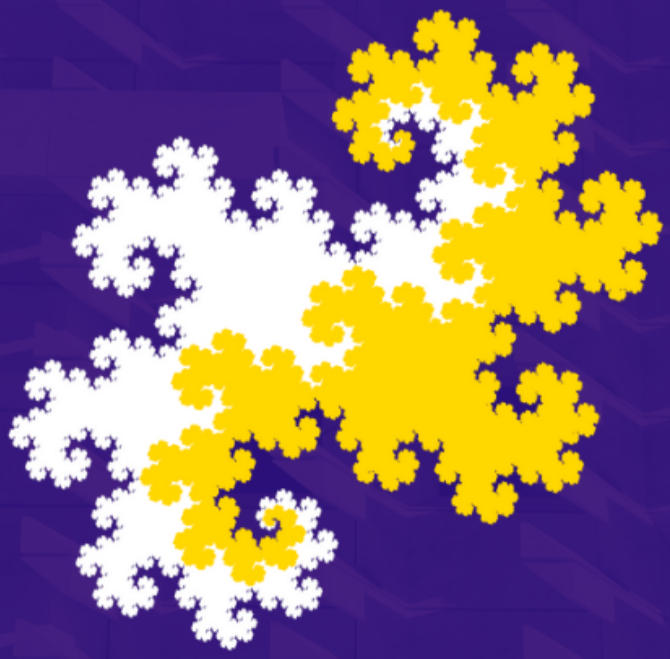


A Byte Irrational

FTC Team 15065

Engineering Portfolio 22-23

0x3AD9

POWER PLAY

PRESENTED BY Raytheon Technologies

ORLANDO SCIENCE SCHOOLS

OSS

022

STEM Charter School

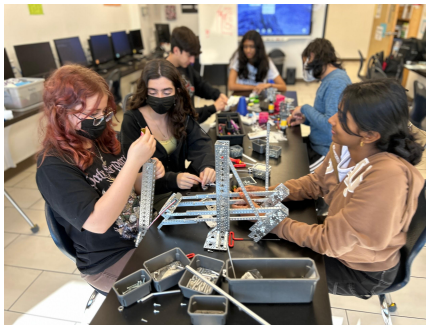
FIRST

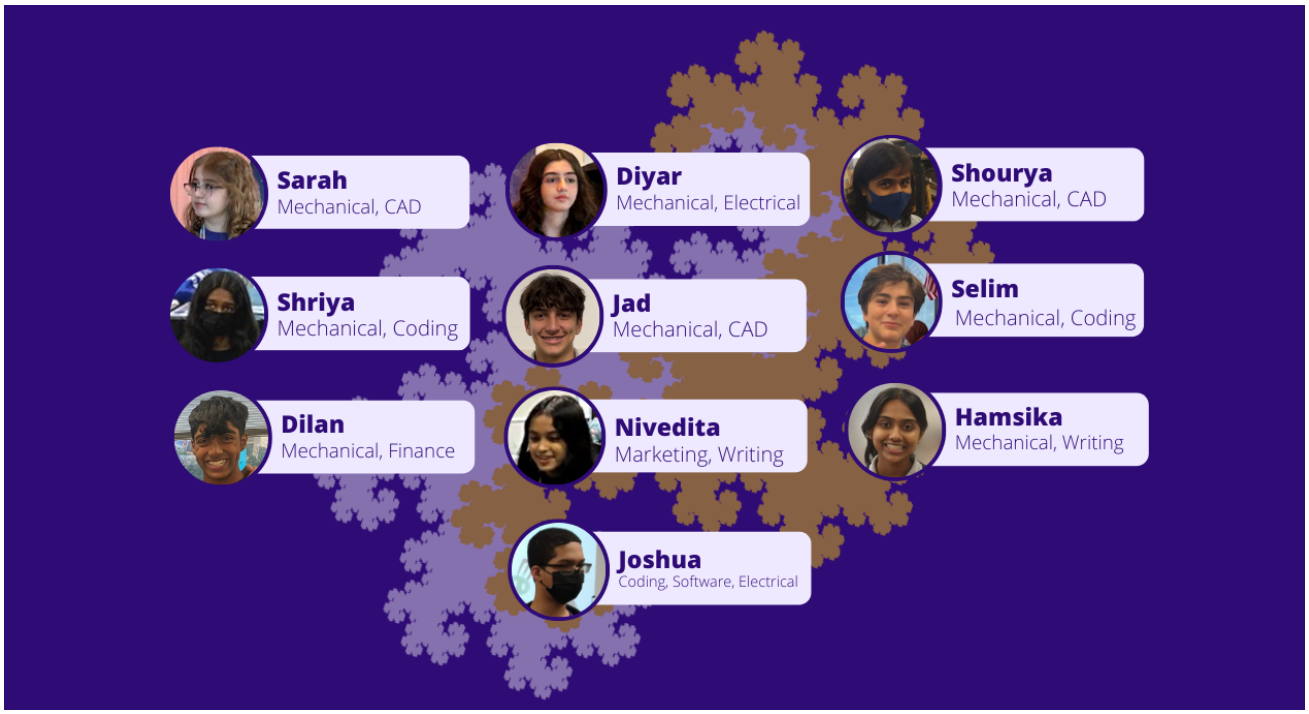
Team Information

Who We Are

We, A Byte Irrational, are a high school FTC team from Orlando Science Schools. We have proudly been Team 15065 since 2019, making it our **fourth season** competing in FTC. We started off with 5 members who were new to FTC and have since doubled our numbers. This season we welcomed three new members and have diversified our skills greatly as a team. We introduced a dedicated marketing team to help coordinate outreach events and create marketing collateral. We also have expanded our programming team to include two new members with coding experience. We have two experienced engineering mentors to guide us on our design journey, Mr. Don Boughton and Ms. Karen Oliver, as well as highly supportive parents.

Like our signature twindragon, we aspire to innovate and create new from old when it comes to design. This season, we took on many challenges proposed by the new game field and created an original design suited for effortless maneuvering and swift movement.





Outreach Projects & Partnerships

Northlake Park Community School

Our team presented our robot from the previous season to younger kids at Northlake Park Elementary School's STEM night. We let the kids drive our robot around in the setup after explaining the buttons, controls, and the proper rules while controlling the robot. Overall, STEM night was successful and our team was able **to reach both parents and students in the FIRST program and introduce them to opportunities in FLL and FTC**. The school was very receptive to the idea of starting a FIRST team at the school and had reached out to us with information and inquiries on how to begin a junior team. We remain in contact with the school and hope to start an FLL team in the near future with them.

Schoolwide Open House Demo

As a school-based and student-led robotics team, we make it a priority to spread the FIRST spirit at school. We encourage new members to join and promote interest in our engineering program. On Dec. 13, 2022, **we presented our robot during Open House**, an event which introduces new students to the clubs our school has to offer. We had a team booth where we demonstrated our robot from the previous year and explained what FIRST is and how our team operates. We met and spoke with many eager families and students, many of whom showed interest in starting their own team or joining an existing one at our school. We were happy to give them details on how to join and look forward to working with them in the future!

Synapse Conference

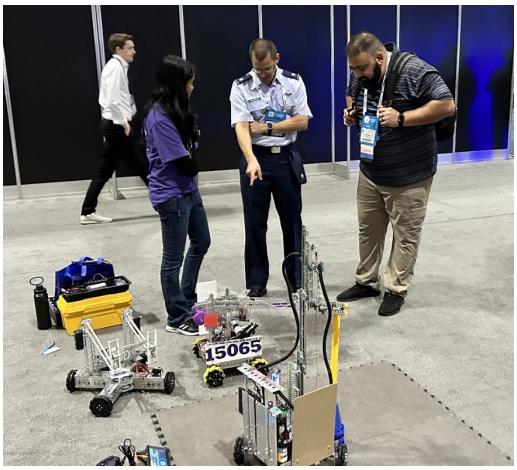
Our team demonstrated our last season's robot at the Synapse Conference on October 21st, 2022 at the Dr. Phillips Center. **The conference hosted 2000+ engineering and entrepreneurial professionals**, many of whom we reached at our booth where we demonstrated our robot's mechanisms and our design process, as well as how we are involved with FIRST and what the program is all about. We were able to meet many leaders in the STEM industry who were eager to provide real-world advice and applications for our team. The event was a great start to this season and gave us the experience we need to coordinate similar events in the future.

FIRST Like a Girl Ambassadorship

The U.S. Department of State's International Visitor Leadership Program hosted a tour titled *Hidden No More: Empowering Women Leaders in STEM* which we participated in on November 1st, 2022. The purpose of the tour was to introduce various national STEM programs to **7 female entrepreneurial representatives from seven developing countries** in order to see examples of how they can introduce STEM to women in their respective nations. **As a 50% female robotics team**, we were invited by FRC Team 1902's program FIRST Like a Girl to present on behalf of the FTC league at the Orlando Science Center. We met with brilliant STEM professionals from **India, Nepal, Indonesia, Maldives, Slovakia, Senegal, and the Palestinian Territories.** Our team members, Sarah, Diyar, Shriya, and Nivedita, each presented their individual experiences as women in FIRST, detailing their introduction to the program as well as FIRST's impact on their confidence, abilities, and future career plans. They gave a live robot demonstration and answered questions one-on-one with each representative regarding the robot, advice for women in STEM, and our team's potential mentorship of students of the representatives. We are very grateful to have met these seven delegates and find their work both inspiring and encouraging. We enjoyed representing FIRST and helping them spread the spirit of FIRST and STEM to their students abroad.

I/ITSEC Exhibition

The Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) is the **world's largest modeling, simulation and training event** and it takes place annually here in Orlando. Our team was able to present at the FIRST exhibition on December 1st, 2022 as the sole FTC league representative. At I/ITSEC we presented our robot alongside innovators from Boeing, Lockheed Martin, Collins Aerospace, Booz Allen Hamilton, and more. **We met with many out of the 17,500+ attendees of the event**, and were able to speak with soldiers, engineers, educators, and even international visitors from the Netherlands.



Maker Faire

The Maker Effect Foundation, a fiscal sponsor of FIRST, holds an event called Maker Faire annually at the Central Florida Fairgrounds to bring together artists and innovators from all across Orlando. **At Maker Faire, we presented our robot alongside other exhibits in the STEM field.** We had team members focus on different tasks such as building/fixing the robot, going out and talking to families about FIRST, and engaging kids in how to operate the robot through a simulated track. The event was a huge success and we **reached around 500 excited children, parents, and even fellow exhibitors** from the engineering community!

Florida Automated Vehicles Summit

The Florida Automated Vehicles (FAV) Summit assembles industry leaders from around the world to address technologies, operations, and policy issues. We worked with an event manager for the conference to coordinate a FIRST exhibit in the event lot on December 15th, 2022. We were able to set up a FIRST booth run by Sarah and Diyar who traveled all the way to Jacksonville for the event. **We reached an estimated 50 people of around 250+ attendees.** The Summit was highly supportive of our participation and invited us back to present next year as well. We plan to invite more teams to participate in the future, after seeing the positive reception. We have reached out to teams in the Jacksonville area as well as local FTC and FRC teams in aims to increase involvement.

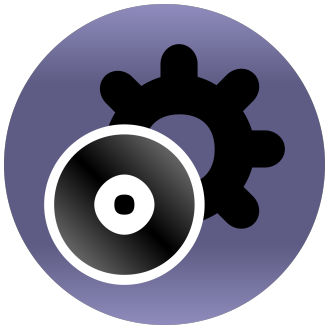
Orlando Science School Robotics Summer Camp

Over the summer, our team helped middle school students design and build robots at the summer camp program organized by Orlando Science High School. Our team members **assisted around 80 students over a period of 6 weeks** by providing interactive feedback and support guiding students through the entire process of building a working robot. Coding and mechanical fundamentals were taught to the students, and at the end of the camp the students participated in mock FTC competitions using the robots they designed. Information on how to start or join an FTC team was distributed to many eager students looking for further involvement in FIRST robotics.

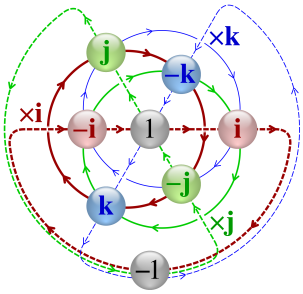
Connections

Mentored by Dr. Hasan Yasar

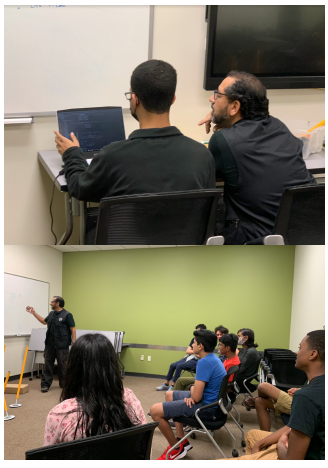
This summer, our team member Sarah had the opportunity to meet Dr. Hasan Yasar who is a **graduate professor at Carnegie Mellon University's Institute of Software Research**. Following Meet Two, Sarah reached out to Dr. Yasar regarding a programming mentorship to improve our autonomous code. Dr. Yasar accepted the request and was happy to connect with us. The meetings were arranged virtually with our mechanical lead, Sarah, our programming lead, Joshua, our electrical lead, Diyar, and our engineering mentors, Mr. Boughton and Ms. Oliver, in attendance. The meetings were held on a weekly basis starting January 13th until the League Championship Tournament. The objective of each meeting was to progress and finalize our autonomous code in time for the tournament, since we finished the mechanical aspect of the robot and shifted our focus to fine tuning its movements. The meetings have been very beneficial so far and our code has developed efficiently through Dr. Yasar's guidance.



Assisted by Mr. Joe Giuffrida



On October 15th, our head programmer, Joshua, reached out to a **GNC Senior Engineer at Lockheed Martin** through one of our mentors, Ms. Oliver, to learn about the uses and benefits of quaternion representations of angles. A quaternion is a combination of a scalar and a 3-dimensional vector. It can alternately be viewed as a set of 4 values whose squares must add to 1. Joshua learned the formulas to convert quaternions to Euler angles and vice versa, along with the reasoning behind them. The use of quaternions removes some of the issues with Euler angles, such as the phenomenon of gimbal lock, which removes a degree of freedom in some situations, lowering the efficiency of certain systems. Quaternions bypass this, but are not necessary for a robot moving on the 2-dimensional plane. The mentorship was a great opportunity for Joshua to ask questions concerning the robot's movement and strengthen his programming abilities.



Partnering with Robo-Knights

During our first meet of the season, we were fortunate to meet a fellow FTC team, Robo-Knights 9330. We were invited to one of their meetings as a way to share advice with each other for mutual benefit. Mr. Abdul Siddiqui, Engineering Mentor for Robo-Knights, to develop autonomous code and run trials to solve issues with overshooting movement. We were able to share our ideas with Team 9330, received feedback, and vice versa. The experience was highly educational and we look forward to working with them again in the future.

Business and Sustainability Plan

Team Funding

To align with FIRST's mission to be fully inclusive, we made a significant change in our source of income. In previous years, we had required an entry fee of $200 per member which went into buying supplies and resources for the team. **We elected to abolish that fee in exchange for a more sustainable and welcoming alternative.** We decided to focus more of our efforts on maintaining long-term sponsorships while reaching out to new ones. We are appreciative of Collins Aerospace and Lockheed Martin for continuing to support our team and of our new sponsors, Publix and 3M Corporation. This season we are sponsored by **Collins Aerospace, Publix, NASA Exploration Ground Systems, Lockheed Martin, 3M Corporation, Raytheon Technologies & Orlando Science Middle & High School.**

Goals for this Season

Expand FIRST in Central Florida

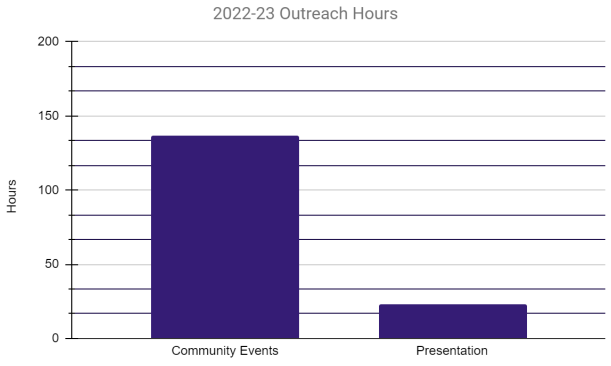
As seasonal demonstrators at Northlake Park Community School's STEM Night, the school had reached out to us in regards to starting an FLL team at the school. This season, we have plans to follow through and **coach a Lego League team** for all interested students. We have been working out the details and hope to finalize the project in the summer.

Coordinate and Exhibit at APEC23

Our outreach coordinator, Nivedita, has been in contact with an event manager for **The Applied Power Electronics Conference (APEC)** which takes place on March 20th, 2023 here in Orlando. Parallel to the FAV Summit, **we plan on coordinating a FIRST exhibit at the conference**. This time, we have reached out to multiple FTC and FRC to host a larger demonstration involving multiple FIRST leagues. Our attendance has been confirmed as well as a few FRC teams we have reached out to. We are looking forward to the presentation.

Reach 150 Hours of Outreach

At a total of 160 hours, our team **exceeded** our original goal of 150 volunteer/outreach hours set at the beginning of the year through summer camp STEM mentorships, demonstrating at local events, presenting at conferences, and giving back to the FIRST community! Since we have much farther to go this season, our new goal is 200 hours.



Engineering Overview

Meet Our Robot: X-ander (Named in reference to the X-chassis!)

Design Features:	
➔ Double-Reverse Four Bar Lifter which can reach all pole heights ➔ X-Frame Chassis for mobility and agility ➔ Gripper with rubber grips and surgical tubing to mold to the shape of the cone and achieve better hold ➔ Omni-Wheel drive-train for smoother movement and strafing capabilities ➔ Vertically mounted motors for space efficiency	

Design Plan

After reviewing this season's challenge, our team decided we had to prioritize two things: **speed,** to reach and place cones on the top of poles efficiently, and **agility,** to traverse the field without being slowed down by poles and obstacles.

Robot Functions:

- Stack cones on all pole heights, with the highest pole reaching 33 inches
- Securely grip onto cones, accommodating for variations in width throughout the shape.
- Easily travel across the game field

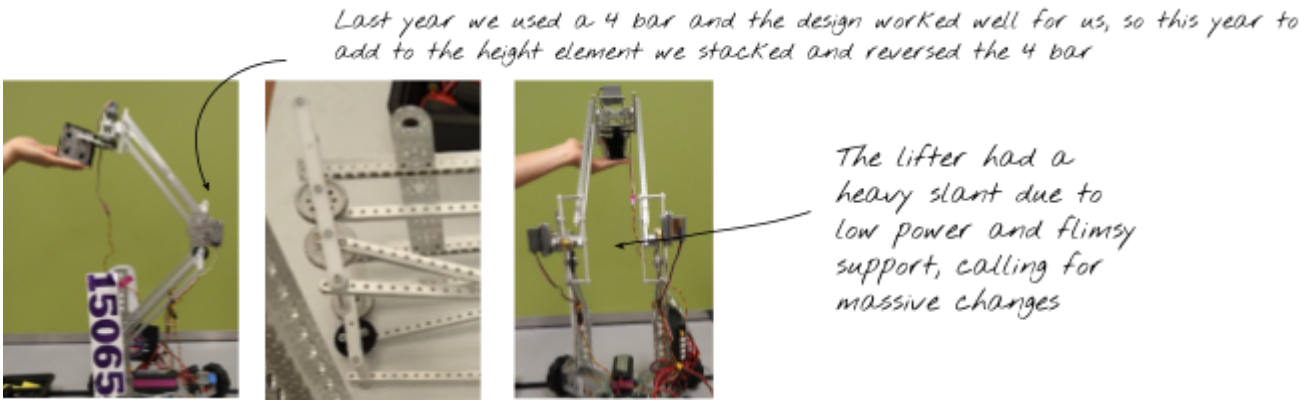
Research:

- Our team explored possible designs by reviewing previous season robots, watching videos of designs from other teams on youtube and other social media platforms, and studying FRC robots that had similar functions to this season's game.

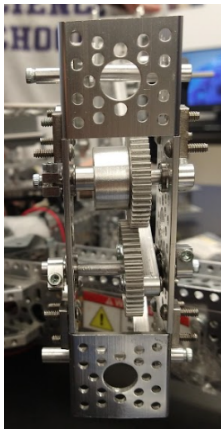
Lifter

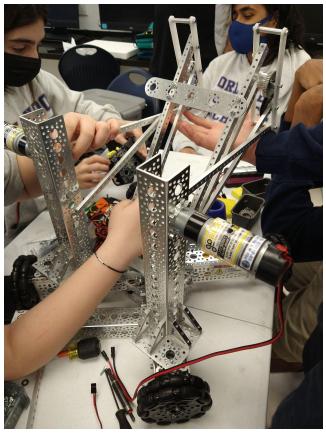
While researching various lifter designs, we noticed that a cascade lift was frequently used by other teams to place cones on the poles. A double reverse four bar was also a possible alternative that was commonly present in more advanced FRC robots. We had used a simpler version of this build, a double four bar, in the previous season, so we found that this gave us a good opportunity to expand and improve previous engineering pursuits. Due to our priority on speed, we decided that the double reverse four bar was more suited for our team. This design would enable us to reach the tallest pole at a faster pace than alternate mechanisms.

Our first design used a custom laser-cut, acrylic plastic flat-beam to connect the gears, however the material was too flexible and bendable. This made the lifter inconsistent and unstable. The first iteration also used servos which were connected directly to the gears. The servos did not have enough torque to move the lifter, and the positioning made the robot bulky. It also did not reach high enough to place a cone on the tallest pole.

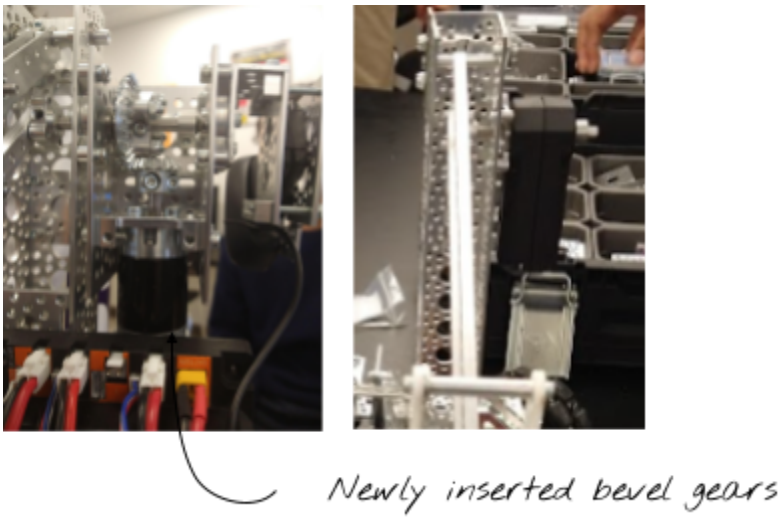


To resolve the insufficient torque, the next lifter design used motors instead of servos. These motors were attached directly to the lifter beams at the base of the robot, which helped make the robot more compact with a stable center of gravity. We also attached u-beams to the flat beams to extend their length, allowing the robot to reach all pole levels. Our design connecting the gears was drastically altered, and we opted for metal parts instead of the previous plastic. To further increase the stability of the lifter, we added ball bearings and standoffs that connected gears to both plates. Long plates connecting the horizontally parallel bars were attached as well.

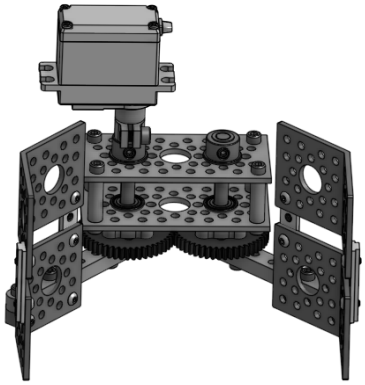




Our final revision to the lifter was with our motor positioning. The horizontal attachment frequently interfered with poles on the game field, and extended past the size limits of the robot. We originally tried using a special motor designed for vertical orientation, however we found that this did not produce enough torque to move the lifter. Instead, we used bevel gears to change the positioning of the motor. This made the robot much more compact, and resolved all the sizing issues we had.



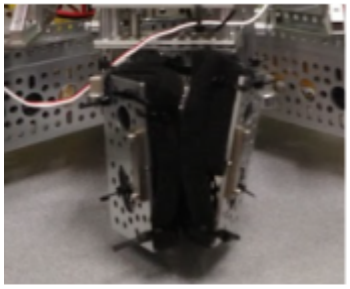
Gripper



While designing our gripper, we took into account the variation in diameter throughout the cone across the y-axis. Since the cones were not consistent in width, we quickly realized that we would need to create more points of contact between the gripper and the cone by using a material that was molded or moldable to the shape of the cone. We also noted that the highest pole was 33.5 inches in the air, so we would need a design that would be able to keep the cone completely stable for long enough to raise the lifter and position it directly over the pole. The frame of our gripper was inspired by our team's previous gripper designed last season, which consisted of 2 metal plates connected to gears turned by one servo.

The first iteration of the gripper consisted of sponges on each plate with rubber bands strung around them. Although the sponges were partially able to compress and mold around each cone when used, their vertical orientation conflicted with the triangular top of the cone. This resulted in the cones constantly dropping out of the gripper. To combat this problem we made the sponges thicker and shaped them into sloped right triangles. We also covered the sponge layer in thick bicycle handlebar tape, which provided enough grip without being too sticky. Despite these revisions, the cones continued to slip out due to insufficient points of contact with the gripper.

The final design of our gripper completely removed the sponges and tape, instead utilizing surgical tubing and rubber. We pulled the surgical tubing taut and tied it onto the metal flaps. We then took rubber stips and stapled them across the surgical tubing. This solved both of our problems by giving us a moldable gripper with the ability to hold the cones 33.5 inches in the air.



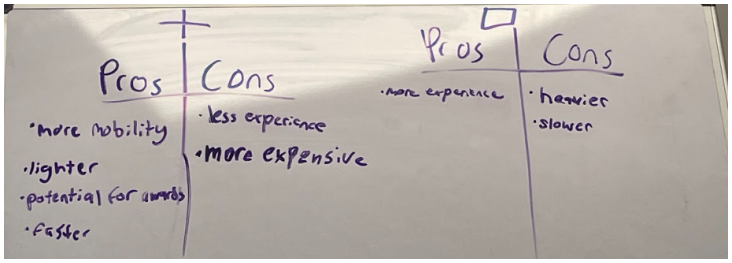
First Iteration

Second Iteration

Third Iteration

X-Chassis

When deciding what chassis shape to use we primarily took into consideration this year's game field. Since the field was much more cluttered with poles and floor junctions at every intersection of the tiles, we recognized that it would be much more difficult to navigate and maneuver through the space this season. This led us to consider more creative ideas for our chassis shape, rather than a rectangle.



To adapt our base to fit the constraints of the game field, we decided to opt for an X design. Due to our shape and size, we quickly realized that mecanum wheels would not be fitting, and omni-wheels would be a better alternative. To achieve the benefit of strafing in any direction that mecanum wheels had, we created a design that consisted of two omi-wheels oriented against each other so that the mini-wheels on would be opposite of those on the other wheel. We attached this wheel mechanism to the end of each u-channel in the X and mounted the motors inside of the u-channels.

Initial Chassis Design Sketch

Double Omni-wheel Design

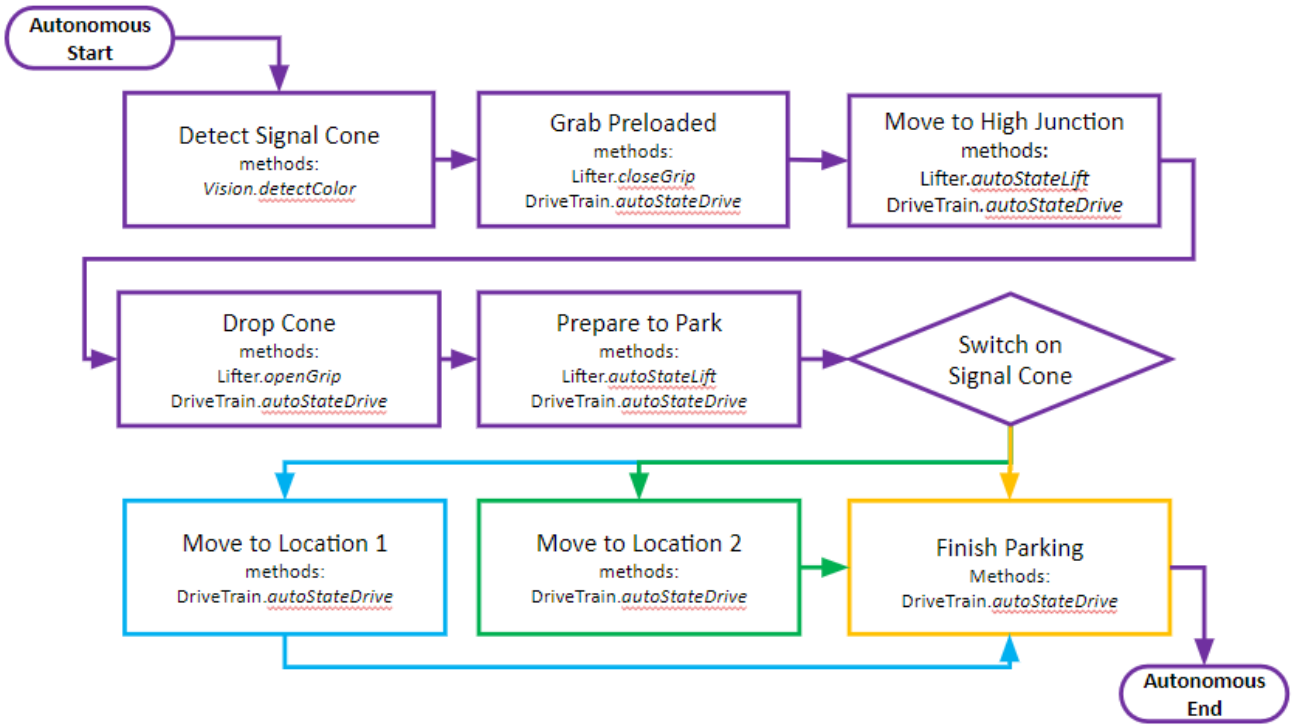
Completed Chassis Design

Software and Control

Software is developed in Java using Android Studio, and version-controlled using GitHub.

Autonomous Summary

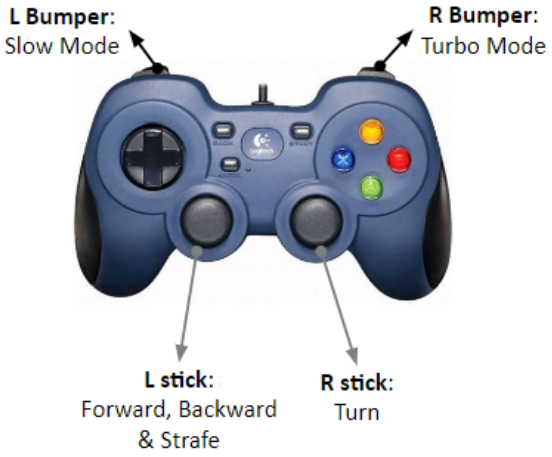
The robot begins the autonomous period by detecting the signal cone's color, which it will later use to determine its parking location. It then grips the preloaded element while moving away from the wall and begins to lift the arm. While still lifting, it rotates and aligns itself to a high junction, with the raised arm centered over the pole. The robot drops the cone, then backs up and strafes to prepare for parking. After rotating, if it is not already in the correct location, it moves to the column determined by the signal cone's color at the beginning of the match, and backs up to park in the middle of the region.



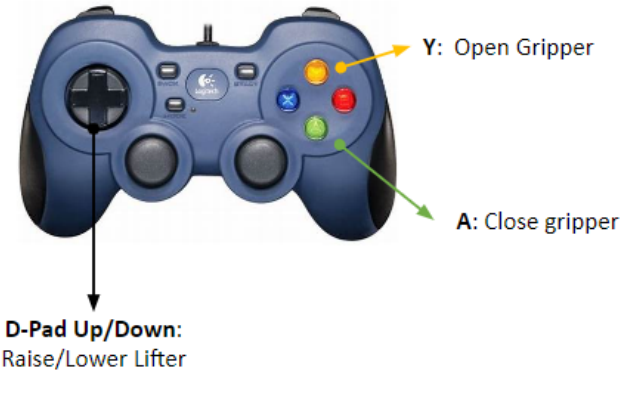
Tele-Op Summary

During the driver-operated period, control over the robot is split between two members of the drive team: one drives the robot's chassis, allowing for movement, while the other drives the arm and claw, picking up and placing cones.

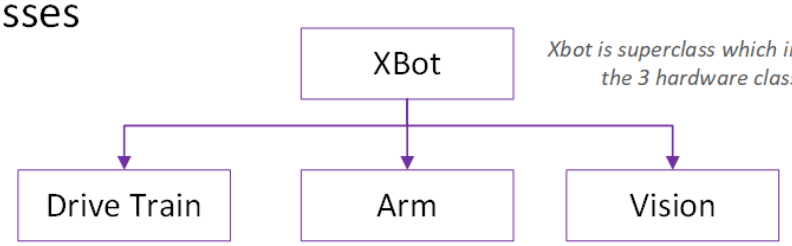
DRIVER 1: DRIVE TRAIN



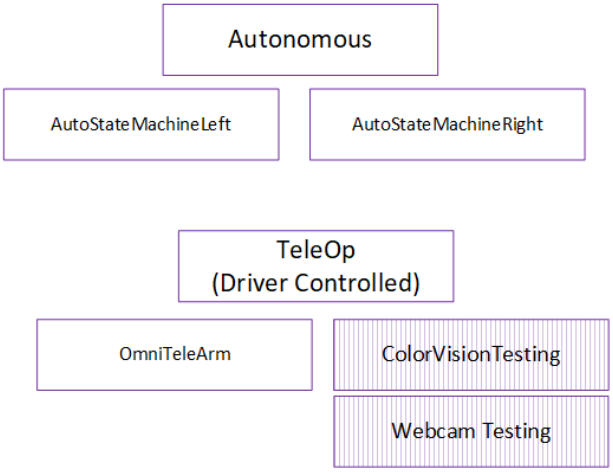
DRIVER 2: MECHANISMS



Main Classes



Op Modes



Legend

Testing Only