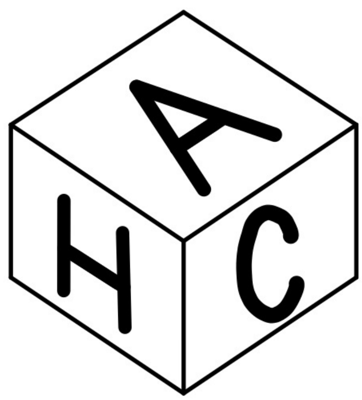
IEEE Region 5 Robotics Competition

Charlie Coleman - facilitator
Amy Guo
Heli Wang

Under Guidance from: Dr. Roobik Gharabagi & Dr. Kyle Mitchell

1 March, 2019



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

Contents

1 Executive Summary

For our project, we are 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'. Our plan is to build a 4-wheeled robot to navigate the course. In order to properly sort the cubes, we created an OCR (optical character recognition) algorithm to identify the letters on the top face of the cube. We used a pi camera and a raspberry pi. 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 weigh over 40 lbs altogether.

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

4.1.2 Mothership

0.25 inch thick oak plywood was 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 inch

Piece "a" has been painted in white. Our next step is to 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 have cut dowels into 15 2" long pieces. For each piece, we drilled a 5/8 inch hole in the center. We have painted these pieces with gray spray paint. We still need to purchase the ping pong balls to place at the top of the dowel.

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. Our blocks and stencils have just arrived on Thursday, February 28th, so our next steps are to work on the blocks.

4.1.4 Competition Board

The competition board has been constructed. It has also been filled with wood-filler and sanded down to provide a smooth surface for our robot to navigate on. Lastly, it has been painted and dried.

4.1.5 Corner Lights

Corner lights still need to be worked on, but this is lower priority compared to other parts of our project. Four blue LEDs will be placed into the competition board, all facing the center.

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.

Although our design for the robot chassis was simple, we had several issues with sizing. To keep costs low, we used two motors with our four wheel design. We later decided to add motor encoders to tell us how much the motors have spun, so it could help us calculate our robot's location. We did not account for the addition area the encoders would add, so we had to minimize our wheel structure and place the gears on the outside perimeter to create enough room for our motor layout.

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 required 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.

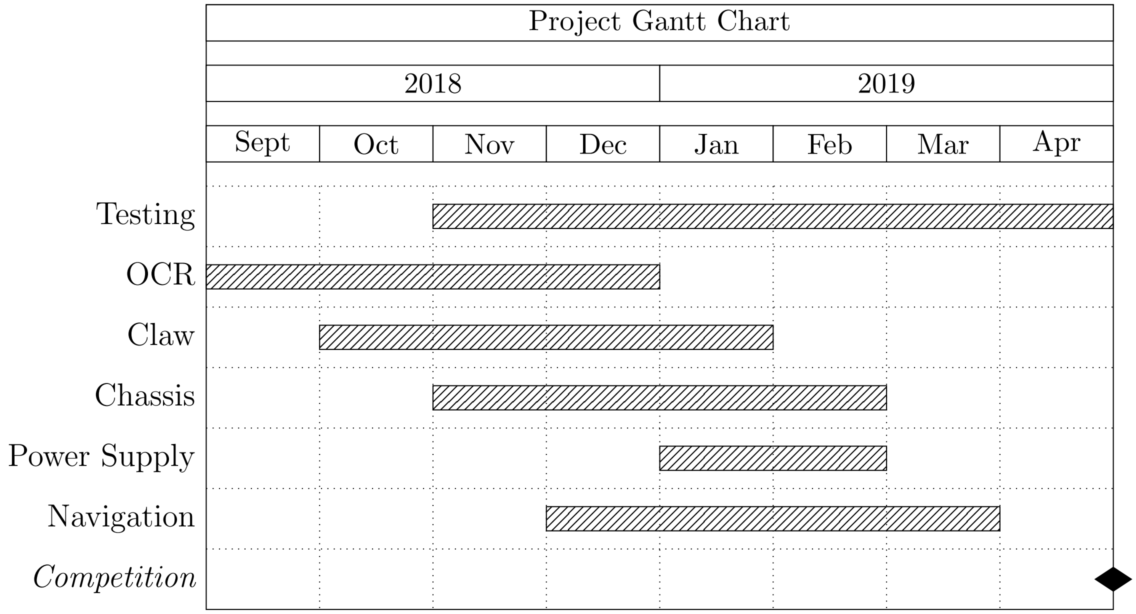
During a preliminary testing, the OCR library we tested was able to correctly identify the letter in the image when it was turned less than 30 degrees off axis. This issue could be corrected in further testing by detecting the rotation of the image and correcting before attempting to find the letter within it. Currently our system is having trouble distinguishing between the letters "C" and "D" when the "C" is rotated twice or upside down. Our plan to correct this issue is to retake better quality images of real cases then rerun the algorithm.

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.

5.1 Budget Report

Item	**Cost**
Chassis	$18.99
2-wire motors	$29.98
Motor controller	$19.98
Steel plate	$4.99
Wheels	$19.99
Drive shaft	$5.49
Wood cubes	$3.99
Stencil	$2.99
Total Amount Spent	106.40(132.75 w. shipping)

6 Implementation Plan



1. Design & build 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

8.1 Specifications

- Robot will have 10 mins before the round actually starts.
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- Only wheeled, tracked or legged robots are allowed and especial one wheel has to keep in touch with the competition board

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

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Education

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

- GPA: 3.36

Projects

Software Defined Radio

- Designed using Nexys 4 FPGA and ATmega328 processor
- Developed SPI hardware communication
- Depicted low-pass filter using digital logic

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, Fall 2018)*

- Deliver lectures on laboratory topics and grade reports
- Demostrated lab equipment process

REU Research Assistant *NIMBUS Lab — Lincoln, NE (Summer 2018)*

- Atmospheric profiling using unmanned aerial systems
- Real-time system integration
- Sensor assessment, field experiments, data recording

ITS Intern *SLU — Saint Louis, MO (2017)*

- Assist students and faculty with technology questions and support
- 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)*

Awards and Volunteer History

Outstanding Undergraduate *IEEE — Saint Louis Section (2018)*
Dean's List *Saint Louis University (2018)*
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

20 N Grand Blvd • Saint Louis, MO 63103
(314) 397-2499• heli.wang@slu.edu

EDUCATION

Saint Louis University, Parks College of Engineering, Aviation and Technology,
Saint Louis, MO

Bachelor of Science in Electrical Engineering, anticipated in 2019
GPA 3.01/4.0
Minor of mathematics department in Math, anticipated in 2018

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

Professional aspect:

Based on atmel:

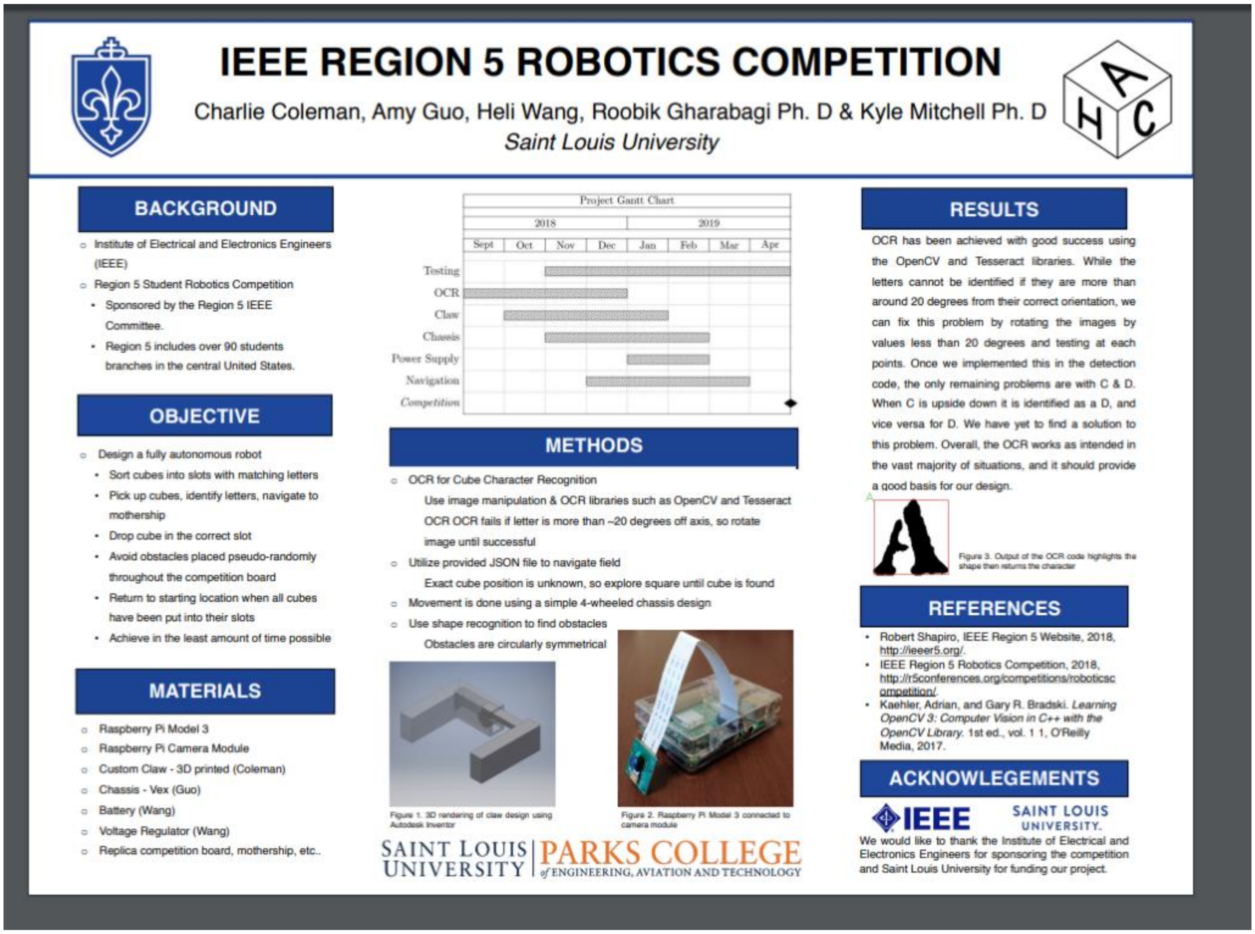
- **Familiar with assembly program: arithmetic, shift, jump, rotate instruction**
- **Have used JTAG II debugger in STK500 finished LED lights**
- **Use asc II in LED lights to function the keyboard. The board can do timing and display number 1 through 9.**

Based on circuits design:

- **Have designed circuits like p-type, n-type, mosfet, p-n junction. In detail it will be common emitter/ collector, emitter, base amplifier. Multiple stage amplifier, ac-dc converter.**

Senior design:

Heli (Leon) Wang



This is a post introducing my senior design project. So far we have built the mothership and the playfield. For the robot we have done the main body part, and the next step is to install the pi into the robot. In software aspect we use raspberry pi as a core to function the letter recognition. In this project I am responsible for the power part and the motor choose. Through discussion and consulting, we choose 7.2v battery and dc motor.

Important class have been taken

- **Microprocessor**
- **Linear system**
- **Electromagnetic fields**
- **Electrical circuits I**
- **Electrical circuits II**
- **Thermodynamics**
- **Automatic control system**
- **Analog integrated circuit design**
- **Communication systems**
- **Electromagnetic waves**

Heli (Leon) Wang

- **CMOS Integrated Circuits Design**

SKILLS

- Software: Microsoft Word, Excel, PowerPoint. Xplain, atmel
- Programming languages: Familiar with Matlab, familiar with VHDL, familiar with atmel
- Language: Fluent in Mandarin Chinese, fluent in English

Special notes: Personally I don’t mind if your company don’t sponsor the H1B

visa. I can still work 3 years without H1B visa.