KURIOSITY ROBOTICS

Preface

My proudest achievement is the nonprofit I founded and grew from a weekend LEGO robot-building pastime with friends into a successful **company**. We designed robots for the FIRST FTC Competition and made significant global and local contributions.

Before delving into the technical details, I want to acknowledge the vital role played by my team and none of this would have been possible without them.

I take particular pride in four robots that were entirely **custom-built** in-house, all developed in my last three years with the team. These custom creations allowed us the creative freedom to design and code without being limited to off-the-shelf solutions. However, since our team was entirely student-run, we lacked mentors to teach us these skills. This meant I had to self-learn CAD, CNC routing, 3D printing, Java/Android programming, soldering/electronics, and then pass on this knowledge to the team

As the team captain, I was deeply involved in every aspect of the team however I'd like to highlight some specific **technical** contributions.

The program we participated in (FIRST FTC) presented us with unique challenges each year and the goal was to build a **robot to solve those challenges.**

***Note**: click the context/challenges link to see a video of each years challenge*

Robot 1: Skystone Year

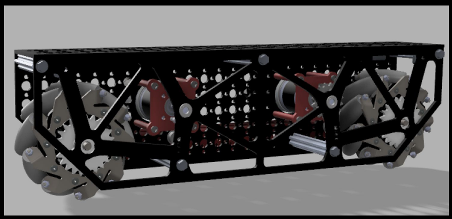
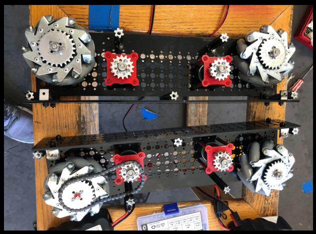
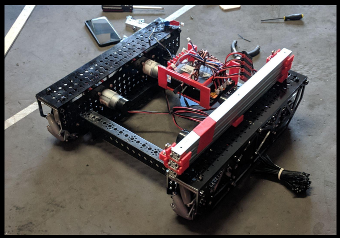
Context/Challenge: This year involved stacking rectangular prism-shaped blocks as high as possible without the blocks falling over

Robot Video

Drivetrain - Foundation of the robot

- Mecanum wheels (special omni directional wheel with rollers placed at 45 degrees) that allow the robot to move in any direction
- 4 19.2 : 1 DC motors
- Chassis made of in house CNC ⅛" thick 6061 aluminum sheets

Photos

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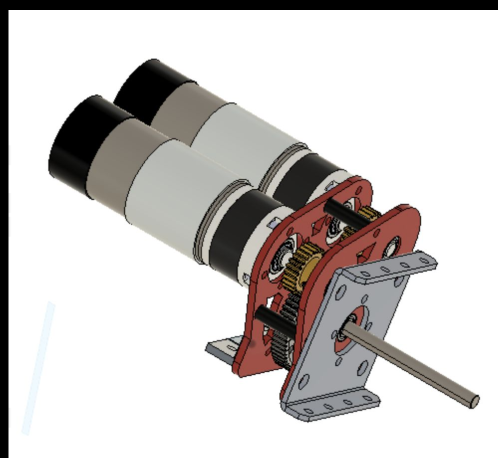
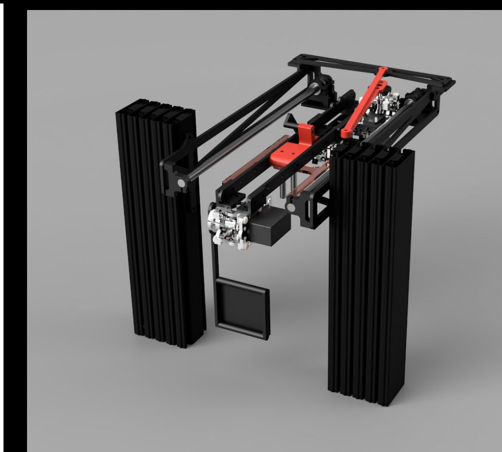
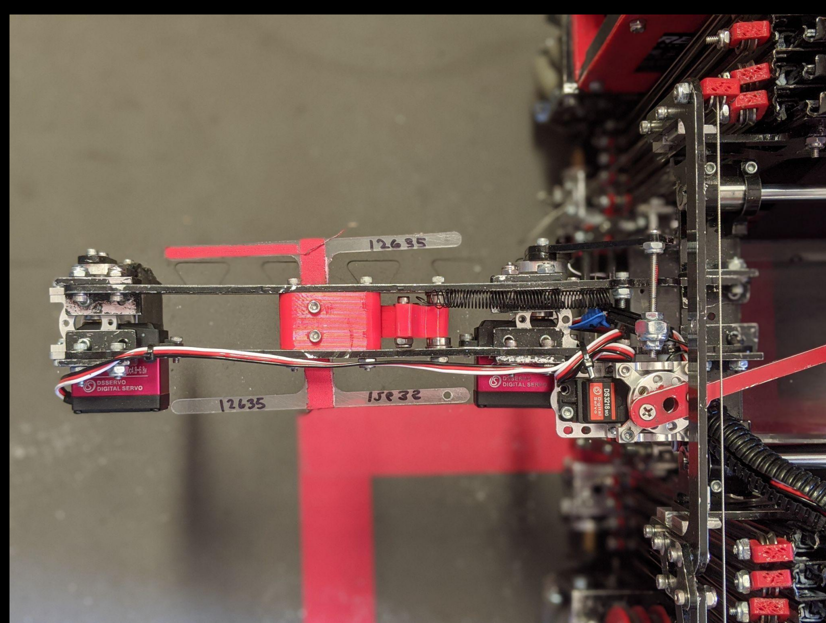
Outtake - Stacking blocks 5 feet off the ground

- Compact 18 in retraction to **5 feet extension** using linear slides (drawer slides commonly found in kitchens)
- Innovative **dual stringing** evenly distributes load when extending linear slides
- Dual motor spool gearbox (I calculated ratios by maximizing for acceleration given motor stall torque and weight constraints)
- **Linkage** and linear rod horizontal extension
- Dual servo claw block grabber

Photos



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Software - Catmull Rom Spline Path Generation, Pure Pursuit Path Following, and Computer Vision

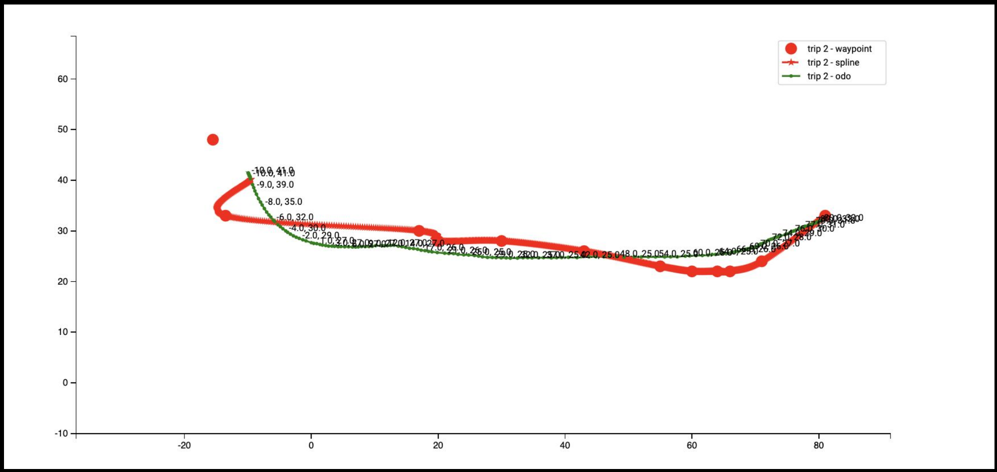
Context: In every challenge, the robot has to do a certain set of tasks autonomously for the first 30 seconds of the match. This means the robot needs to navigate the field in an efficient manner. To do this there are 2 problems to solve, knowing **where you are** (localization via odometry) and following a **generated path**.

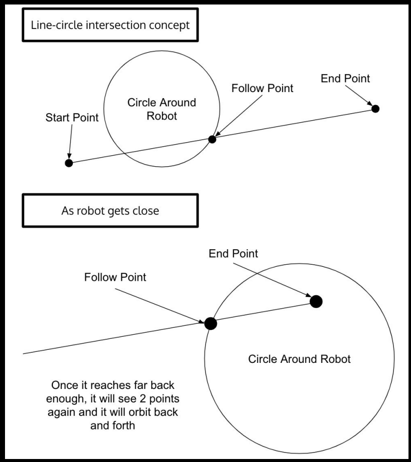
I was involved in the latter, creating an algorithm to generate a **catmull rom spline** between a set of waypoints (maximized acceleration) and a **pure pursuit** algorithm that followed a look ahead point to stay on the path using a line circle intersection.

I also wrote code that used **tensorflow** to detect which randomized block would have a vision target on it to determined what path the robot would take.

The code can be found **here** and a link to a video of the robot running autonomously **here**.

Photos





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Robot 2: Ultimate Goal

Context/Challenge: This year picking up rings and shooting them into a tower (goal)

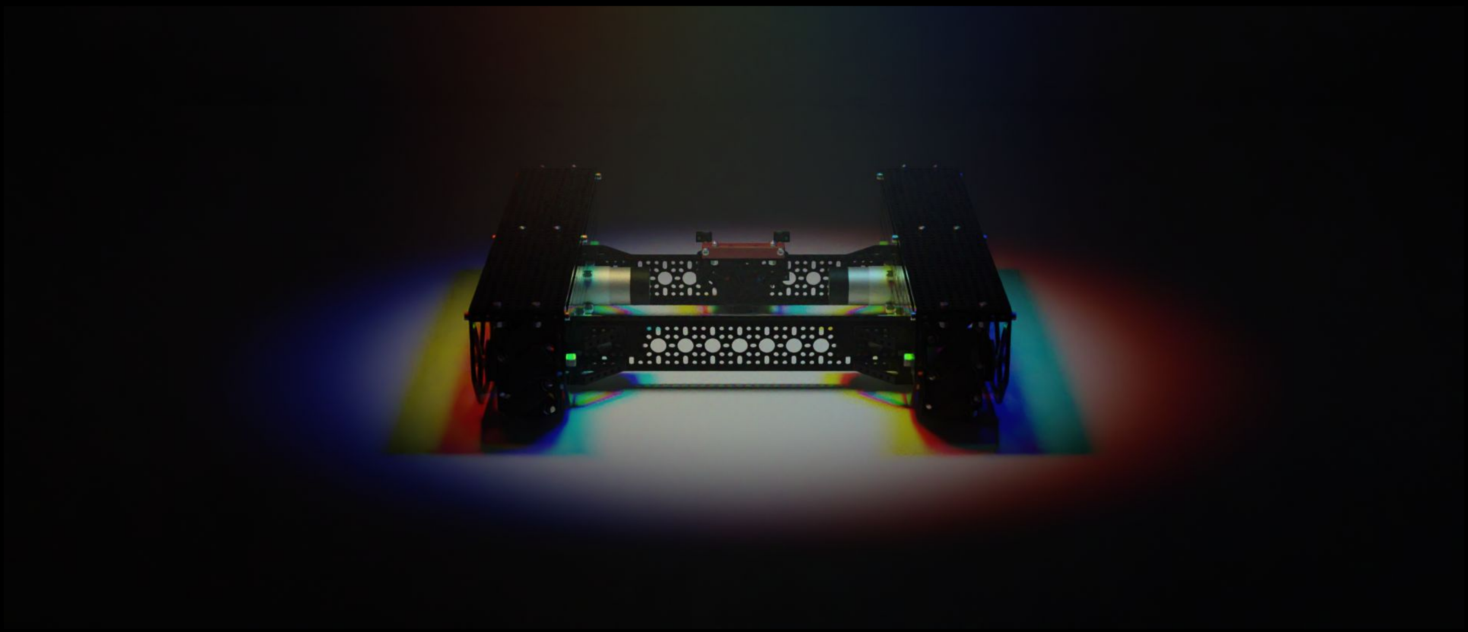
Robot Video

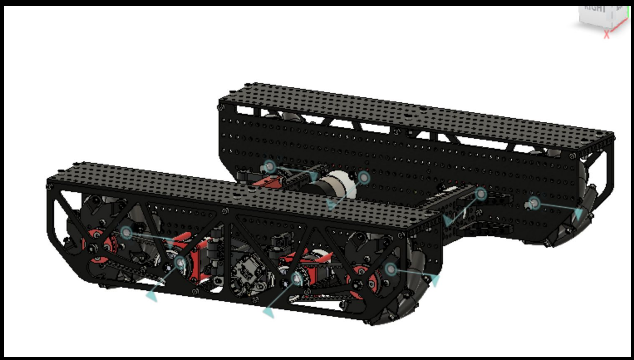
Drivetrain - Foundation of the robot

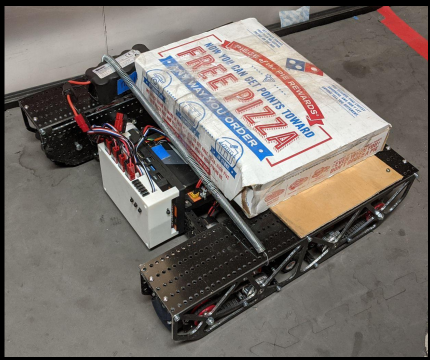
To improve on the drivetrain in the previous year, I designed the wheel module to use a **dead axle system** which increased rigidity as well as a timing belt drive for increased accuracy.

I also designed a more rigid odometry module that used **linear rods** instead of a pivot system. The drivetrain is so reliable that the team still uses it to this day.

Photos







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Shooter and Hopper - Firing rings over 16 feet

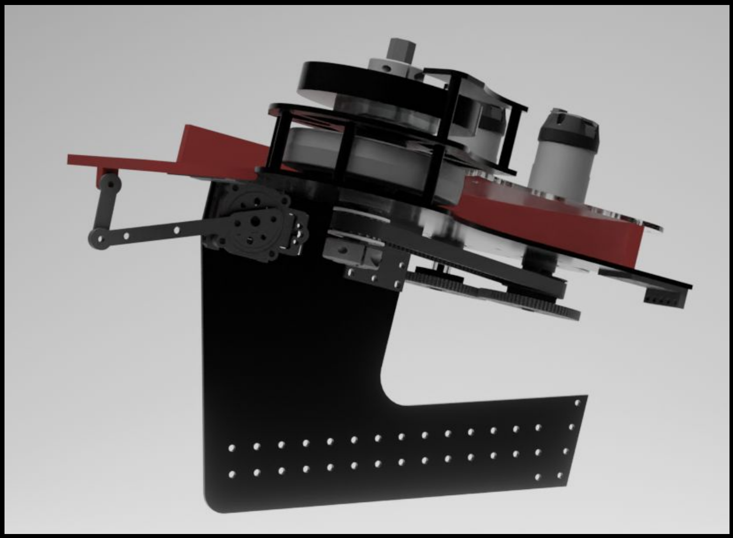
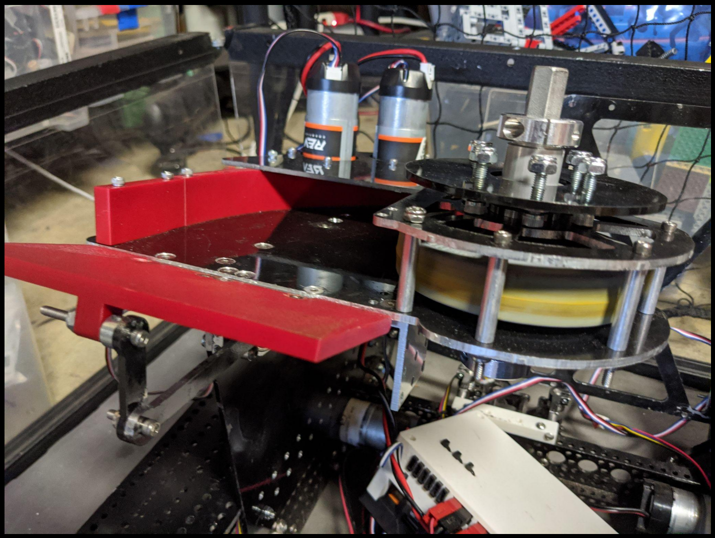
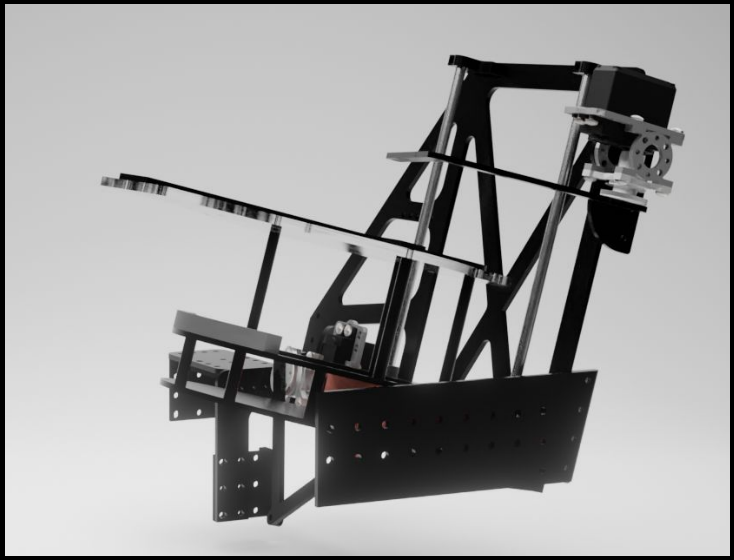
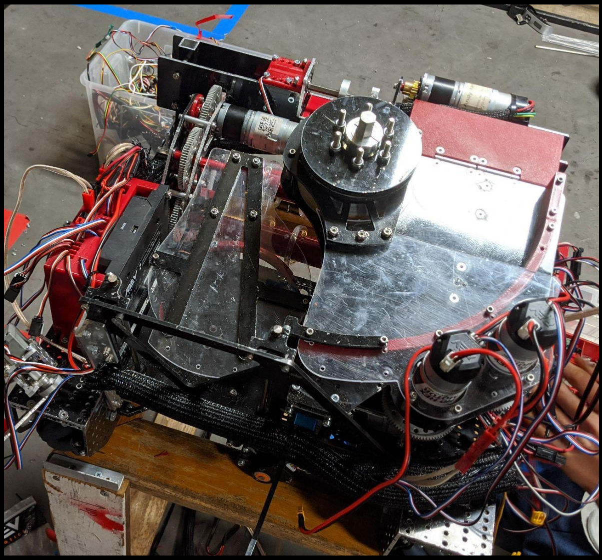
Shooter

- 8,000 rpm dual motor **flywheel** shooter on a quarter circle track to accelerate the ring
- Weighted disk **increases** inertia to allow for faster shooting
- Flap adjustment to control **exit elevation angle**

Hopper

- Linear rod and **linkage system** allows for quick transfer of 3 rings from the intake to the outtake
- **Servo indexer** allows for rapid firing of rings

Photos

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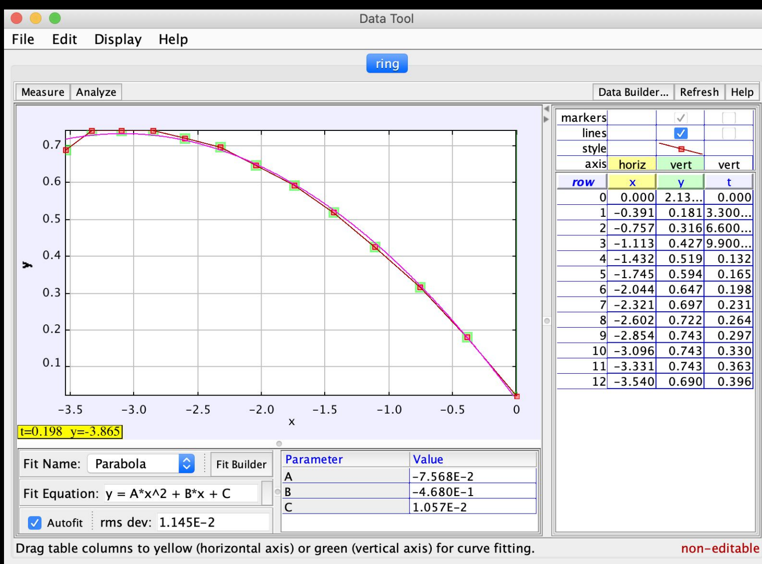
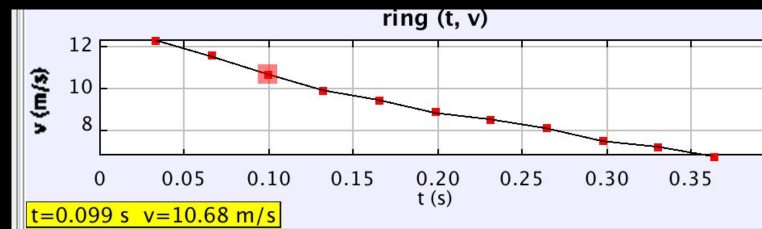
Software - Computer Vision, Shooter Interpolation, PIDF

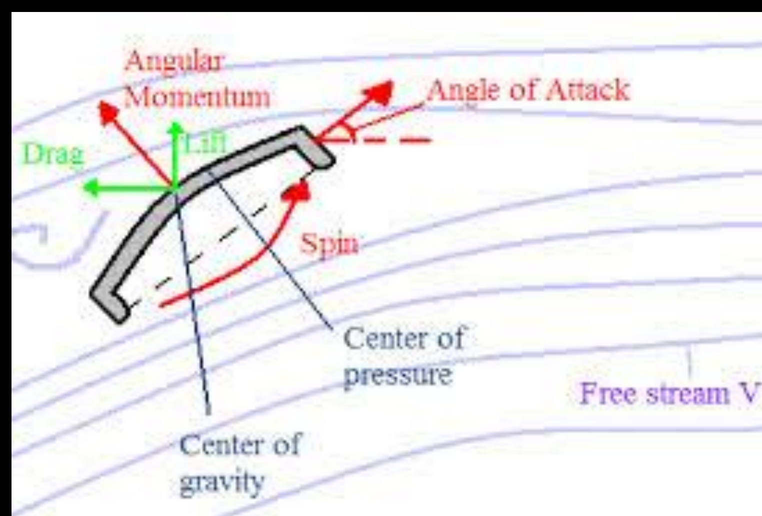
- Wrote vision code using **Android Camera API** to detect the height of the ring stack
- Wrote algorithm to **interpolate** flap angle and flywheel speed to automatically shoot from anywhere on the field
- Created **PIDF controller** to maintain velocity of the flywheel

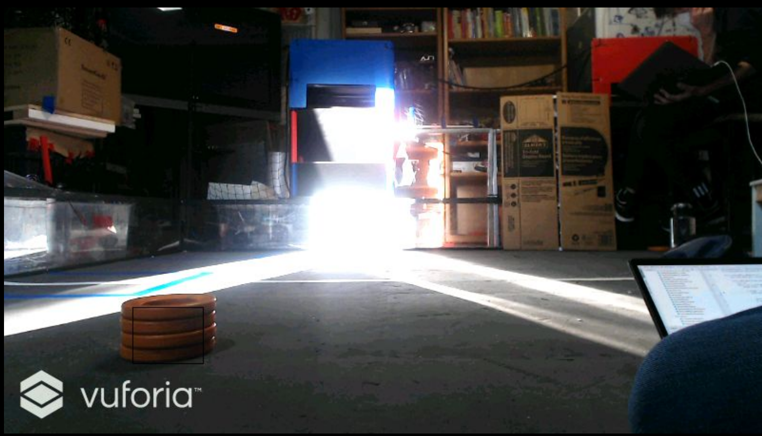
Code be found **here** and autonomous can be seen in the first 30 seconds of the robot video on page 4

Photos









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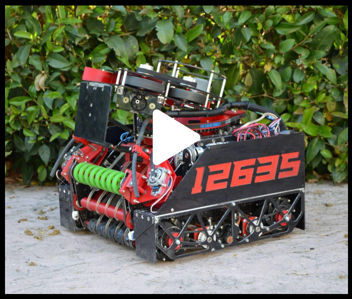
Robot 3: Ultimate Goal

Context/Challenge: This robot was built within the same year except it was a completely new robot that went about the challenge in a new way.

Robot Video



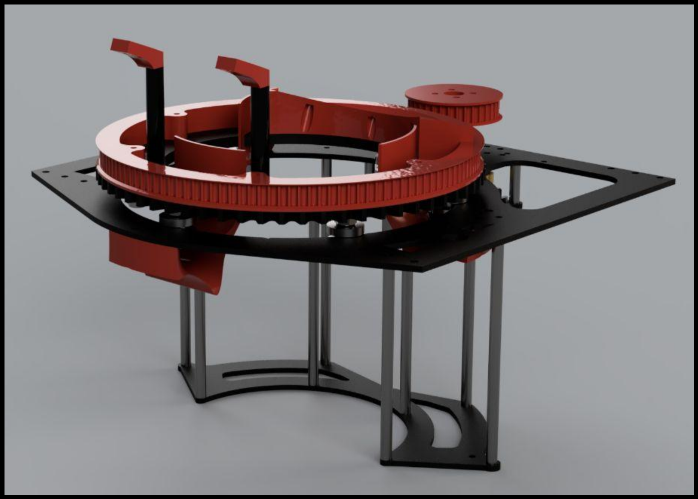
Turret - Semi continuous transfer of rings

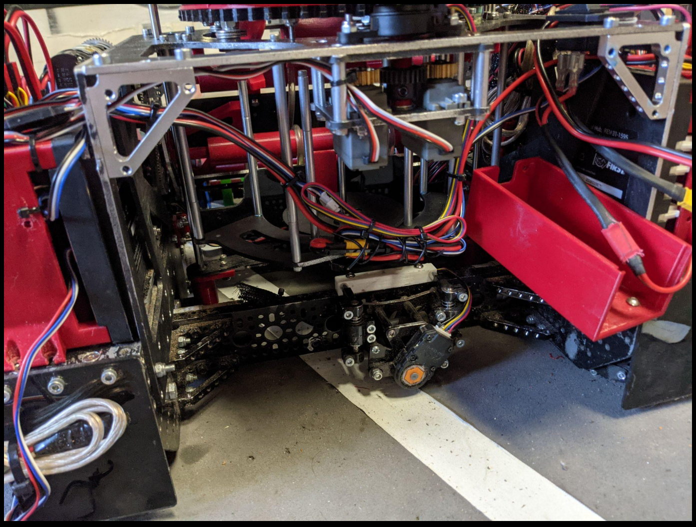
These next 2 mechanisms were probably the most complicated mechanisms I've ever designed and the ones I am most proud of at that.

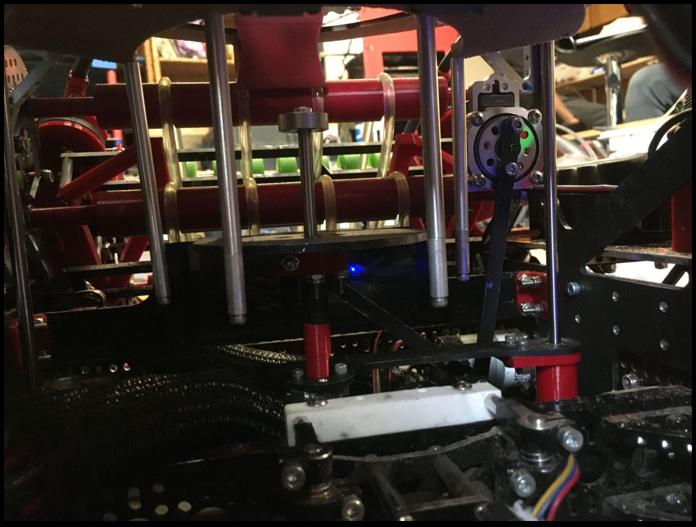
We wanted to be able to shoot rings without having to turn the robot so we decided to put the **shooter on the turret.** The turret was complicated because we need a **semi continuous** way to feed rings up through the turret into the shooter.

To achieve this I used a plate riding on linear rods powered by a **linkage** that would push the rings up.

Photos







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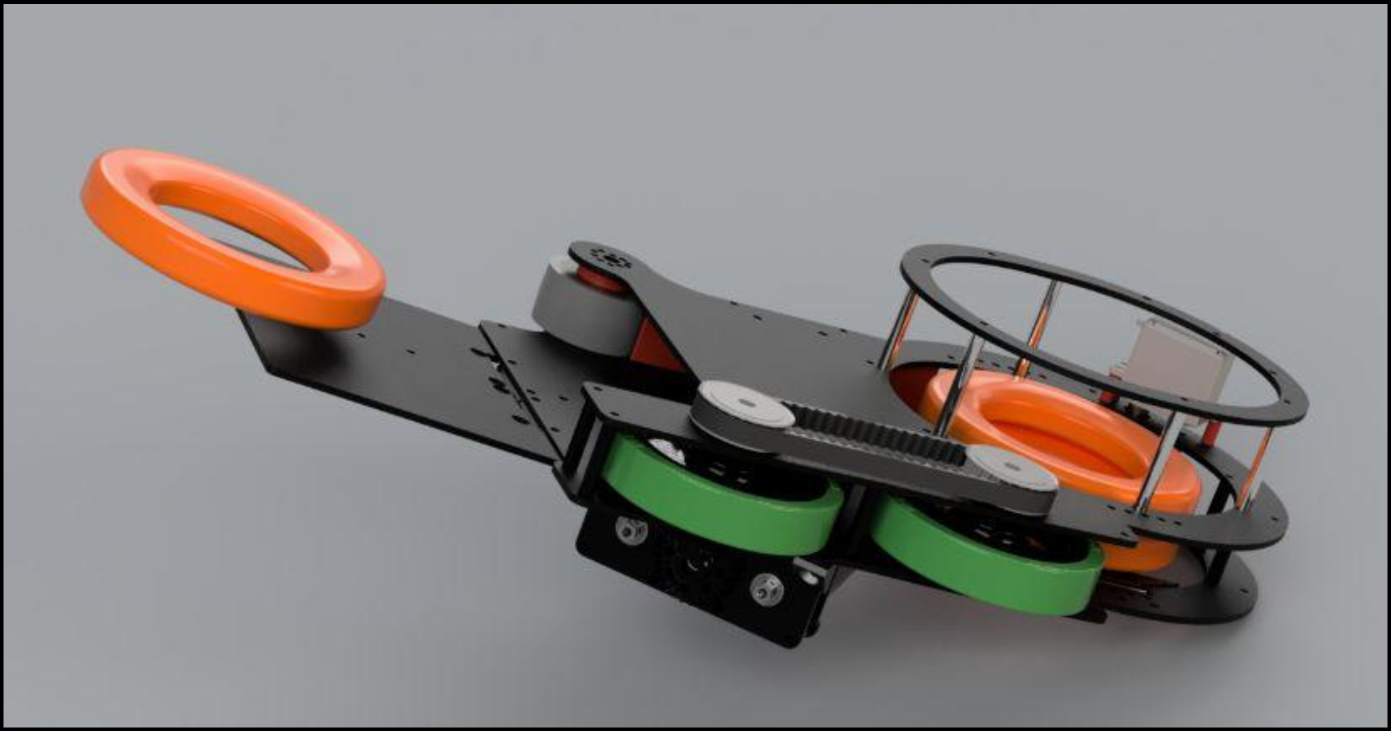
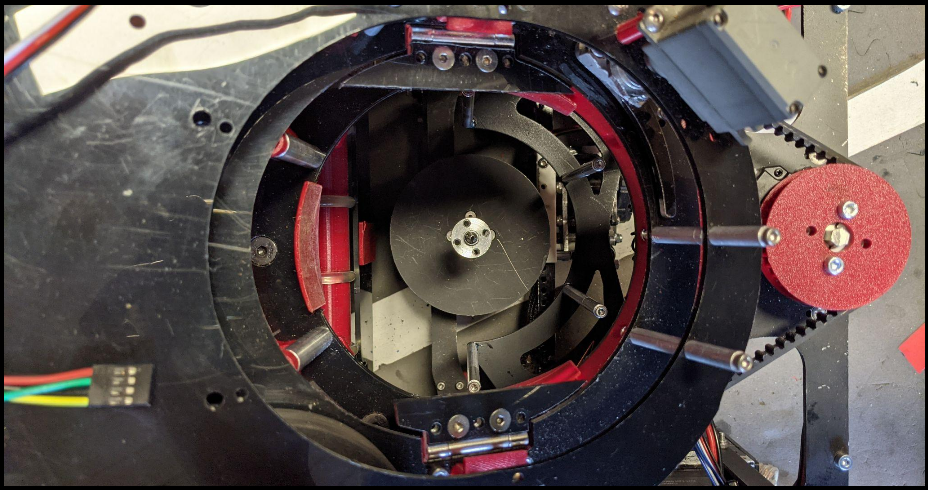
Shooter - Linear dual flywheel shooter

- 8,000 rpm dual motor **dual flywheel linear shooter**
- One day door locking system for semi continuous firing

This shooter was **innovative** because it allowed for rings to be fired **semi-continuously** using a set of **one way doors** right above the turret. This way when the rings would get pushed up, regardless if there was a ring there already, the ring would get pushed into the shooter.

Photos





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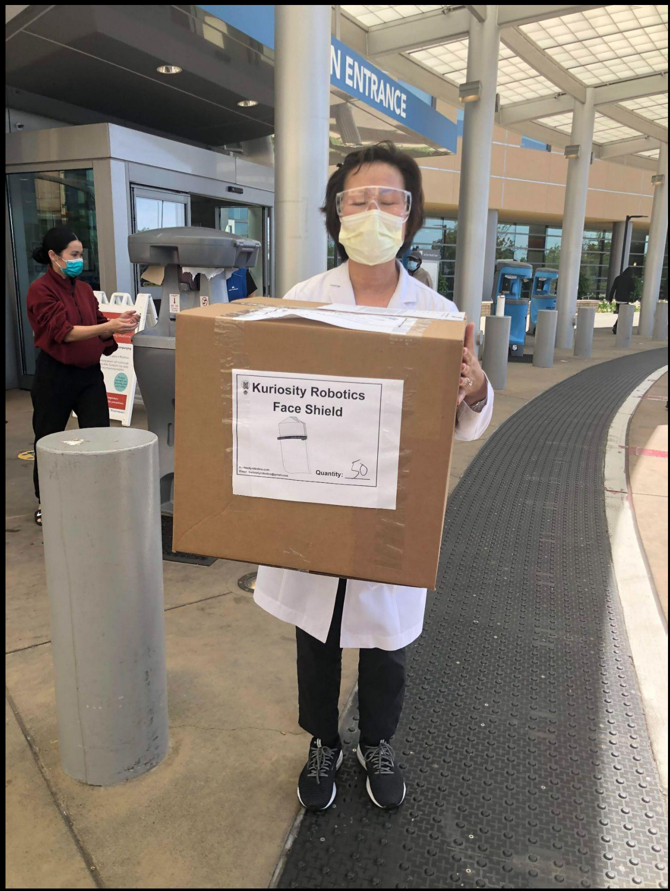
Face Shield Initiative - Saving lives using robotics

While I love building robots, I realized I found the most fulfillment in applying my skills to **solve real world problems.** During the COVID-19 pandemic, I co-lead with 2 other teammates to design, manufacture, and donate over **7,000 face shields** to front line workers in need of face shields.

The full story can be read **here.**

Photos



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Robot 4: Freight Frenzy

Context/Challenge: This challenge involved moving "freight" which were cubes and spheres into a wobbling tower

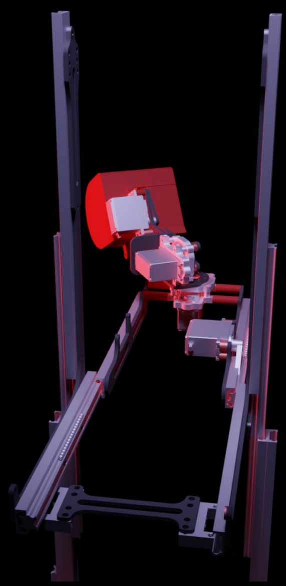
Robot Video

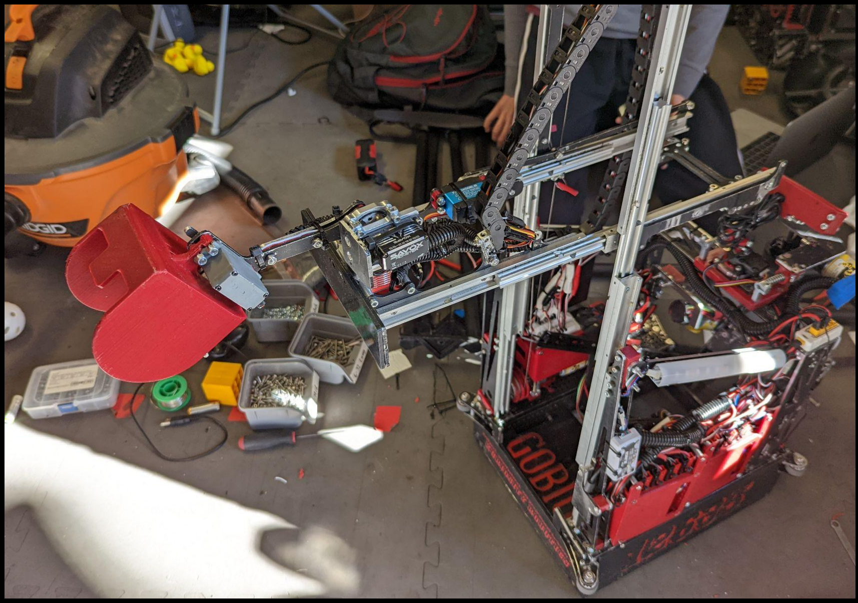
Outtake - Fast controlled deposit anywhere

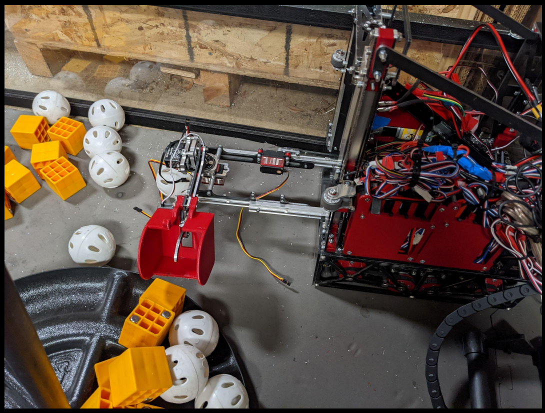
This was my last year and in a way this mechanism was very fitting as it incorporated many concepts from all the mechanisms I designed in previous years

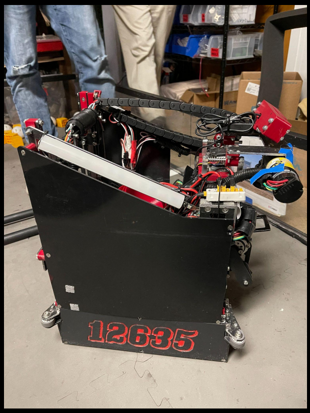
- Vertical linear slides allow depositing at **variable heights**
- Horizontal slide powered by a **linkage**
- **Turret arm** to deposit at any angle
- Claw to grip both types of freight elements

Photos









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Software - Autonomous Path Tuning & Teleop Enhancements

For software, since some much of the infrastructure had been built up over the years, I focused on tuning autonomous paths to optimize them to be as fast as possible.

I also integrated driver controlled macros to **automate tasks** as well as state designations using LEDs on the robot.

The code can be found **here** and a video of the autonomous can be found **here**.

Photos