ENGINEERING PORTFOLIO

TEAM-24474

FIRST TECH CHALLENGE

INTO THE DEEP

VILNIUS LYCEUM ROBOTICS

Instagram:
@24474_vilnius_lyceum_robotics
@lituanicax

Facebook:
Lituanica X – Team Lithuania

MEET THE TEAM

Viltė Sap, Maksimas, Akvilė, Nojus, Domas, Algirdas, Tadas, Arnas, Matas, Martynas, Aistis, Jokūbas, Viltė Šč, Saida, Adam, Marius, Jurgis, Povilas

MEET OUR MENTORS

Algirdas

Mentor at **Lituanica X** since 2018, known for his involvement with **FIRST.**

OUTCOME: introduced First Tech Challenge, its values. Lessons learnt include organizational, teamwork and communication skills.

Justinas

A true expert in the field of **CAD design,** a consultant from our dear sponsor company **INRE.**

OUTCOME: CAD design, brainstorming and developing ideas.

Darius

A superb professional in the Lithuanian education system, one of the two main **mentors** in Vilnius Lyceum. Among other things, he is responsible for communication between the team and the **Lyceum Community Fund.**

OUTCOME: Provided and taught how to use school's equipment (e. g. using 3d printers)

Bronius

Most decorated Vilnius Lyceum teacher in the field of computer science, second of the two **mentors** in Vilnius Lyceum.

OUTCOME: Helped in the creation of the team, communicating with the school administration. Taught us organizational and computer science skills.

Team structure:

CAPTAIN
Povilas

ENGINEERING
Matas

- Domas
- Algirdas
- Jurgis
- Jokūbas
- Martynas
- Tadas
- Viltė Šč
- Arnas
- Marius

PROGRAMMING
Nojus

- Aistis
- Maksimas
- Viltė Sap
- Saida
- Akvilė
- Adam

OUTREACH
Viltė Sap

MEDIA/PRESENTATIONS
- Viltė Šč
- Tadas
- Akvilė
- Maksimas

CLUB HOSTS (INDIVIDUAL)
- Saida
- Povilas

DRIVE TEAM:

Coach:
Povilas

Drivers:
Akvilė
Nojus

Human player:
Matas

TEAM HISTORY:

2023

SPRING

- Team 24474 was founded by Povilas in Vilnius Lyceum.
- It was established with 10 new members and one second year, the captain Povilas (had participated in FGC tounaments).
- Became part of the LTX community.
- Mentor is Algirdas Augustaitis.

SUMMER

- The robot was improved and prepared in anticipation of the upcoming season.
- Work on a training robot, intended for the FTC Powerplay task, began. It helped the team members get to know the FTC ecosystem, learn about the process of making a robot and, most importantly, it allowed the team to make mistakes early, learn from them and start the Centerstage season with experience.

AUTUMN

- KICKOFF of the season was met by participating in the "RIMI" marathon and the joining of 3 new members.
- The Energy and Technology Museum provided facilities for the construction of the robot.
- FTC Netherlands league meet where the team placed 3rd.

2024

WINTER

- One new member joined the team.
- FTC Netherlands 2nd league meet where the team placed 6th and qualified for the final.
- FTC Benelux league qualified for the elimination round and placed 7th.

SPRING

- March 9th-10th team won Italian Inspire award and qualified for the World Championship.
- Participated and won the Judges Choice Award in the 2024 World Championship.

SUMMER

- Povilas, Viltė Ščer. and Matas participated in the 2024 season of the FIRST Global Challenge.
- New members joined the team in programming (Maksim, Akvilė, Aistis) and in mechanical (Marius, Arnas, Algirdas, Jurgis, Tadas) teams.
- Training was also held for newcomers both in the programming and mechanical team departments.

AUTUMN

- Brainstorming new ideas fo the new season.
- Building the first prototypes of the Into the Deep robot.
- Many online and real life meetings were held with other teams and schools.
- Many new team sponsors were found.

- Participated in more LTX games.
- Further work on the robot and programming.

TEAM PLAN

ENGINEERING

1. Develop **new versions or models** of the existing **systems** with **improved features** (e. g. enhancing the elevator's gearbox, experimenting with different materials for the arm mechanism)
2. Explore new **markets** or **applications** for the **team**'s products, potentially branching out to different **industries** where their technology could be **beneficial**.
3. Integrate more **advanced technologies**, such as **AI** and **machine learning**, especially in areas like **sensor development and automation**.

OUTREACH

1. Form **strategic** partnerships with other **companies, research institutions, or industry experts** to leverage external **expertise and resources**.
2. Engage in **educational initiatives, workshops, or public demonstrations** to showcase our **work**, **attract talent**, and **inspire innovation in the community**.
3. Develop a **long-term vision** that aligns with emerging trends and technologies, ensuring the team remains at the forefront of innovation.

SUSTAINABILITY GOALS

1. Using Google Forms and social media we share our achievements and try to recruit new members to the team. New member recruitment is done every Spring, however people can join all year around.
2. Consistently build our social media presence and gain popularity.
3. Continue to host seminars, workshops and other forms of education and encourage FTC related activities throughout our school community and Lithuania.
4. Communicate with other teams and gain experience in the process, learn to maintain consistency and stability within the team.
5. Do team-building activities such as escape rooms, have a ritual for rookies as a welcome ceremony to the team.
6. Maintain constant funding, including long-lasting sponsorships and new partnerships.

LITUANICA X

We are a part of Lituanica X, a community that encompasses robotics all over Lithuania. We are one of the biggest and most successful teams there. Lituanica X organizes the LTX Robot games, monthly FTC unofficial events. Our team heavily engages in both participating and organizing the events. For example, our team members' parents volunteer as referees, we lend our field equipment, help to set everything up.

Long term goals

- Ensure a long-lasting team in and a thriving community within Vilnius Lyceum
- Establish a local FTC league
- Continue educating the youth about the thrilling world of robotics!

Skill acquisition

Programming:
During the off season, rookies will get projects assigned by the programming lead which will teach them how to use libraries like **RoadRunner**, **FTClib**, **OpenCV** and dynamic programming.

CAD design:
Every single rookie will have proper training on how to use **SOLIDWORKS** and will be assigned to at least one small project during and off season.

SEARCH FOR SPONSORS

YUKON ADVANCED OPTICS	Financial contribution towards the future of the team
NORDCURRENT	Financial contribution towards robot parts and manufacturing
ŽALVARIS	Financial contribution towards robot parts and manufacturing
CITY OF VILNIUS	Financial contribution towards travelling expenses
VILNIAUS LICEJUS	Tools, working spaces, financial contribution
IN RE	Solidworks consultations and financial aid

Our budget for this season was about **18000 euros**. We used some of it to pay for **competition fees** in both, FGC and FTC, buy **new tools** for our workshop, buy **robot parts** and cover **other team-related expenses.** However. we did not use this money only for us - we also bough **a starter kit** for a **new local team we formed**. At this moment, we have used about half of the available money.

In summer and autumn of 2024, our team intensively **searched for sponsors**. Our main communication method was **LinkedIn's Sales Manager** through which we messaged high ranking officers of many different companies in Lithuania introducing us, our history and goals. We offered the chance to meet up and discuss potential partnership opportunities.

Įmonė	Per ką rašyta	Įmonės žmogus kontaktas	Kontakto nuoroda	Status	Kas rašo	Ar yra LTX sponsorius?	Pirmos žinutės data	Notes
Rimi	LinkedIN	Dalia Cenkiene	https://www.linkedin	Ignoras	Povilas	No	2024-07-03	
Thermo Fisher Scientific Baltics	LinkedIN	Justas Plankis	https://www.linkedin	Atrašė	Povilas	No	2024-07-03	Nukreipė parašyt egidijus.jaseliunas@thermofisher.com, kuris dėjo ignorą
Black Swan Space	LinkedIN	Marius Klimavičius	https://www.linkedin	Sponsor	Povilas	No	2024-07-03	Paremė 500 eur ant spausdintuvo
Nord Security / Hostinger	LinkedIN	Eimantas Sabaliauskas	https://www.linkedin	To do		No		
Hostinger	LinkedIN	Kristina Strimaitė	https://www.linkedin	Ignoras	Povilas	No	2024-07-03	
Oxylabs	LinkedIN	Julius Černiauskas	https://www.linkedin	Ignoras	Povilas	No	2024-07-12	
Cyber Care	LinkedIN	Ina Bielskė	https://www.linkedin	To do		No		
Sigli	LinkedIN	Dima Dubavets	https://www.linkedin	Rašom ar ne?		No		
Robotikos mokykla	LinkedIN	Paulius Briedis	https://www.linkedin	To do		No		
Shift4 Payments Lietuva	LinkedIN	Tadas Vizgirda	https://www.linkedin	Ignoras	Povilas	No	2024-07-18	
Delfi	LinkedIN	Vytautas Benokraitis	https://www.linkedin	Įvyko meetas	Povilas	No	2024-07-03	Nukreipė parašyt tomas.stasiukevicius@delfi.lt, meetas rugpjūčio 6 dieną gyvai, pakvietė kalbėt LOGIN'e
RSI EUROPE	LinkedIN	Tomas Milašauskas	https://www.linkedin	Įvyko meetas	Povilas	No	2024-07-08	Nukreipė parašyt Liudvikui Jaskunui (Linkedin)
Altechna	LinkedIN	Antanas Laurutis	https://www.linkedin	Ignoras	Povilas	No	2024-07-08	
Surfshark	LinkedIN	Vytautas Kaziukonis	https://www.linkedin	Ignoras	Povilas	No	2024-07-09	
FIMA	LinkedIN	Vytenis Pinaitis	https://www.linkedin	Declined after meet	Povilas	No	2024-07-11	Pasakė, kad susisieks personalo vadovė
Litgrid	LinkedIN	Rokas Masiulis	https://www.linkedin	Declined	Povilas	No	2024-07-09	
Optogama	LinkedIN	Tadas Lipinskas	https://www.linkedin	Ignoras	Povilas	No	2024-07-11	
Astrolight	LinkedIN	Laurynas Mačiulis	https://www.linkedin	Ignoras	Povilas	No	2024-07-11	
Harju Elekter Lithuania	LinkedIN	Tomas Prūsas	https://www.linkedin	Ignoras	Povilas	No	2024-07-11	
Techvitas Robotika	LinkedIN	Arūnas Talvaševičius	https://www.linkedin	Ignoras	Povilas	No	2024-07-11	
Sentante	LinkedIN	Edvardas Satkauskas	https://www.linkedin	Declined	Povilas	No	2024-07-11	Startuolis, negali paremt whomp whomp
Elektrum Lietuva	LinkedIN	Martynas Giga	https://www.linkedin	Ignoras	Povilas	No	2024-07-11	
Iglu Tech	LinkedIN	Edgaras Adomaitis	https://www.linkedin	Ignoras	Povilas	No	2024-07-11	
ABOVO red	LinkedIN	Arnoldas Puodžius	https://www.linkedin	Ignoras	Povilas	No	2024-07-11	
SEB	LinkedIN	Julius Vankevičius	https://www.linkedin	Ignoras	Povilas	No	2024-07-18	
Tele2	LinkedIN	Aidas Tamošiūnas	https://www.linkedin	Ignoras	Povilas	No	2024-07-18	
Lidl	LinkedIN	Eglė Radžiūnė	https://www.linkedin	Atrašė, bet vėliau ignoras	Povilas	No	2024-07-18	Pasakė, kad perduos žinią apie komandą kolegoms
Teltonika	LinkedIN	Arvydas Paukštys	https://www.linkedin	Ignoras	Povilas	No	2024-07-18	
Invest Lithuania	LinkedIN	Elijus Čivilis	https://www.linkedin	Ignoras	Povilas	No	2024-07-18	
Prusa Research	LinkedIN	Martin Bach	https://www.linkedin	Ignoras	Povilas	No	2024-07-18	
Lemona Electronics	LinkedIN	Anrius Zareckis	https://www.linkedin	Ignoras	Povilas	No	2024-07-18	Remia Litbotą
Nordcurrent	LinkedIN	Viktoria Trofimova	https://www.linkedin	Sutiko susitikt	Povilas	No	2024-07-20	Meet 11-14
Green Genius	LinkedIN	Ruslanas Sklepowicz	https://www.linkedin	Ignoras	Povilas	No	2024-07-20	
Senukai	LinkedIN	Artūras Rakauskas	https://www.linkedin	Ignoras	Povilas	No	2024-07-20	
Avia Solutions Group	LinkedIN	Gediminas Ziemelis	https://www.linkedin	Ignoras	Povilas	No	2024-07-20	
SoliTek	LinkedIN	Julius Sakalauskas	https://www.linkedin	Ignoras	Povilas	No	2024-07-20	
Neste Lietuva	LinkedIN	Julija Matisonė	https://www.linkedin	To do				
Turing College	LinkedIN	Lukas Kaminskis	https://www.linkedin	Įvyko meetas	Povilas	No	2024-08-12	Pasiūlė atvaryt į offisą susitikt (data dar derinama)
Eneba Games	LinkedIN	Vytis Uogintas	https://www.linkedin	Atrašė, bet vėliau ignoras	Povilas	No	2024-08-12	Pasakė parašyt Unicorns.lt vadovei - parašiau, bet praignoravo
Axioma Metering	LinkedIN	Ignas Vosylius	https://www.linkedin	Declined	Povilas	No	2024-08-12	- Parašyt jų HR vadovei Živilei zivile.vikertiene@axioma.e po **Rugpjūčio 26 dienos** - Parašiau Živilei 08-27 - paraše kad dabar negali paremt
Detra Solar	LinkedIN	Juste Alisauskaite	https://www.linkedin	Ignoras	Povilas	No	2024-08-12	
Yukon Group / PULSAR	LinkedIN	Liudas Abisala	https://www.linkedin	Sponsor	Povilas	No	2024-08-12	- Parašė parašyt kolegai Germanui g.kavalskis@yukonww.com - Įvyko susitikimas jų offise, praėjo gerai
IKI	LinkedIN	Nijolė Kvietkauskaitė	https://www.linkedin	Įvyko meetas	Povilas	No	2024-08-12	Pakvietė į renginį rugsėjo 4 dieną
Brolis Semiconductors	LinkedIN	Dominykas Vizbaras	https://www.linkedin	Sutiko susitikt	Povilas	No	2024-08-12	Meetas kažkada paskutinę rugpjūčio savaitę
Tec Industry	LinkedIN	Vaidas Laukaitis		Parašiau, bet dar neatrašė		No	2024-09-18	
Telesoftas	LinkedIN	Šarūnas Putrius		Parašiau, bet dar neatrašė		No	2024-09-18	
Pigu.lt	LinkedIN	Šarūnas Trakselis		Parašiau, bet dar neatrašė		No	2024-09-18	
Energus	LinkedIN	Povilas Šidlauskas		Parašiau, bet dar neatrašė		No	2024-09-18	

REWE
Dein Markt

Over this time we reached out to more than **50 companies** and had **8 meetings** and even got invited to a networking event where our captain presented the team to officers from the German supermarket giant REWE and the Lithuanian supermarket network IKI.
The status for every single reach-out-attempt was recorded in google sheets and was documented. The screen shot of the document can be seen above.

We feature our sponsor logos on our team T-shirts, as seen above.

We are also set to have a meeting with our main sponsor **YUKON** soon. The meeting was supposed to happen in November but got pushed around multiple times

EDUCATIONAL OUTREACH ACTIVITIES

As an FTC team, we try to be an educational beacon in our local communities, shining light not only on robotics, but on STEAM in general. That is why our team organizes multiple re-occurring academic activities aimed at educating individuals outside our team or FTC.

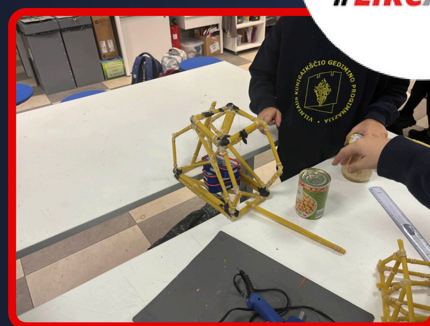
SINCE SEPTEMBER
SAIDA'S STEAM CLUB FOR GIRLS

Saida's weekly STEM club for girls, based at the Lithuanian National Library, focuses on inspiring confidence in its member to combat gender stereotypes in STEAM fields and foster logical thinking through activities such as bridge building, photography and programming with Scratch.

The main aims of this workshop are to:

- Grow self-esteem and motivation to learn;
- Encourage asking questions and seeking help;
- Learn about concepts that surround us in everyday life;
- Promote teamwork and sharing ideas;
- Develop logical and critical thinking, as well as creativity;
- Inspire to create future goals and reflect on projects.

FIRST #LikeAGirl



POVILAS' CAD CLUB

Our team captain Povilas has started a weekly CAD club for year 9-10 students at our school. In his lessons, the students are taught the basics of Solidworks and 3d printing. This is done with a goal of preparing potential future team members for when he graduates and the team will have to survive without him and other current 12th-year student team memebers.

FIRST-RELATED OUTREACH ACTIVITIES

FIRST GLOBAL CHALLENGE, ATHENS 2024

Three Vilnius Lyceum Robotics team members Matas, Viltė and Povilas represented Lithuania in the **First Global Challenge** 2024 season, forming strong bonds with **Ukrainian, Latvian Seychelles and Togo teams.**

Considering **Seychelles** and **Togo** teams wishes to start **FTC** teams, **VLR team** gifted personally developed **mecanum wheels** to their members.

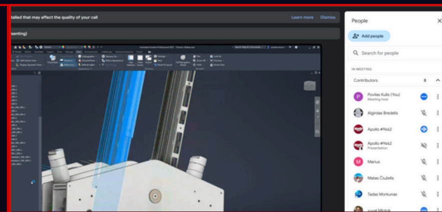
We always try to embrace the global aspect of FIRST and frequently meet-up with different teams from all over the world to discuss our experiences, share ideas and simply connect. Here are some online meetings that we had documented.

OCTOBER 3RD MEETING WITH TEAM APOLLO 9662

Discussed the new season kickoff, our ideas and plans for robot design as well as planned outreach activities.

OUTCOME:

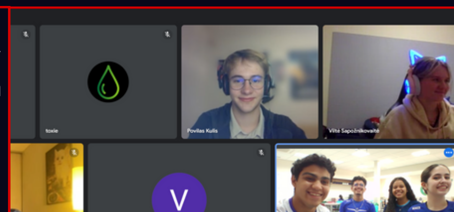
Gained valuable ideas for our robot's telescopic arm



NOVEMBER 1ST MEETING WITH TEAM DUMONTERS 22977

Reviewed both teams' robot designs, shared ideas about the incolvement of all team members and the team's integration into the community.

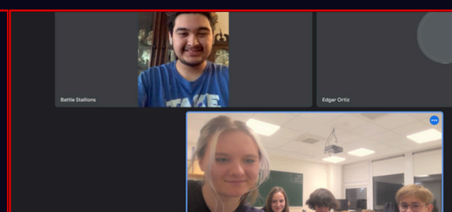
OUTCOME: got advice on team management



NOVEMBER 29TH MEETING WITH TEAM BATTLESTALLIONS 13896

Talked about working as second-generation FTC team (from their experience).

OUTCOME: we got insights on how to set the team up for next season when many founding members will have graduated.



DECEMBER 7TH MEETING WITH TEAM CERBOTICS 15600

Showcased our CAD model, design process and programming approach.

OUTCOME: shared our desrign choices with their team

DECEMBER 21ST MEETING WITH TEAM THUNDER KITES 21651

This team reached out to us wanted to get consulted on what slides would best fit their robot

OUTCOME: We shared what we knew and helped a fellow team out.

BENJAMIN FRANKLIN INTERNATIONAL SCHOOL
THUNDER KITES

LOCAL FIRST-RELATED OUTREACH ACTIVITIES

Lithuania is a quickly growing FTC region with quite a few strong teams. To assist in creating more teams, our team often organizes presentations to students of vastly different ages (from kindergarteners to fellow peers) to educate them about FIRST and perhaps even start a team of their own.

Through these presentations, we impacted around 300 students in total by educating them about FIRST and First Tech Challenge. However, the most successful event we hosted happened in Vilnius M. Biržiškos gymnasium. Here the opportunity to participate in FTC was a huge hit: the event drew in a lot of students and a few of them came after the event to ask about what can they do to take part. **Our team decided to spend 1500 euros and buy them a REV starter kit to provide these students with essential parts.**

ESTABLSHING ENGINEERING ENVIROMENT FOR FUTURE GENERATIONS

This season our team received a new dedicated workspace within our school where we can fit all of our tools, newly acquired 3D printer and the game field.

Thanks to our initiative a new printer has been purchased for student use. Around 1000 euros from the Lyceum's Support Fund were allocated to the purchase of this appliance.

We have started to refurbish our school's old CNC machine for use in further robot developments

THE PEGASUS MECANUM WHEELS

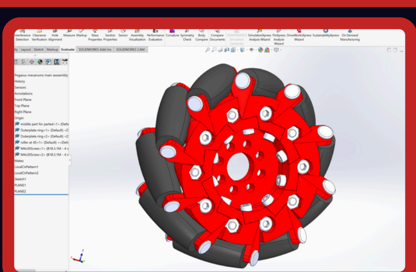
The **Mecanum wheels** are a very popular wheel choice in **FTC**, however not all teams are able to use such wheels because:

- They're a rookie team with a little budget;
- They're a team that can't get good mecanums shipped to them for a decent price;
- They're a team that wants to build multiple robots simultaneously and don't have multiple mecanum wheel sets.

To combat this problem we created the Pegasus Mecanums – a free open-source project that anyone owning a 3d printed and basic workshop tools can build for themselves at a relatively low cost.

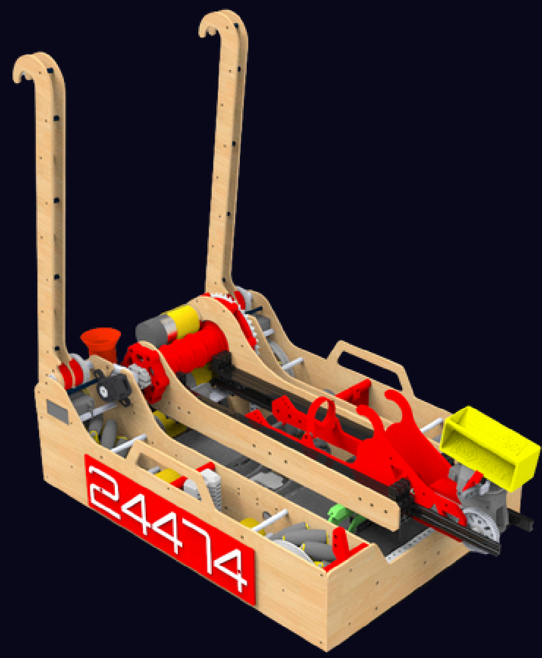
The material cost for a set of 4 of these wheels is about 25 euros.

The documentation and .STL files will be available for download at our website **robotics.licejus.lt**.



We have made a few sets of the Pegasus Mecanum wheels ourselves and given them out to people interested in starting out in FTC. They include local teams in Lithuania as well as teams in the First Global Challenge Athens 2024.

MECHANICAL DESIGN



Current robot statistics:

- Max achievable speed in field: 3.84 tiles/s (8.5 m/s)
- LEVEL 3 ascend time (from the ground): 10-15s
- Cycle time (sample delivered from the submersible to the high basket): 9s
- Robot weight: 9kg
- Best solo match result: 153
  - 3 high-bucket samples in autonomous + LEVEL 1 ascent (27 points)
  - 12 high-bucket samples in teleop (96 points)
  - LEVEL 3 ascent (30 points)

Design goals:

When planning the design of the current robot we wanted to make sure it:

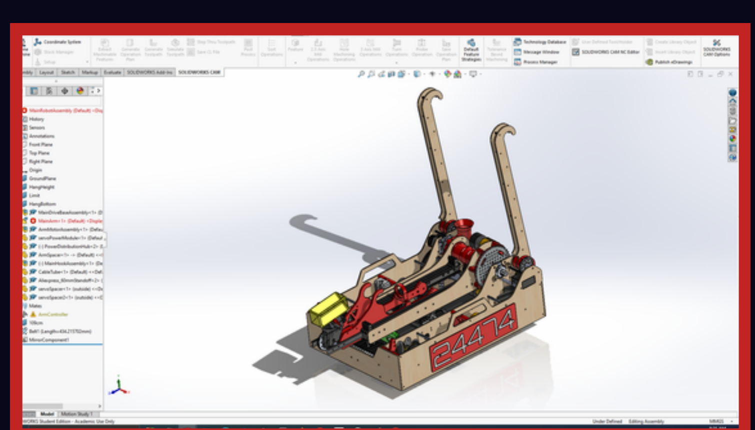
- Had a low profile to allow our drivers to easily see the submersible when trying to pick up samples;
- Used a single universal system for both game-element pick-up and deposit to eliminate the need for a complicated sample transfer sequence;
- Was fast and light;
- Had a low center of mass;
- Was able to achieve a LEVEL 3 ascent in under 15 seconds.

Current version description and overview:

- Drivetrain: Uses bare goBilda motors with a 12:1 GT2 belt reduction and a set of goBilda's GripForce Mecanum wheels.
- Odometry: Uses 2 Swingarm Odometry Pods from goBilda and a Pinpoint Odometry Computer.
- Battery: Modern Robotics 12V, 3000mAh battery
- The arm: The arm is rotated by a stationary gobilda motor with a chain drive. The arm uses a goBilda 12mm HEX Aluminum shaft.
- The lift: It is a rather complicated coaxial system with the arm that is driven by 3 bare goBilda motors that are connected to the main string hub with a gear drive. The lift is a double 3 stage system that utilizes the 14 inch slides from bwtlink.
- The Claw: A complex system of 4 different Axon servo motors that allows for a fast and precise sample pickup from the submersible.
- The Hanging system: Consists of two symmetrical assemblies of Axon MAX servo actuated hooks and 2 hooks attached to the lift.

Workflow overview:

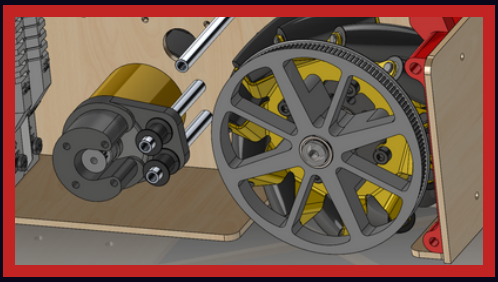
- We design our whole robot in Solidworks and manufacture some of our parts by 3d printing them with our members' personal or our school's 3d printers. We also often use our school's CO2 laser cutter to cut out the parts from 3mm wood.

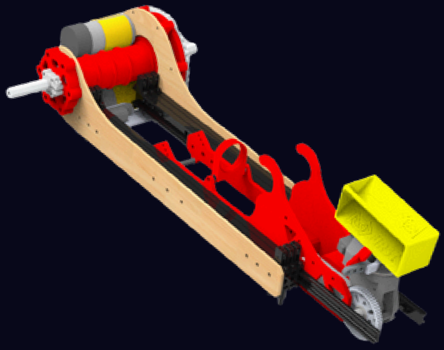


INDIVIDUAL SUBSYSTEM OVERVIEW

Bare motor drivetrain

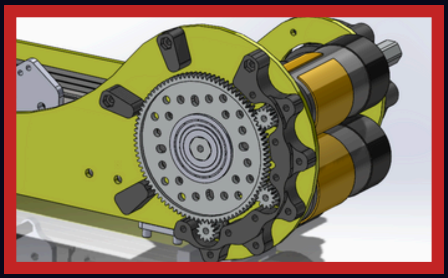
- Unlike most FTC robots, we use bare motors to drive our robot. Since one of the goals was making the robot as light as possible, we considered removing the gearboxes of the drive motors, as each of them weighs 194 grams. Instead, we designed our own custom GT2 belt reduction system that was about twice as light. The biggest reduction we were able to achieve was 12 : 1, which is not a bad thing, as this makes our robot noticeably faster than our competitors on the field.

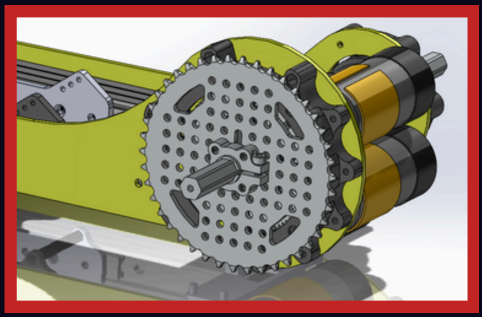




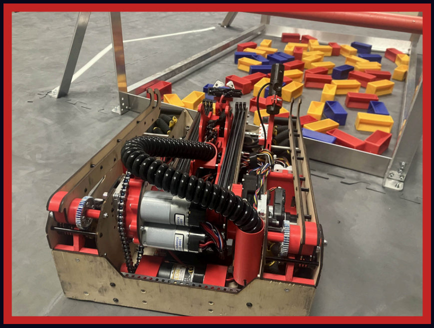
Coaxial arm and slide system:

- The lift slides we decided to invest in this season were the bwt-link 14 inch slides, because they were specifically made for FTC use and had a low profile. This was important because we wanted to make the whole arm as narrow as possible and also decrease its weight.
- The whole lift is driven by 3 separate motors. This may seem overkill, but this is the system that must lift the whole robot of the ground. All of them do not have gearboxes, which saves on weight, but also makes our encoder readings not accurate enough, which sometimes fails our ascends. This is a problem we are working on to fix. The gear ration here is 1 : 7.5.
- The arm shaft and lift pulley module are coaxial. Making this design choice was crucial in making the arm work, however it complicated the whole assembly.



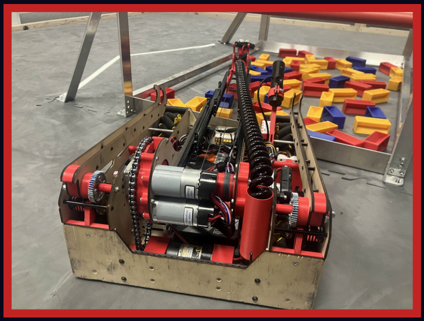


- The arm pivot motor is the only motor in the robot with a planetary gearbox. It also has an additional 1 : 3.2 chain reduction. So it has plenty of power lifting the arm up and down.



Cable management:

- As our claw uses 4 servos, a lot of wires are needed to be efficiently routed through the robot's lift assembly. To solve this issue, we purchased a big coiled-up cable that has 12 22AWG rated wires inside.

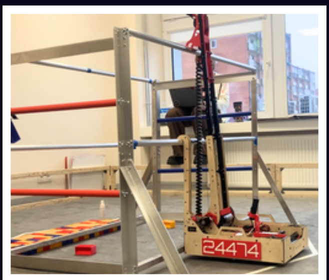


INDIVIDUAL SUBSYSTEM OVERVIEW

Ascent mechanics explained:

Step 1:
The robot drives up to the lower bar with its arm hooks deployed

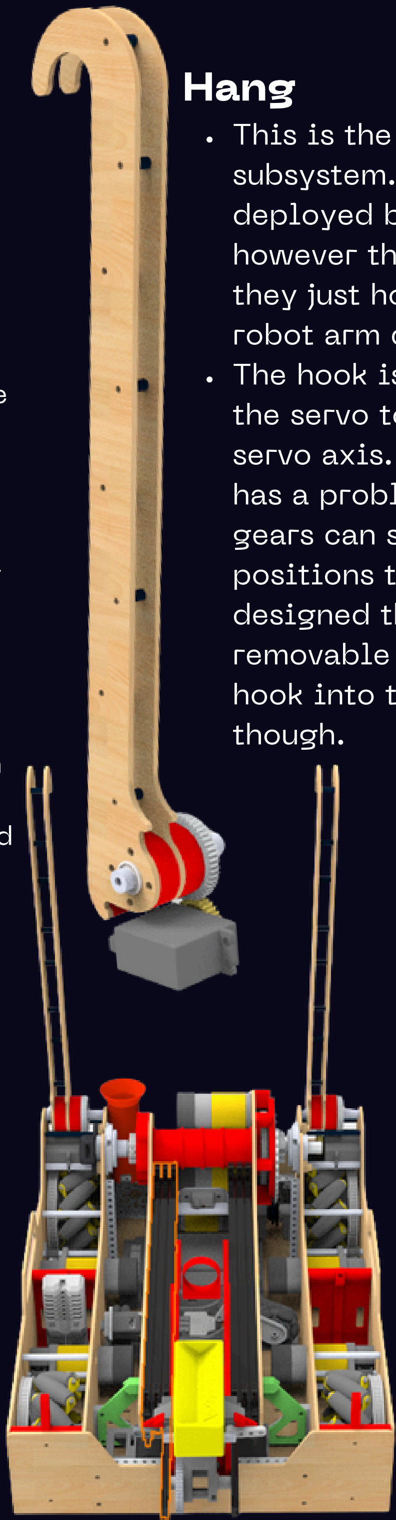
Step 2:
The robot hangs itself on the lower bar while being supported by the lower barrier. The servo-actuated hooks are unfolded and deployed onto the lower bar too.



Step 3:
The robot extends its arm to match the height of the high bar. It is now suspended in the air by the servo actuated hooks.

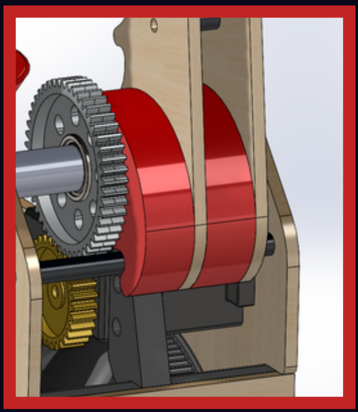
Step 4:
The robot then deploys its hooks onto the high bar and starts lifting up.

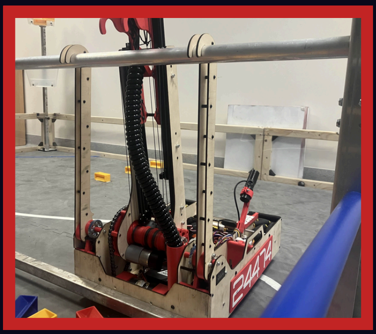
Step 5:
The robot folds its servo-actuated hooks and the arm to suspend itself above the low bar and achieve a LEVEL 3 ascend



Hang

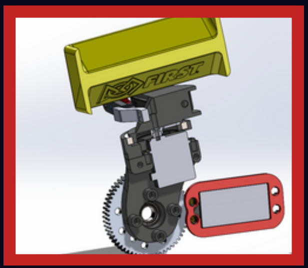
- This is the 4th iteration of our hang subsystem. These hooks are deployed by Axon MAX servos, however they do not lift the robot, they just holt it in place, while the robot arm does all the heavy lifting.
- The hook is not directly driven by the servo to reduce load on the servo axis. However, this approach has a problem - sometimes the gears can skip and the servo positions then get inaccurate. We designed the arm to be easily removable to be able to place the hook into the right position easily, though.

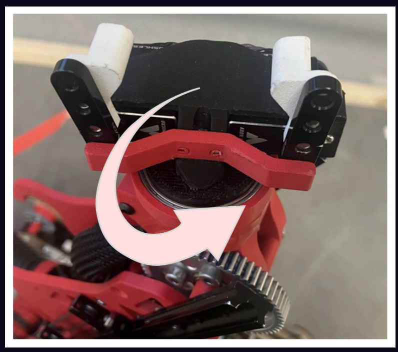


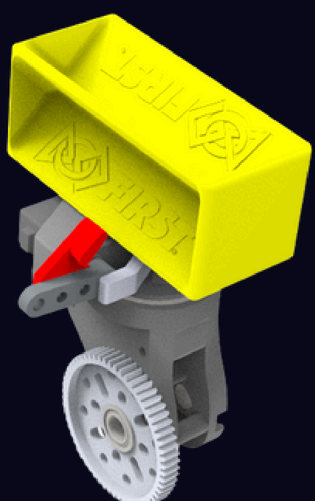


Claw:

- This is the 5th iteration of our intake design. It is a claw that has 2 rotatable wrists and 2 small fingers, all actuated by Axon servos.
- The first wrist is powered by an Axon Mini indirectly and has a gear transition. It used to be powered directly by an Axon Micro, but this part of the claw often experienced transverse loads and we ruined two Axon micro servos this way.
- The second wrist is powered by a hidden Axon Micro and can turn the claws to allow our drivers to pick up samples from different angles.
- The claws are also powered by Axon Micros. The key feature in our design is the red top guard placed on the servos axes. It helps the motors deal with non-axial loads and improves their lifetime. A simple, but smart solution.

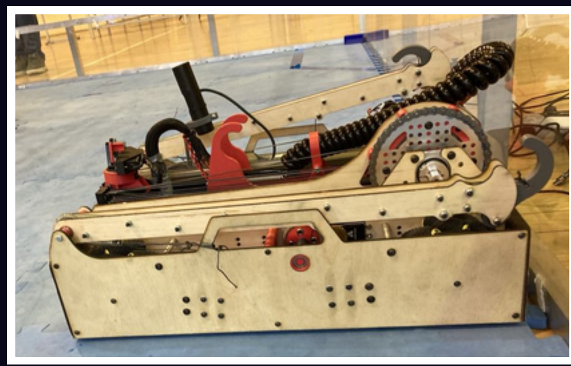




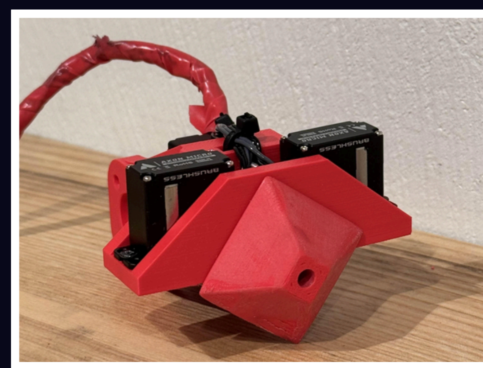


SCRAPPED DESIGNS

Some photos of past hang subsystem ideas:

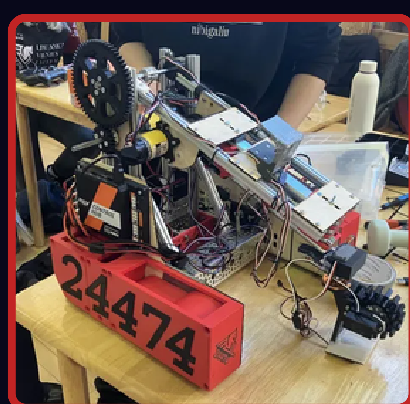


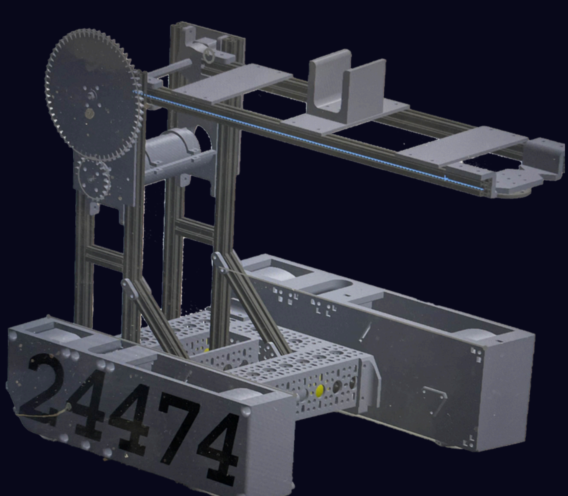
Different claw ideas and approaches:



Robot in one week

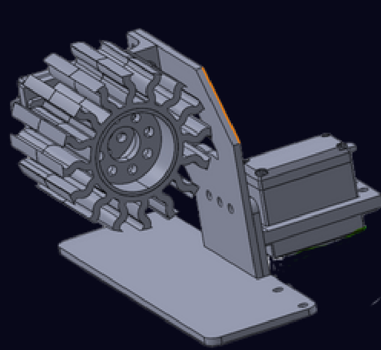
After brainstorming ideas for the new season, we decided to participate in the "Robot in one week" challenge. We decided to base the robot on the goBILDA FTC Starter Bot with a custom pick up mechanism. For the base of the robot it was decided to repurpose our old drivetrain from the previous robot and adapt it for this iteration.





All of that was a learning experience for our team. The robot was built in around 3 days. With that robot we participated in the kick-off LTX games and got to see which design choices worked and which ones didn't.

The robot was performing quite poorly: it was very imbalanced and tended to fall over. This version was also very slow. Also, our custom designed pick up mechanism was not very reliable. Although we faced those difficulties, we learned from our mistakes and seek to improve the weak parts with the current version of the robot.



We believe that the best words to describe our experience with the robot this season are rapid progress – although we had a very rough start with a robot barely able to score any points, now we have a very competitive robot that we are very proud of.

PROGRAMMING

AUTONOMOUS

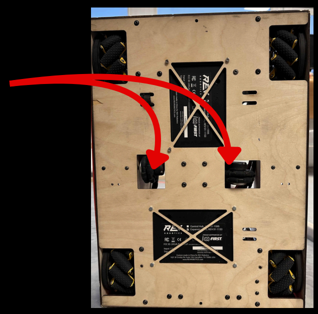
TOOLS

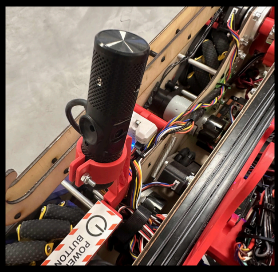
PENDRO PATHING

After using RoadRunner last season, this time we decided to try something new and use **Pendro Pathing**. It's an advanced Reactive Vector Follower developed by FTC Team 10158, which is provides **more precise and faster** movements, **better execution** and **real-time** adjustments.

DEAD WHEEL ODOMETRY

The dead wheels measure the displacement of the robot on the field. Not only do they play a crucial role during the **autonomous period driving**, they also have enough accuracy to **grab and deposit samples and specimens** from the field, meaning there is no need for reading AprilTags.





VISION

A versatile solution to most of the possible missteps and hours of tedious tuning, especially in Autonomous mode.
This technology is based on **OpenCV** and uses **edge detection with colour recognition** to assess the situation and make necessary changes to achieve best results.

FINITE STATE MACHINE CONTROL MODEL

By defining a finite number of states and modeling transitions between them, we have created a robust framework for the main components of the robot, that allow us to easily add more states and tune transitions without breaking the existing code. It also enables us to implement fail-safes effectively, such as disabling certain commands or preventing transitions between specific states if things were to go wrong. For example, if the driver wants to go directly from the intake position to the deposit position, the code ensures the arm retracts into the robot first before activating the deposit command.

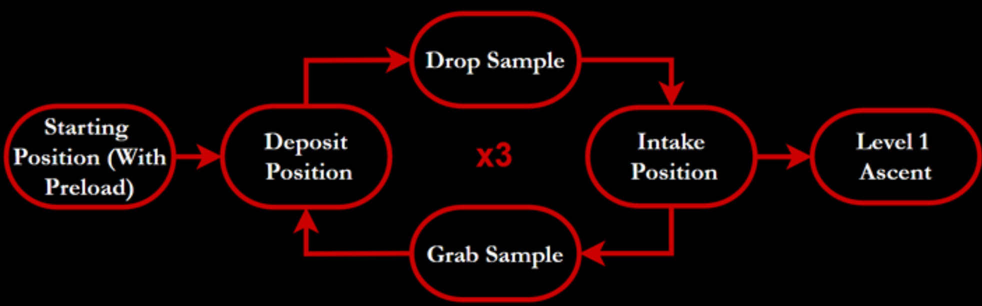
MOTION PROFILES WITH FEEDFORWARD GRAVITY COMPENSATION

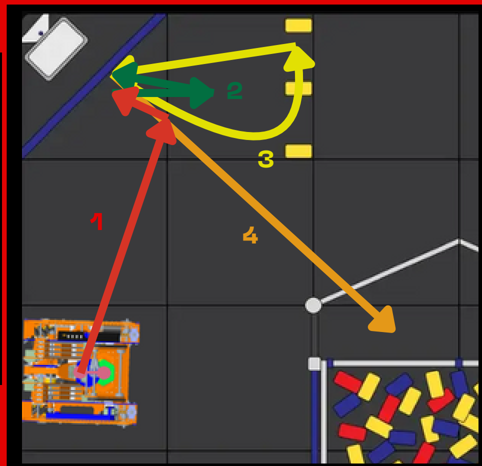
Our FTC robot's telescoping arm uses an asymmetric motion profile based on kinematic equations to calculate position, velocity, and acceleration setpoints during movement. These setpoints are sent to a PIDFVA controller. The asymmetric profile ensures faster acceleration with slower deceleration to prevent overshooting and damage while maximizing speed. To account for the shifting center of gravity during extension, feedforward compensation is interpolated with the slide extension for precise rotation and positioning.

GAME STRATEGY

In order to achieve the maximum amount of efficiency and earn as many points as possible no matter what side of the field our team starts on, we decided to develop **2 variations** of autonomous mode – **Basket and Specimen**. This also allows us to adapt to our alliance's other team in case of sudden malfunctions or code bugs during the competitions.

1ST VARIATION (BASKET)

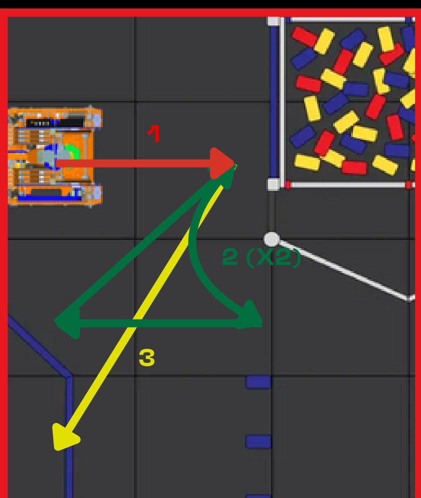




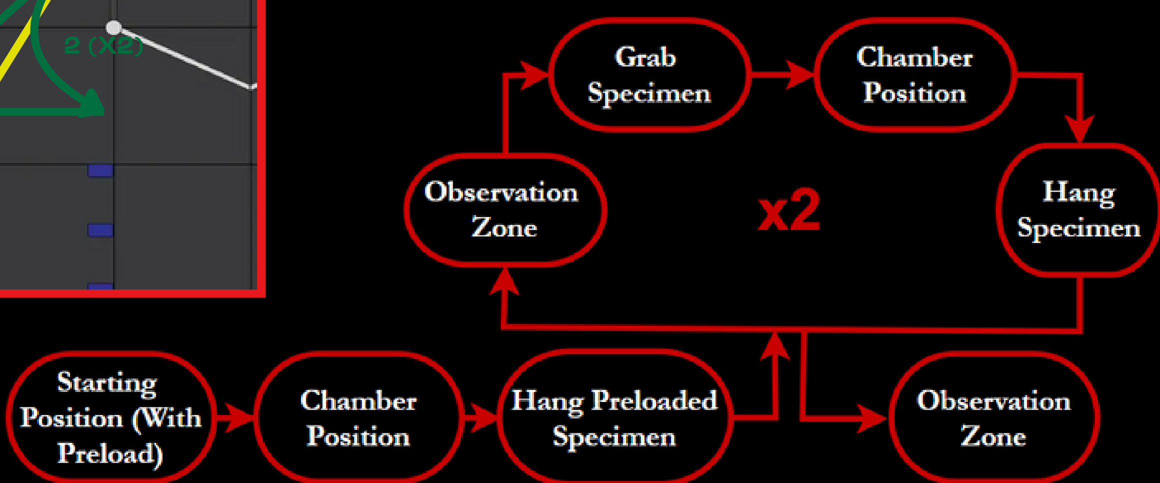
Robot path visualization on the basket (left) side of the playing field (from alliance's perspective)

The goal of this situation is to **score 4 samples into the upper basket,** achieve **level 1 ascent** and earn **64 points.** One of the said samples is a pre-load, while the other 3 are acquired from the neutral sample spike marks on tile B6 or E1 (according to our alliance's colour).

2ND VARIATION (SPECIMEN SIDE)

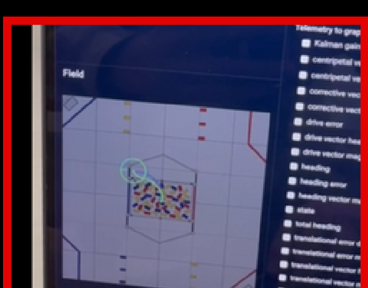


The Objective: score **63** points by hanging **3 specimens** on the **high** chamber and **parking** in the Observation Zone. One of the specimens is pre-loaded, while other are taken from the human player stash.



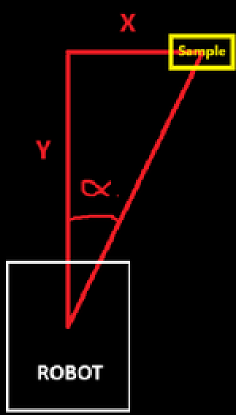
DEVELOPMENT

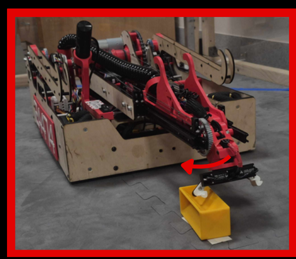
Even the best tools have their downsides and in our case the faster, cleaner autonomous mode costed us **numerous hours of tuning** the movements.



Firstly, we had to adjust **the primary PID (Proportional-integral-derivative) controller** for base functions, so that our robot could **drive and rotate cleanly and precisely** without shaking or overshooting. In addition, this would **eliminate the chance of disruptions** in the routine after any interruptions or collisions with obstacles on the field.

When our robot could drive neatly and the TeleOp mode was mostly done, we started working on **polishing the Autonomous mode paths**, because small missteps were causing huge point losses, for example, slighly missing samples while grapping or depositing.

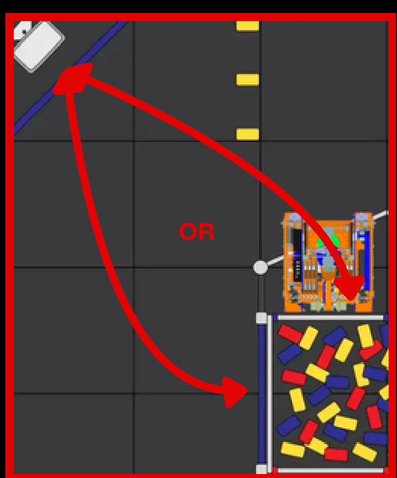




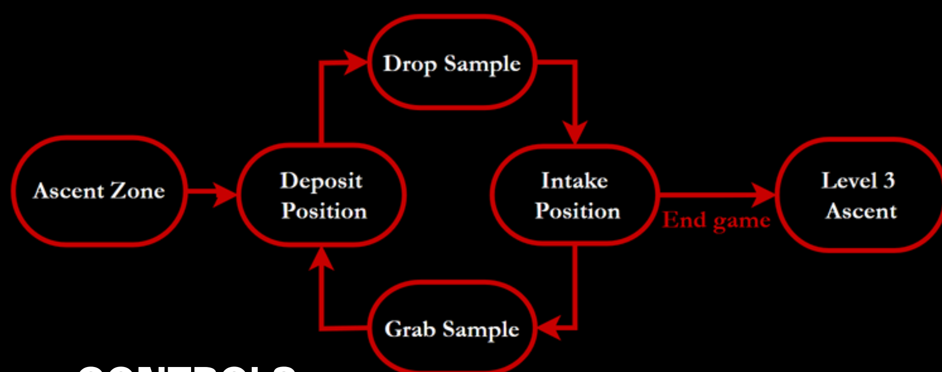
In order to improve the results even more, **the robot's vision** was implemented. Using colour recognition and edge detection, the center of the item is found. Then, with ray tracing and trigonometry, distances and angles to the object are calculated. This was implemented into the Basket variation, so that the movement error would be compensated and the claw could accurately and successfully grab all the samples.

TELEOP

GAME STRATEGY



The intention of this strategy is to get as many points as possible by depositing samples from the Submersible into the higher basket, scoring ~6 * 8 + 30 = 78 points on average.



CONTROLS

1st driver

– Bumpers –

ASCENT
Starts the Level 3 ascent sequence

ASCENT STEP REGULATION
In ascent mode, works as a confirmation for further actions

DRIVING
Drives the robot forward and backward, strafes left and right.

ROBOT ROTATION
Rotates the robot left and right.

2nd driver

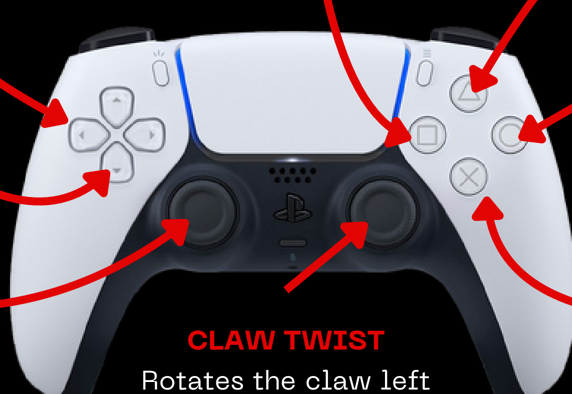
CLAW ANGLE
Raises and lowers the claw.

NORMAL
Sets the robot into a default state.

DEPOSIT
Switches normal robot mode to deposit mode.

OVERRIDE
Forces the arm into the desired mode in case of a malfunction.

CLAW STATE
Opens and closes the jaws.



LIFT EXTENTION
Slowly increments the lift slider's position.

CLAW TWIST
Rotates the claw left and right.

INTAKE
Puts the robot from normal to intake mode.

DETAILED CONTROLS

NORMAL (STATE): Mainly consists of **retracting the arm** from whatever position it was in previously to a safe position within the robot. This is usually necessary for tasks like navigating between the baskets and the submersible.

DEPOSIT (STATE): The arm lifts up and extends above the high basket, the claw rotates to the correct angle. When the sample is deposited, the claw leans back while the lift is retracting, then it leans forward and the arm lowers down.

INTAKE (STATE): The robot extends the slide, the claw opens and bends down. After successfully grabbing a sample, the claw closes and lifts up and the lift retracts.

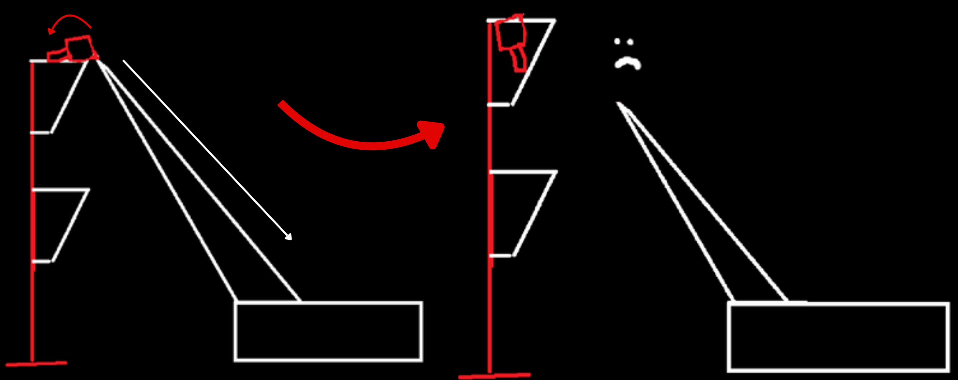
ASCENT: The ascent process is not one singular action. As a safety measure, we have added checkpoints during it. There are 5 stages of the sequence and every single one is done only after the confirmation from the driver, that the current position is suitable for further development.

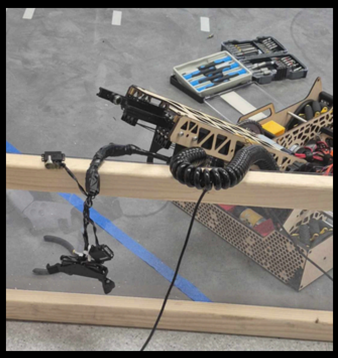
DEVELOPMENT

THE AXON INCIDENT

This is what our team calls our **biggest failure** up to this date. A **small programming mistake** costed us one of our most expensive components and initiated a **partial redesign** of the arm subsystem both mechanically and code wise.

The mistake was brought to the light during driver practice the day before one of our community's local events. During TeleOp period, after depositing a sample into the higher basket, the "normal state" command was called **too early** and **the claw got caught in the basket**. Because of the huge force of the lift still trying to retract, the claw **got pulled off**, which did significant damage to the Axon servo motor.





CONSEQUENCES:

- A Wait command and an **additional claw angle change** was enforced to avoid getting hooked on the baskets;
- The claw frame was **remodeled and strengthened** to withstand stronger forces and hits;
- The importance of safeties was **revaluated** and **no** possible future mistakes are overlooked, left untreated.