IEEE Region 5 Robotics Competition

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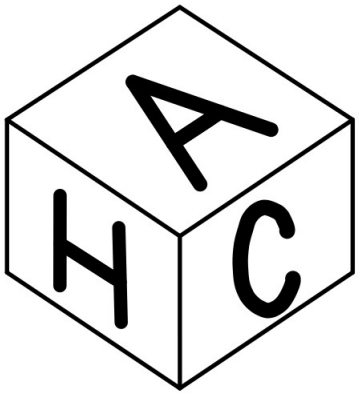


Keywords: Pick and Place Robot, IEEE, Robotics Competition, Optical Image Recognition, Mothership, Raspberry Pi, Claw, Omiwheels

Contents

1 Executive Summary

In this project, we are tasked with designing a robot that is capable of navigating a board with various obstacles, picking up labeled cubes, and placing them in corresponding slots in a 'mothership'. The teams recommended solution is a fairly simple 4-wheeled robot design to navigate the course. In order to properly sort the cubes, we will use OCR (optical character recognition) to identify the letter on the top face of the cube. This will require a camera and a separate processor. To avoid the obstacles present on the course we will use the provided JSON file to find a course through the obstacles.

2 Intro & Background

The Institute of Electrical and Electronics Engineers (IEEE) Region 5 Student Robotics Competition is sponsored by the Region 5 IEEE Committee. Region 5 includes over 90 students branches in the central United States. [1] Students with a IEEE membership can enter the contest where each team is challenged to build an autonomous robot that avoids obstacles and picks up lettered cubes to place in the corresponding lettered box. [2]

3 Market, Social, & Ethical

Pick and place robots are frequently used to benefit manufacturers with ease and automation. The main benefits for these robots are speed and consistency. Pick and place robots can be used in factories for: assembly, packaging, bin picking, and inspection. The benefits of speed and consistency provide return on investment (ROI) and help in profitable outputs. [3]

The social aspect of this competition will motivate other students at Saint Louis University to compete in the IEEE Region 5 Robotics Competition. Our work will be showcased in the poster symposium and the walls of McDonnell Douglas Hall. With our work and advertisement, we will encourage students in the Electrical and Computer Engineering department to increase IEEE membership and involvement. IEEE membership is a great way to stay up to date on current technological discoveries, amazing student networking, attending conferences, and other career development tools. [4]

Robotic ethics will not be a concern because this design will only interact with simulated environments. The course is pre-determined and controlled, so all decision making systems will be based off of predefined rules. Though our system is autonomous, machine learning is not used to control response in the system's behavior.

4 Design Parameters & Specifications

4.1 Design Parameters

4.1.1 Robot

Single or multiple robots may use to complete the task. All robots must fit in 1'X1' and not weighing over 40 lbs together.

Finishing light is required to flash once the robot finishes that round. Finishing light must be placed in the highest point of the robot.

4.1.2 Mothership

0.25 inch thick oak plywood will be used to cut into different kinds of pieces like

1. 1 - 8 $\frac{1}{2}$ inch x 13 $\frac{1}{2}$ inch
2. 2 - 8 inch x 6 $\frac{1}{4}$ inch
3. 4 - 4 $\frac{1}{2}$ inch x 1 $\frac{1}{4}$ inch
4. 4 - 2 $\frac{1}{2}$ inch x 1 $\frac{1}{4}$ inch
5. 2 - 8 $\frac{1}{2}$ inch x 1 $\frac{1}{4}$ inch
6. 6 - 8 inch x 2 inch1

Piece "a" will be painted in white. Paint letters A-F with stencils in the 2.5 inch X2.5 inch in the center square.

4.1.3 Obstacles & Blocks

To build obstacles, we need to cut dowel into 15 2 inches long pieces. For each pieces, drill a 5/8 inch hole in the center. Paint these pieces by gray spray with 2 to 3 layers. Place the ping pong ball in the hole after it gets dried.

Blocks need to be sanded and paint them white. Use the stencil A-F to place a single letter onto the blocks and paint black.

4.1.4 Competition Board

5 2X4 pieces will be cut into 2 equal 4 feet long pieces. Paint them in black.

4.1.5 Corner Lights

Put 4 blue LED into the competition board. Each of them have to face the center of the project board.

4.2 Specification

- Robot will have 10 mins before the round actually starts.
- Once a round starts, no repair and changes can be made.
- Explosive and volatile liquid is banned in the robot.
- Only wheeled, tracked or legged robots are allowed and especial one wheel has to keep in touch with the competition board

5 Technical Analysis & Recommendation

For our solution, we utilized a very simple chassis/driving mechanism for the robot to allow us to focus our efforts on the navigation & OCR parts of the robot. For our robot's navigation,

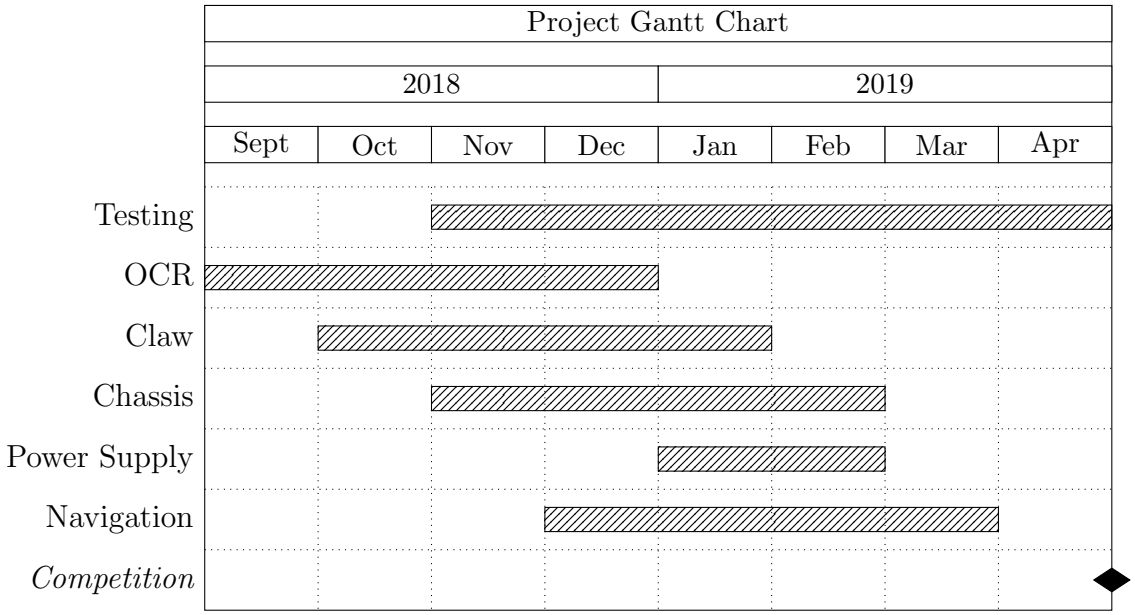
we could have used a secondary camera and used computer vision to identify and navigate around obstacles. We decided against this approach as it would increase the computation power needed in our onboard processor greatly. With the JSON file provided, we should be able to generate a 2D representation of the playing field and navigate the robot between obstacles fairly easily.

In order to identify and place the cubes in their respective slots, we have decided to recognize the letter on the top face of the cube using OCR. This requires the use of a camera and a decently powerful processor. We will need to provide ample light to the camera to get a good quality picture, so we will also need some form of lighting.

During a preliminary testing, the OCR library we tested was able to correctly identify the letter in the image when it was turned less than 30 degrees off axis. This issue could be corrected in further testing by detecting the rotation of the image and correcting before attempting to find the letter within it.

After identifying the letter on the cube, we will need to move the cube to the mothership elsewhere on the playing field. We will do this using a claw designed to transfer the rotational movement of a motor to linear movement of the closing claw. By keeping the parts of the claw parallel as it closes, we are able to more easily keep the cube in the claw. The alternative to this, using a claw that pivots around a shared point, could push the cube forward instead of trapping in the claw.

6 Implementation Plan



1. Design & build or find a chassis - Amy & Heli
2. Design & build a claw - Amy
3. OCR Development - Charlie
4. Navigation Logic - Charlie
5. Hardware Assembly - Amy & Heli
6. Power supply design & implementation - Heli

7 References

References

[1] Robert Shapiro, IEEE Region 5 Website, 2018, http://ieeer5.org.

[2] IEEE Region 5 Robotics Competition, 2018, http://r5conferences.org/competitions/robotics-competition/.

[3] Robotics Online Marketing Team, Pick and Place Robots: What Are They Used For and How Do They Benefit Manufacturers?, 03/13/2018, https://www.robotics.org/blog-article.cfm/Pick-and-Place-Robots-What-Are-They-Used-For-and-How-Do-They-Benefit-Manufacturers/88.

[4] IEEE, The Benefits of Membership, https://ewh.ieee.org/reg/3/IEEE_member_value.pdf.

8 Appendix

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8.2 Resources

8.2.1 Facilities

- Fabrication Lab
- Senior Design Lab
- Electronics Lab
- Microprocessors Lab

8.2.2 Lab Equipment

- Laser cutter
- Digital Multimeter
- Power Supply
- Oscilloscope

8.2.3 Computer Applications

- OpenCV
- Tesseract OCR
- Raspbian

8.2.4 Specialized Hardware

- Raspberry Pi
- Raspberry Pi Camera Module
- Servo Motors
- DC Motors

8.2.5 Communication Protocols

- Universal Serial Bus
- Camera Serial Interface

8.3 Testing

8.3.1 OCR

1. Test using computer generated images based off stencil
   (a) 1 image per letter rotated to various angles
   (b) Run on lab computer
2. Test using Raspbery Pi camera
   (a) 10 images per letter
   (b) Taken in well lit environment
   (c) Run on lab computer
3. Test using Raspberry Pi + camera
   (a) 10 images per letter
   (b) Taken on the assembled robot
   (c) Run on the onboard computer (Raspberry Pi)

8.3.2 Claw

1. Test on & off the chassis
2. Should pick up cubes with very high reliability
3. Test 20+ times

8.3.3 Navigation

1. Use assembled chassis, competition board, & obstacles
2. Verify the robot can reach any location a cube could be autonomously.
3. Should be run with 5/10/15 obstacles (based on competition rules)
4. Should be tested at least 10 times at each level

8.3.4 Completed Robot

1. Match competition rules exactly
2. Test 10+ times at each level of competition
3. Record time and points as defined in the rules

8.4 Personnel

See following pages.