STORMING FC

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6/22/2021

1. Abstract

In this season of RCJ Open soccer, Storming FC decided to revisit last year's design and find what was successful. Storming FC created a thorough and revised robot for the open league competition. Keeping the similar circular design of the robot from last year, parts of the chassis were printed using a 3D printer. We decided to create two identical robots and implement both a “dribbler” and a “kicker”. The “dribbler” is a motor that applies back spin to the soccer ball, which allows the robot to keep hold of the ball while moving around the field. The “kicker”, on the other hand, applies a force on the ball using a solenoid to project the ball away from the robot in order to score goals allowing the robot to simulate a kick. To prevent the robot from crossing field and goal boundaries, we planned to use 8 light sensors (90 degrees of separation from each pair of light sensors) and sense it’s position on the field.

In the winter season, Storming FC began planning the parts we needed to purchase online. While reusing some older parts, we purchased many new parts such as motors, Arduinos, and Cameras online.

2. Introduction

After not being able to compete in last year's Robocup Junior Soccer lightweight competition, Storming FC was ready to learn from their past errors and move up to the heavy weight competition. In early October, we decided to invest time in learning openCV to implement a camera for the next competition. Through learning about how to use Raspberry PI and understanding the fundamentals to filtering an image, we were able to recognize different objects and contours using an attached camera. With this new found knowledge, we were set on applying this to recognizing the ball on the field.

3. Robots and Results

Storming FC decided to use a modular design for the bottom plate of both robots to allow for ease of access to the different parts on the bottom and a simpler system to change batteries. The goal of the modular system is simplicity and efficiency. Our bottom plate is divided into five 3D printed parts or "modules" about 4 mm thick. The center module is a circle with a radius of 32.5 mm holding the kicker. The other four modules are quadrants which make up the remainder of the 105 mm radius circle that is the bottom plate as a whole. These four modules have two light sensors, a motor with a wheel, three standoff holes, and a space to hold half of the battery pack. Each of these parts' wires ends in 3 pin male cable connectors which are attached to the female ends, leading to the arduino. The modular system allows for testing and debugging on the modules since they can be replaced and tested easily.

(Image that displays the old model, in gray, and the new design displayed on the monitor)

For example, if one motor seems to be defective and moving far slower than usual, we can easily test the motor to confirm it is flawed. Afterwards we can replace the motor by taking the motor's module off the robot and its mount without having to disconnect any of the other wires. Another example is the kicker. The solenoid can easily be separated from the bot without disturbing other modules by unscrewing the center module. Now, the kicker can be tested for its power and edits can be made easily if necessary.

When it was time to begin drafting a design for the different plates we used our past design (from RCJ light weight 2020 competition) to create a basic CAD on Autodesk inventor.

Originally we planned to 3D print both the top and bottom; however after re-evaluating our options we decided to laser cut our top plate to have a more thorough and refined hole placements as well as a lighter material. At first, we also considered creating a 3rd plate to place the camera on; however, after realizing the height of the camera was an issue as it wasn't able to see the ball, Storming FC didn't implement the third plate.

Further elaborating on the process we went through when iterating our top plate, for our first chassis design we realized that the holes needed to mount the dibbler were too close to the edge making it very structurally weak.
See the first iteration of our top plate, and what became of it.

For the second design we moved holes a little further back; however the dribbler was still too close to the divet because the ball was not close enough to the divet where we could apply backspin to keep the ball with the robot at all times. In the third plate attempt the dribbler holes were measured to fit a ball inside the divot.

The standoffs to hold the modular bottom plate to the top plate were originally held through with thin circular standoffs. Due to the five different parts of the modular design, we needed stronger support from the standoffs connecting the top plate to the bottom plate, so we purchased an abundance of large octagon shaped standoffs to hold the plates together more sturdily. See our second top plates.

For the last design iteration for the top plate, we made some big changes. We made the hole in the center of the design for the wires much bigger to allow for more breathing room, and moved the LCD display back to make room for the OpenMV camera. We also shifted the dribbler design to the top plate so we could get a better angle on the ball. However, the tradeoff we had to make for all of these new features was that we had to revert back to 3D printed plates, because of the verticality of the new plate being difficult to laser cut. See the final CAD of our top plate.

After a bit of revising our first draft bot design was printed on a Lulz bot 3D printer. We utilized a sturdy plastic to ensure that physical contact with other robots will not disrupt our motors and sensors from operating.

Due to the COVID-19 pandemic many parts took a long time to ship, so as the parts arrived we began assembling the pieces and attaching the parts to the bot, with all parts arriving by mid April. Starting with the light sensor, to prevent any shortage and loose connections we soldered each wire to a JST-PH 2.0 Male and

Female Connector Cable which allowed us to organize the wires. After wiring we placed heat shrink at the ends of the wires to further protect the wires from shorting. The motors we decided to use were 63:1 Gearmotors x 8 with a D shaft, which went along with the metal GTF Robots wheels. The wheels are omni wheels which allow our robot to travel in different directions fluidly.

For the kicker each of our robots have, we used a standard large 12v solenoid motor from Adafruit. To power the solenoid effectively, we used a TIP120 power transistor and the 1N4004 diode for its ability to handle flyback (i.e. reverse voltage) from the solenoid. We also used a pulldown resistor on the gate to avoid false triggering on a floating voltage driven input. Our kicker sits at the center of our modular design, in between the four surrounding plates, and in order to close the distance between the solenoid and the ball, we used material from the old cuts of our board to make attachments to the kickers. This extended the range of our kicker and allowed us to reach the ball effectively when launching. Kicker with circuit attached, with range extender

After the national competition, we continued to iterate our kicker and gave the extending piece a much cleaner finish, 3D printing the piece as well as increasing the area of the surface that connects with the ball. This allowed for a much more consistent and powerful kick.

New Kicker with range attachment

Both robots also have a dribbler. Last year our dribbler was unfinished and flawed. We used two thin lego wheels with the corresponding tires, a few lego technic gears and axles, and a weak 3D printed mount. This year we knew we needed to change the design. We decided to use a cylinder instead of the two wheels since the dribbler would now be able to get the ball spinning as soon as it comes in contact with it thanks to the far greaters surface area. The cylinder is made up of a 3D printed d-shaft attachment and a glue stick cut in half, crazy glued together and wrapped in tape for extra support and friction with the ball. The cylinder is held within a 3D printed mount screwed to the top plate and the motor, a micro gearmotor with a 1:10 gear ratio, is held within a 3D printed sleeve on the right side of the cylinder when the robot is facing forwards. This dribbler is made almost completely from scratch aside from the motor since we designed and printed the sleeve, mount, and d-shaft attachment ourselves.

The robot was assembled using different standoffs to hold up the different modules and top plate. Using short standoffs connected to one another we made a handle capable of supporting the whole robot. To prevent too much stress on the top plate we used large washers to distribute the force applied from the handle along a larger surface area. Additionally, the same washers were used to prevent the handle bar (made out of rubber) from ripping through the screw. Here are the washers we used and the washers on the robot

Our initial logic pattern for the robot was to first locate the ball, gain possession of it, find the goal, and then shoot it. This meant we had to utilize a camera, multiple motors to move around, along with some line sensors and an IMU for navigating the field.

We used an OpenMV H7 camera to search for the ball. An immediate issue was communicating between the Camera and Arduino. We settled upon using Serial to talk between the 2 devices. In order to test this program, we used the website TinkerCAD, as we did not have a convenient way to view multiple Serial monitors. TinkerCAD's circuit tool allowed us to simulate sending messages between 2 devices.

Although we had finished making the communications between the Camera and the Arduino, the actual method for detecting the ball and goal was still in the works. We were used to using OpenCV, but our experience had some issues. The range and contour detection we were used to using did not exist in OpenMV, so we had to resort to using the find_blob() function. This took in several thresholds in LAB colorspace, along with several parameters to limit the shapes it would return.

An issue we faced while finding the thresholds for the camera was the tool our IDE provided. The OpenMV IDE's threshold editor looks like this.

It has several shortcomings in how it is only able to test thresholds on one image at a time, while also only being able to use 2 color spaces (LAB and Grayscale). In order to resolve this issue, we designed our own color slider tool with additional features:

See our new color slider tool.

This program is essentially identical to the OpenMV IDE's threshold editor. The only difference is there are 2 combo boxes to select which image to view, and which colorspace to use. In the end, this program was not used, as calibration using OpenMV's live camera feed and histogram was much more effective.

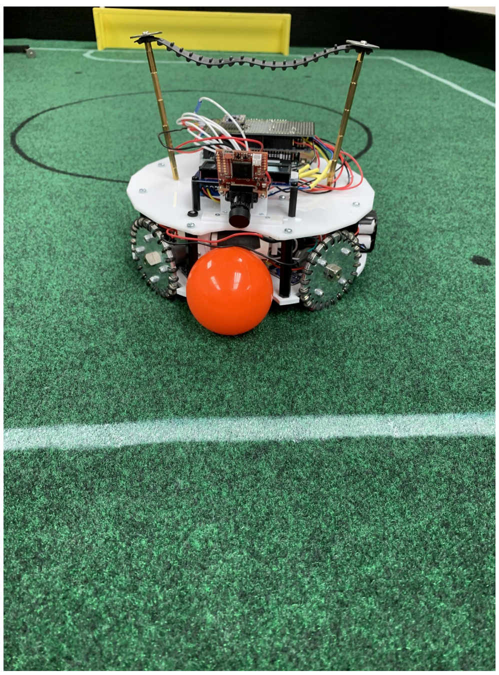
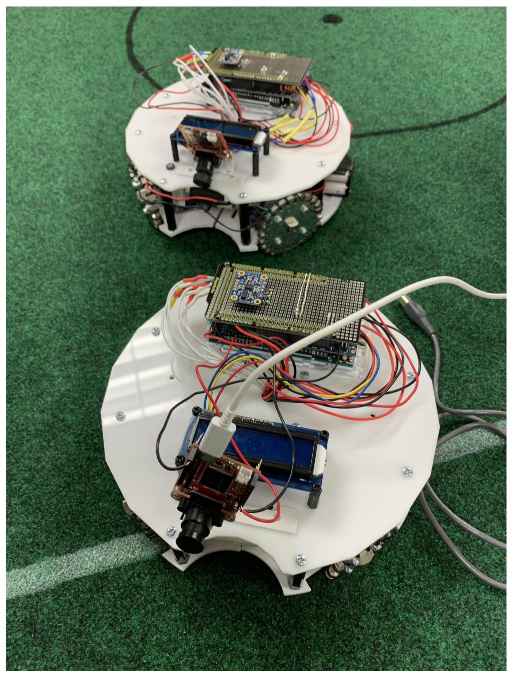
This tool showed the range of colors that existed in an area selected on the live camera feed. Not only did this tool immediately give us values we could use for the threshold, it also allowed for easier testing for different objects. Our original tool was only able to take in picture files, and could not utilize the camera during testing.

Data / Results / Analysis:

Our final product/robot consists of 5 different custom 3D printed modules as the bottom plate which are each made out of plastic with holes designated for a motor mount, standoffs, and two light sensors. Two additional rectangular holes were added to help the modules hold on to each other using a velcro strap (if needed). Our center piece on the bottom plate is a circular piece that contains a divot for a solenoid/kicker, 4 holes for standoffs and 4 rectangular holes to hold onto side modules for extra stability. Some examples of our modules.

As mentioned previously, the top plate ended up being 3D printed despite our former iterations being made of white acrylic. The design consists of holes for standoffs to connect to the bottom plate, holes to attach a metal handle, a place to connect a motor on the bottom to serve as a dribbler, and standoff holes to attach a camera, LED display, Xbee, Adruino Mega, an IMU sensor, as well as our new addition of a dribbler. Again, see the final CAD of our top plate.

After an extensive and difficult journey working on the dribbler, Storming FC found out that the dribbler would work if only the motor we bought provided enough torque. We replaced the dribbler motor in the new design with the new top plate, utilizing a 63:1 12V DC motor from adafruit. We also adjusted the angle of the dribbler to get a better angle on the ball, which both provided results and made the dribbler much better and more consistent.

Storming FC's robot is capable of efficiently navigating the field within the white boundaries while tracking the orange ball. As it tracks the ball using the OpenMV camera, the robot will look for the opposing goal and shoot using the solenoid or "kicker" as it approaches the goal. The robot can also defend the goal within the goal lines and go for the ball when it reaches within a certain distance.

Conclusions and Future Work

In summary our project has once again given us valuable experience in electronics, design, planning, management, coding, and much more. We hope to bring these experiences for our future to learn more about robotics and participate in the soccer competition in future years.

4. Miscellaneous Images / Diagrams:

- The cylinder for our dribbler motor.
- The final top plate.
- The Camera Mount.
- Each of our modules with motors and standoffs.
- Each of the modules for our robot.
- Male JST headers soldered to our motors.
- Completed motors with headers.
- One of our modules while attached to our plate.
- The CAD for the center modules.
- The CAD for the front modules