost over the limit of $600.

The finished Micromouse design should be able to navigate through the maze solving for the fastest route to the center. The Micromouse' exploration or mapping of the maze as well as its' deciphering and use of the fastest path must be done within the allotted 10 minutes. In order to achieve this, our team must design a robot with a sufficient power supply, efficient motors to handle the sharp turns throughout the maze, responsive sensors to detect the walls of the maze, and a precise algorithm coded to control and navigate our Micromouse via microcontroller to its destination; the center of the maze.

Block Diagram

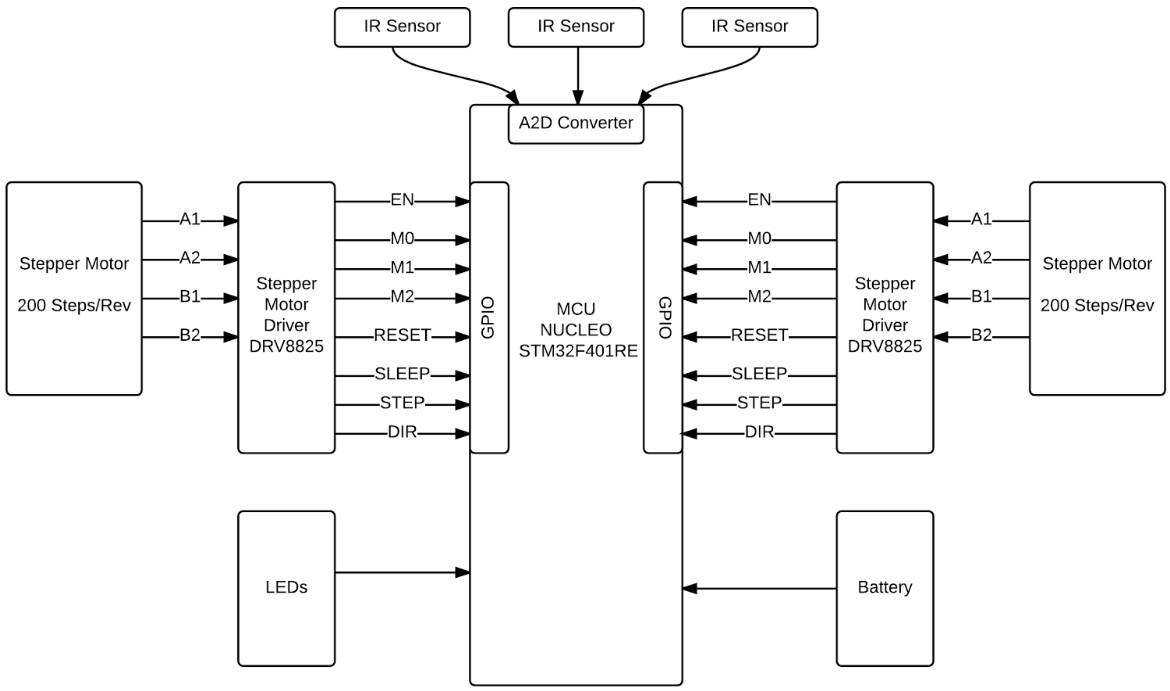

Figure 1

The block diagram depicts how every individual part will connect to the microcontroller. The microcontroller will communicate with the stepper motor drivers and IR sensors. The microcontroller outputs pulses to the stepper motor drivers in which they will control the stepper motors' direction and velocity based on outputted pulses. Furthermore recording certain number of pulses will allow us to track the Micromouse's position in the maze. The IR sensors will feed a certain voltage based on the distance from the walls, we will have sensors on every side of the mouse besides the rear; as we intend to turn around rather than move backwards. With the IR sensor's data the microcontroller will adjust the speed of the motors to avoid collisions if necessary.

Illustrations

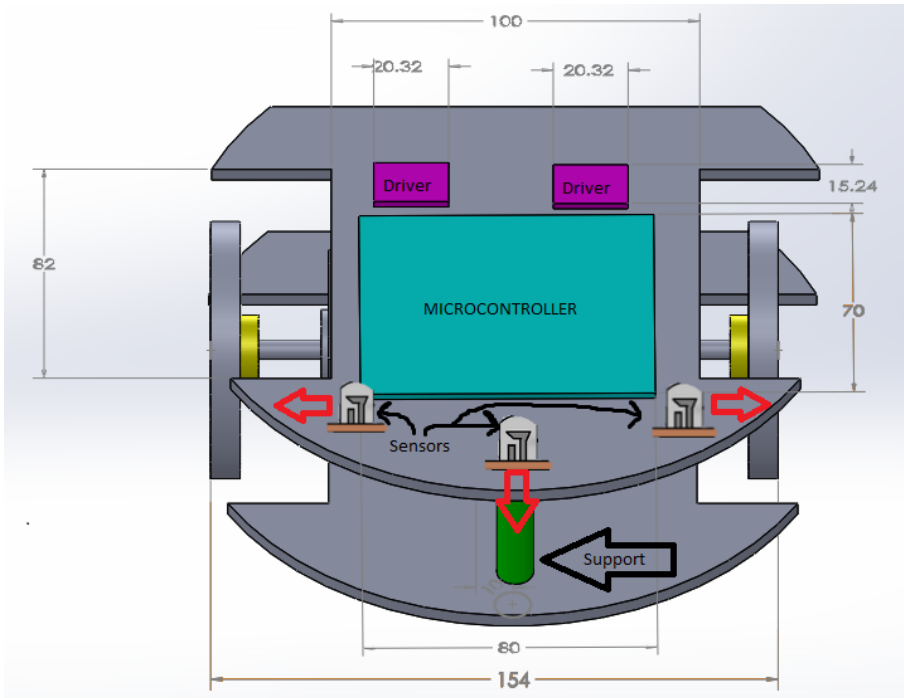

Figure 2: Top View - The top of our micromouse will be consist of the microcontroller, drivers, and sensors

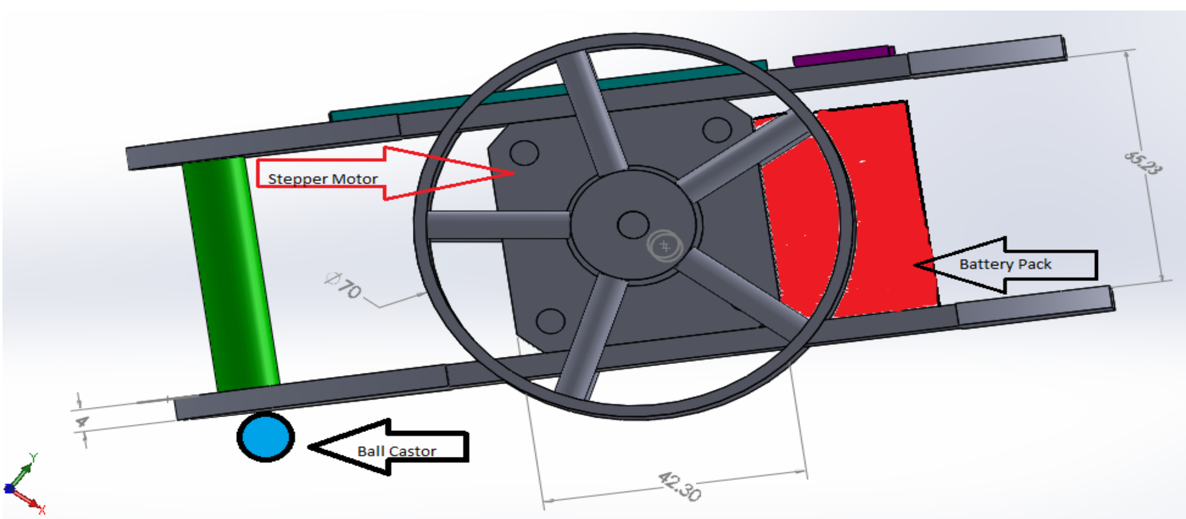

Figure 3: Side View - The middle will consist of the stepper motors, battery, support. Bottom will have the ball castor.

Constraints

Environmental and Social Factors

For this project, the environmental constraint would be the use of combustible parts, which are not allowed according to the IEEE micromouse rules. The mouse will use low power components that will not affect the environment greatly. The only or rather most potential hazardous waste item we will have would be our lithium polymer battery. All batteries in fact have been deemed hazardous due to their metal content.

Socially, it must abide by the IEEE micromouse competition rules with a façade that is presentable in professional settings.

Maintainability

The mouse will be under constant maintenance until the project is complete. Tests will be done in order to make sure it will operate successfully for the competition at the conclusion of the semester on Design Day. This requires that all the sensors, motors, wheels, and microcontroller work properly to complete the task of solving the maze. Within a reasonable budget, parts will all be replaceable.

Serviceability

During the construction of the mouse, each part will have to be serviced regularly in order to make sure that every part is working properly. We will construct a mouse with optimum modularity in order reduce massive reconstructions. Once the mouse is assembled, it will be tested within the maze. This is where resetting the mouse’s position and changing the mode using the external user interface will be the key focus.

Manufacturability

It is unlikely that our mouse will be manufactured, but there is a possibility that it may be used for teaching purposes in order for other students interested in doing similar projects. With the design and construction of our mouse this will be achievable.

Economic Constraints

The budget limit for a micromouse under IEEE competition rules is $500 in parts. Knowing we are not making a competitive mouse, we will not need to spend the whole $500 to put onto our robot. Rather, most of our money would be used for testing and maybe replacing various parts; such as motors, drivers, microcontrollers, and sensors. After testing several parts, we will decide which parts would be used for our robot. So with a budget of $600 we estimate our final robot to have $150-$200 dollars worth of parts. That would leave us with approximately $400 for experimenting and testing other parts.

Testing Procedures

Motors and Drivers

To evaluate the motors and drivers, a simulation of pulses from a microcontroller is needed. This will be done by using a function generator. To simulate a 12V battery, a power supply in the lab will be used as well as for a logic voltage of 3.3V for the power supplied from the microcontroller to the stepper motor driver. Before plugging anything in and applying power to the circuit, it is necessary to follow the data sheets of the motors and the motor drivers on how the leads should be connected to specific pins. Once everything is set, to theoretically solve for the stepper motor speed, this equation will be used: (v = desired motor speed, nm = micro stepping level, *Ө*step = full step angle)

$$f_{step}\left(\frac{\mu steps}{second}\right) = \frac{v\left(\frac{rotations}{minute}\right) * 360\left(\frac{\circ}{rotations}\right) * n_m\left(\frac{\mu steps}{step}\right)}{60\left(\frac{seconds}{minute}\right) * \theta_{step}\left(\frac{\circ}{step}\right)}$$

Once these values have been solved for, the experimental values (actual values) will be found by applying the found frequencies from the theoretical step. To keep in mind, this first trial will be done without a load on the motor. We will repeat this procedure with the wheels attached along with a load, i.e. slightly touching the wheel while spinning. Doing this will give a general idea as to how the micromouse will run.

Sensors

The Sharp IR sensors we chose are Sharp Microelectronics GP2Y0A51SK0F these output certain voltages dependent on their distance from a wall or object. The reasoning behind this selection is that the sensing distance available is from 2 to 15 cm; which is more than enough to detect the distance of our mouse within a 18x18 cm cell. For testing, we linked the sensor to a power supply and an oscilloscope. then using a ruler and a piece of the maze board, we measured the output voltage at several instances. We were also able to determine the delay the sensor has as well.

Microcontroller

We decided that we will use the STM32 Nucleo-F401RE microcontroller board to control the micromouse. To evaluate the microcontroller, we will be connecting the sensors and stepper motor drivers to the general-purpose I/O (GPIO) and advanced controller timers (TIM). Because we have tested sensors and stepper motor drivers and recorded data previously, we will be monitoring the output of the GPIO and TIM1 pins to ensure that the output matches the data. We will also be connecting a battery to power up the microcontroller instead of the USB ST-Link connection.

Because the performance of the microcontroller is directly linked to navigating the maze, the majority of time will be used for testing the following:

- Adjusting and matching velocities on both stepper motors
- Measuring distance from the walls, to prevent collisions with the wall
- Turning between cells of the maze
- Navigating through the maze in a timely manner
- Returning from the center to the origin

Project Plan

Again our team's mission is to build a micromouse that combines stepper motors, sharp IR sensors, a STM 32 microcontroller and an efficient program to navigate and decipher the maze in a timely manner. Below is a list of the resource materials we plan to utilize in order to assemble our Micromouse.

- Sharp Microelectronic Sensor GP2Y0A51SK0F
- Stepper Motor Bipolar, 200 Steps/Rev, 42×38mm, 2.8V, 1.7 A/Phase
- Nucleo STM STM32F401RE
- DRV8825 Stepper Motor Driver Carrier

To test and build these supplies together, we require the following:

- Power Supply
- Digital Multimeter
- Oscilloscope
- Solder
- Function Generator

The next page is the Gantt Chart which shows the deadlines and responsibilities of each team member we expect to complete the tasks.

Budget

Items	**Cost**

Stepper Motors and Drivers	$44.35
Sensors	$41.85
Microcontroller	$19.69
Batteries/Power Supply	$38.84
Hardware Parts	$19.90
Total(No tax):	$164.63

Knowing that our micromouse design only has a $600 budget, we plan on using the majority of our money on testing and experimenting on parts.