MINI SUMO ROBOT

PROJECT PROPOSAL

By:

Julian Allotta
Diane Moore
Arthur Rubio

Francis Enriquez
Roberto Rodriguez
Linh Ton

Submitted to: John Kennedy and Lal Tummala
Design Co. Ltd, San Diego, CA
INTRODUCTION

Abstract

Mini sumo is a competition between two autonomous robots that are placed in a ring (dohyo). The robots will then autonomously compete in a head-to-head match with the objective of forcing the opponent robot out of the ring. The designed robot, Robo Ronin, will have the ability to quickly detect the position of the opponent at the start of the battle and win the match by knocking the opponent out of the ring.

Project Description

To design our robot we adhered to the rules of the Robogames Unified Sumo Rules. The robot must weigh a maximum of 500 grams, not exceed a length and width longer than 10 cm, and be built with a budget of $500. The robots are allowed no weapons, and are not allowed to flip the opposing robot. The robot will start as soon as it receives an RF signal from the referee.

The inception of the design is focused on two aspects: maximum wheel base power and opponent recognition speed. This brought us to the design of a two-wheel robot with a front downward-tilted plate. The plate will be able to deflect any kind of potential scoop on the opposing robot. Another purpose for the front plate is to lift the front of the opposing robot, and thus gain an advantage by displacing it. The weight ratio of our robot will have a 45/55 front to back weight differential. This is to increase the weight at the wheels, and thus stabilize the robot’s center of gravity. Most of the components will be placed inside the frame in order to avoid damaging them.

Sharp analog distance sensors and QTR-1C reflective sensors will be implemented in order to create a competitive robot. Four QTR-1C reflective sensors will be mounted on the four corners of the robot, allowing it to detect whether the surface under the robot is black or white. Eight Sharp analog distance sensors will be placed on the robot, a total of two on each side. This will allow the designed robot to have an almost 360 degree view of the ring and accurately detect where the opponent is located.

The decisions and functionalities of this autonomous robot will be controlled by an Arm-Cortex based microcontroller. This microcontroller will mostly focus on monitoring the sensors and make decisions on where to go and when to turn depending on the results. The secondary function of the microcontroller is to drive the MC33926 Motor Driver Carrier. The motor driver
will, as a result, drive the two motors and allow for the robot to head left, right, forward or reverse.

In order to implement this design, the microcontroller must have at minimum twelve ADC pins for the sensors, two PWM pins for the motors, and some other general purpose input/output pins. This can be seen in figure 1 and is further explained below.
DESIGN

Block Diagram

Figure 1
Mock-Up Illustrations

Figure 2
Performance Requirements

Our designed robot will contain the minimum performance requirements listed below:

- Detect opponent from any location
- Provide enough force to maneuver opponent outside the ring
- Detect whether the surface is black or white, so that it only maneuvers within the ring
- Have the ability to supply enough power to all the peripheral components.
- Detect start signal from the referee

TESTING AND VERIFICATION

Testing Procedures

The first stage of testing procedures is testing the performance of each component to verify whether or not they meet the requirements. After constructing the robot and implementing the software we will then test its functionality and capabilities.

First stage

- Sensor testing:
  - Proximity sensor: An input voltage of 5V was supplied to the proximity sensor, while its output voltage was measured through a DMM. Since the exact distance of an object is not relatively important, the testing was primarily on detection range and angle. In order to test range, an object was put in front of the sensor and slowly moved away. The output voltage dropped as the object moved further away from the sensor. At approximately 80 cm, the output voltage of the sensor was roughly .35V. To measure the angle detection range an object was waved left to right, and top to bottom, in front of the sensor. This information was recorded in order to estimate how many sensors it would take in order to obtain a 360 degree view around the robot.
  - Reflection sensor: Just like the proximity sensor, the reflection sensor output voltage will determine whether or not the sensor is picking up a signal. The reflection sensor will be tested on its ability to detect white and black surfaces. The output voltage for when it senses a white color, black color and the edge of a black and white surface will be recorded.
Motor and H-bridge testing:

- In order to maximize the wheel base power, research on the fundamentals of motor power was necessary. These fundamentals can be described from force and torque equations. Given the following equations $F = ma$ and $T = Fr$, where $F =$ force, $r =$ radius (wheel), $m =$ mass, $T =$ torque, $a =$ acceleration, it was possible to calculate the robot’s maximum torque capacity. Given that the max mass is 500 grams, and assuming unity for the static coefficient, it was calculated that the robot has the maximum potential force of 4.9 N. Taking into account this force, and the robot’s large wheels, it’s calculated that the robot can achieve 31 oz of torque. It must be noted that this value has been increased by a factor of two in order to reduce the current necessary to drive the motor.

- In order to test the functionality of the MC33926 Motor Driver it was essential to become familiar with the pin layout and required voltage needs by reading its documentation. Five pins on the H-bridge need to be connected to a microcontroller. A PWM input is necessary to control the speed of the motor. Three I/O pins will control whether the robot will move forward, reverse, left, or right by individually spinning each wheel forward or backwards. The last pin will output a logic level high necessary to enable the motor driver. After making these connections, it then was connected to a power supply to supply the required 9 volts to the motor. A tachometer was then used to measure the speed of the motors in RPM under a no load condition. The resultant data can be seen in figure 3. A measurement of the time on for each duty cycle of the PWM can be seen in figure 4. As a result of testing, it was confirmed that this H-bridge would be able to provide enough power and ample current for the motor. Further testing will be done for the motors while under load.
**Figure 3**

Duty Cycle VS RPM

![Graph showing duty cycle vs RPM](image)

- **56:1 metal gear motor (RPM)**
- **Fingertech Silver Spark 50:1 motor (RPM)**

**Figure 4**

Duty Cycle(%) VS Time On (µs)

![Graph showing duty cycle vs time on](image)

- **Series1**
Microcontroller testing:
  o Since working with the sensors and the motors are the most important tasks of the microcontroller, focus was directed towards pulse width modulation and analog to digital conversion. In order to test the PWM, its duty cycle was decremented/incremented while the voltage output was tested through a DMM. The higher the duty cycle the higher the voltage output was, ranging from about 0V to about 3V. The ADC was tested by connecting an analog distance sensor to the microcontroller. The value that the microcontroller received was relative to the output voltage given by the sensor. The output voltage of the sensor increased as the distance between it and the test object decreased.

Second stage:

  o The ability to sense the start signal and react
    o A remote control will be used to send an infrared light signal to the robot and test its response time

  o Opponent detecting and making direction decision
    o To test this, another moving robot will be placed on the ring. As soon as the start signal is sent out, our Robo Ronin will have to detect the opponent and make the decision on which direction to move to close in on it. This action will need to be quick and precise since it is one of the most important keys for victory.

  o Pushing capability
    o Pushing capability will be tested on both a stationary object and a mobile robot. Objects with different mass will be used to test the robot.
PROJECT MANAGEMENT

Project Plan

Task decomposition

The team has been broken up into three different sub-teams. This allows the team as a whole to work in parallel.

- Team one is responsible for the sensors and the microcontroller
  - Integrating sensor logic with microcontroller so that it can make accurate decisions
- Team two is responsible for power and motor differential drive
  - Powering up motors and integrating it with an H-drive system
  - Power bussing
- Team three is responsible for programming
  - Program writing and interpreting sensor logic to control other components.
  - Strategy algorithm
Project management

- Each sub-team will be responsible for conducting their own milestone. This will allow the project as a whole to quickly advance in parallel.
- Each person will be given a task to complete within their respective sub-teams. The summary of their accomplishments will be turned in as weekly reports. This will ensure that the project’s completion is advancing.
- Project management will be conducted using Microsoft Project Professional. As can be seen in the task schedule, we are utilizing both the block and Gantt chart.

Milestones

- Integration between: microcontroller, H-drive and motor (October 2, 2015)
  - This was the connection between the micro controller in which we programmed the PWM and sent GPIO commands to the H-bridges to control the motor speed as well as the rotational direction.
- Assembling Robo Ronin (October 17, 2015)
  - Assembling Robo Ronin in only two front proximity sensors as well as reflection sensors under the robot. However, we will minus the packaging part. This will help in identify potential issues with components as well as allow the computer engineers to start programming.
- Test Robo Ronin with no opponent. (November 4, 2015)
  - This will be a test in which we will place objects in front of Robo Ronin and see if the robot can identify the object in front and then apply some action. This would require that all sensors be mounted and functional programmed. The main goal would be no to go beyond the white line on the battle platform.
- Test Robo Ronin with test opponent. (November 13, 2015)
  - In this test we will take the improved robot and apply an opponent in the battle ring. The opponent will be that of the RC time constant robot that would simulate the real opponent; however, less intelligent.
- Finalize the packaging of Robo Ronin (November 28, 2015)
  - This will incorporate the final look in both aesthetics as well as functionality of the robot. This will place a unique look that will show that much time and effort has gone into the final look.
BUDGET

Cost Analysis

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Budget</td>
<td>$500.00</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$362.64</td>
</tr>
<tr>
<td>Remaining Budget</td>
<td>$137.36</td>
</tr>
</tbody>
</table>

- First round of purchasing consisted of purchasing 2 different sizes of wheels, 2 different motors, and 3 types of sensors (analog distance, pressure, and reflectance).
- After testing each part, another order will be placed for parts that will be used in the final design.
What is a Mini-Sumo robot?
A fully autonomous robot that:
- Can compete in a pushing match similar to traditional sumo matches
- Has a length and width no more than 10cm
- Is no heavier than 500g
- Has no weapons
- Can stay within the circular arena called the Dohyo

Robo Ronin Team:
Arthur Rubio
Project Manager
Diane Moore
Powerpoint
Linh Ton
Technical Illustrations
Julian Allotta
Web Design
Robert Rodriguez
Editor
Francis Enriquez
Parts

Our Design:
- Two 56:1 Gearmotors
- Two 1.75in Urethane wheels
- Four reflectance sensors
- Eight analog distance sensors
- Custom printed chassis

Mini-Sumo robotics contest: December 10th