IEEE Region 5 Robotics Competition

Charlie Coleman - facilitator
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Under Guidance from: Dr. Roobik Gharabagi & Dr. Kyle Mitchell

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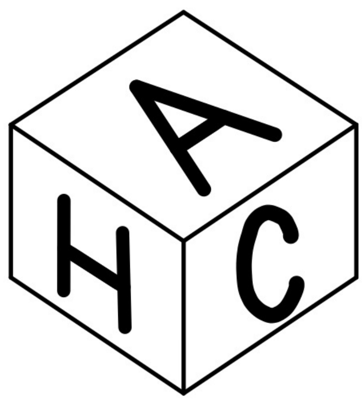

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Keywords: Pick and Place Robot, IEEE, Robotics Competition, Optical Image Recognition, Mothership, Raspberry Pi, Claw, Omiwheels

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. 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

8.1 Specifications

- Robot will have 10 mins before the round actually starts.
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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.

Amy Guo

2524 Jennifer Crossing, Granite City, IL 62040 — (618) 225-2769 — amy.guo@slu.edu

Education

Bachelor of Science in Computer Engineering , May 2019
Saint Louis University – Saint Louis, MO
- GPA: 3.3

Projects

Ultimate Frisbee Statistics Tracker
- Records player statistics throughout a tournament
- Different modes for offense and defense
- User-friendly interface allows for simple data entry and retrieval

Skills

Languages	Python, Java, C, C++, Assembly, VHDL, Matlab Fluent in English, Mandarin, and Fuzhou
Miscellaneous	FPGA Design, Eagle CAD, SolidWorks, LaTeX, Git, ROS, macOS, Windows, Linux

Work History

Teaching/Lab Assistant *SLU — Saint Louis, MO (Spring 2017, Present)*
- Taught students how to utilize lab equipment
- Graded students' reports
- Prepared and delivered lectures on laboratory topics

Research Assistant *UNL NIMBUS Lab — Lincoln, NE (Summer 2018)*
- Research Experience for Undergraduates (REU) Program
- Atmospheric profiling using unmanned aerial systems
- PTH sensor assessment
- Field Experiments, Mission planning, data recording

ITS Intern *SLU — Saint Louis, MO (Spring & Fall 2017)*
- Assist students and faculty with technology questions and support
  * Help with both hardware and software questions
- Maintained system security by exhaustive identity verification

Conferences

Women in Physical Sciences Conf. — University of Nebraska,Lincoln (2018)

Papers

Assessment of Pressure/ Temperature/ Humidity Sensors for Unmanned Aerial Systems — UNL NIMBUS Lab (2018)

Leadership

Secretary *SLU Branch of IEEE — Saint Louis University (2017-2018)*
Vice President *SLU Branch of IEEE — Saint Louis University (2018-2019)*
Social Chair *SLU Branch of SWE — Saint Louis University (2018-2019)*

Volunteer History

Volunteer *Make A Difference Day — Saint Louis University (2015)*
Instructor *Billiken Bots — Saint Louis University (2015-2018)*
Instructor *Scout-botics — Saint Louis University (2015-2018)*

Charlie Coleman

2912 36th St, Des Moines, IA 50310 — (515) 724-2838 — me@charlie-coleman.com

Education

Bachelor of Science in Computer Engineering, May 2019
Saint Louis University — Saint Louis, MO

- Departmental GPA: 3.96, Cumulative GPA: 3.58

Projects

Karnaugh Map Solver Website

- Written using Javascript, HTML, and CSS
- Uses the Quine-McCluskey Algorithm in combination with Petrick's method to perform boolean simplification
- Allows the user to enter the truth table through multiple methods

Schedule Maker Website, Github

- Written using JavaScript, HTML, and CSS
- Allows users to plan and create a class schedule
- Converts the class data to a base 64 encoded JSON string
  - This allows the current schedule to be bookmarked/saved
- Allows the user to export the schedule as a calendar file
  - Compatible with Google Calendar and Outlook

Fractal Generator Website, Github

- Written using JavaScript, HTML, and CSS
- Generates fractal images using Lindenmayer systems
- Can generate very complex fractals using recursive methods
- Allows the user to export the final fractal as a PNG file

Technical Skills

Operating Systems	Windows 7/8/10, Linux Mint, Ubuntu, MacOS
Languages	C++, C, Java, Python, VBA, JavaScript, HTML, CSS, Assembly, VHDL
Miscellaneous	Microsoft Office, Autodesk Inventor, Git/Github, Agile (scrum) Development

Work History

Software Engineering Intern *Cerner — Kansas City, MO (2018)*

- Re-implemented an existing piece of software in Node.js and ReactJS
- Used Scrum development practices to communicate progress with my manager and team and get feedback
- Used Git/Jenkins/Crucible to test & review code

Tech Repair Technician *Office Depot — Des Moines, IA (2017)*

- Ran diagnostics and repaired customers' computers
- Communicated with team members on what needed to be done
- Worked with customers to diagnose and solve problems

IT Intern *PurFoods LLC — Ankeny, IA (2016)*

- Gathered information on the company's computer system
- Documented computer inventory of the company
- Created tools to facilitate easier access to the data for editing/viewing
- Took a project description and decided the best path forward
- Worked mostly independently while giving updates to superiors

Volunteer History

Camp Counselor *Catholic Youth Camp — Panora, IA (2014-2018)*

Heli (Leon) Wang

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EDUCATION

Saint Louis University, Parks College of Engineering, Aviation and Technology, Saint Louis, MO
Bachelor of Science in Electrical Engineering, anticipated in 2018
GPA 3.17/4.0

EXPERIENCE

Referee, Intramural sports, Saint Louis University **Fall 2015**

- Helped people negotiate and communicate for scores and balance
- Learned the health safety training
- Cooperated with other referees to run games normally and keep the rules of the game

Captain for the basketball team, South-central University for Nationalities, Wuhan, China **Fall 2013**

- Led the team to get the fourth in 2014 freshman basketball contest
- Learned how to summarize the lesson for the failure of the game
- Organized whole team to collaborate together
- Communicated with teammates to solve the conflicts between regular student life and basketball
- Learned how to balance the relationship among teammates, coach and captain

Membership of P.E Department of Student Union, South-central University For Nationalities, Wuhan, China **Fall 2013- Spring 2014**

- Helped organize and launch the basketball league
- Helped organize school athletes game
- Handled the problem of launching a school athletes game

Chinese teacher's assistant, Xinzhuang High School, Shanghai, China
Fall 2010- Spring 2013

- Helped students who were not good at Chinese
- Learned how to make other people learn Chinese

SKILLS

- Software: Microsoft Word, Excel, PowerPoint. Google Docs
- Programming languages: Familiar with Matlab
- Language: Fluent in Mandarin Chinese