TECRA BOT

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ENGINEERING NOTEBOOK

A DEEP DIVE INTO OUR TEAM

Team Introduction

We are FTC Team #21573, TecraBot, from Depok, Indonesia. We are a school-based team who first compete in Powerplay (2022 - 2023).

Last season, during Centerstage, we proudly claimed victory as the 24/23 Nusantara Regional, **Winning Alliance Captain**, as well awarded with **1st place in Innovate Award** and **3rd place in Design Award**.

Team Members

Rafif
Leader & Mechanic

Gema
Lead Mechanic & Programmer

Zhafran
Mechanic

Akbar
Mechanic

Daffa
Mechanic

Alif
Team Manager & Media

Ganesh
Media

Syamil
Media

Rozan
Media

Ghazi
Programmer

Arslan
Programmer

Previous Experiences

Following our regional successes, **three** our of our **eleven** member, had **competed in the FTC 2024 World Championship**. As they were invited to join team #19829 after the 23/24 Nusantara Regional, who previously qualify for Worlds by winning the Nusantara Regional, Inspire Award.

Houston, 2024
FTC World Championship

23/24 Nusantara Regional

Two of our members also had experiences in the 2024 First Global Challenge, by joining the **Indonesian FGC Team** who had great success competing in **Athens, Greek.**

By combining their expertise, teamwork, and shared experiences, we aimed to build a strong team capable of competing not only in our regionals, but also at the world stage.

2024 FGC Team Indonesia

Mechanic
CAD-designs, Assembly, Testing

Programmer
Programming, Controls, PID

Media
Instagram posts, Decoration, Outreach

Our team is divided into three divisions: Mechanic, Programmer, and Media. Each division focuses on specific tasks—Mechanic handles the robot's build, Programmer manages coding, and Media handles content creation. We also have a team manager overseeing operations, while each division has its own leader to ensure tasks run smoothly and to communicate to other devision.

In TecraBot we organize tasks using a timeline and a weekly to-do list. Every Monday, we create a list of tasks to accomplish for the week. At the end of the week, the division converts the completed tasks into a timeline, keeping us on track and well-coordinated.

Timeline

TecraBot Timeline

TASK ID	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION IN DAYS	PCT OF TASK COMPLETE
1	**Media** 🎬					
1.1	Short Animation	Ganesh	10/22/24	11/10/24	39 Days	100%
1.1.1	Video progress edit / week	Syamil	10/28/24	12/22/24	55 Days	95%
1.2	Portofolio	Alif	10/31/24	11/24/24	55 Days	100%
1.3	**Instagram Posts**	Rozan & Alif				
1.3.1	Fun fact	Rozan	10/22/24	11/04/24	7 Days	100%
1.3.2	Win - Lose system		10/22/24	11/02/24	2 Days	100%
1.3.4	About the game	Alif	10/23/24	10/25/24	2 Days	100%
1.3.5	Jersey Reveal		10/24/24	10/24/24	1 Days	100%
1.3.6	Scoring system		10/23/24	10/25/24	2 Days	100%
1.4	**Merchandise**	Ganesh				
1.4.1	Keychain - CANCELED		11/06/24	11/14/24	8 Days	0%
1.4.2	Sticker		11/06/24	11/14/24	8 Days	100%
1.5	**Decoration**					
1.5.1	Flag		10/22/24	10/22/24	1 Days	100%
1.5.2	Backdrop Banner		10/22/24	10/30/24	1 Days	100%
1.5.3	Figure Display "Owl Man"		10/22/24	10/30/24	39 Days	100%
1.5.4	X Banner		10/22/24	10/30/24	1 Days	100%
1.6	**Mics**					
1.6.1	Cover EB / Portofolio		10/31/24	10/31/24	1 Days	100%

October																				November
WEEK 1							WEEK 2							WEEK 3						
M-28	T-29	W-30	T-31	F-1	S-2	S-3	M-4	T-5	W-6	T-7	F-8	S-9	S-10	M-11	T-12	W-13	T-14	F-15	S-16	S-17

- **Interviews: FT. #21572 & #21574**

Every Friday for the pas 6 weeks, we, Tecraknight, and Full Steam Ahead share our progress and experiences from the FTC (FIRST Tech Challenge) competition. This practice encourages reflection, collaboration, and the exchange of ideas, helping teams grow and learn from each other. It fosters a supportive environment where challenges are discussed, solutions are explored, and teamwork is strengthened.

Things we improved since last year

- Better Planning: Every Monday, we ensure that each role has a clear plan for the tasks to be accomplished. A manager oversees this process to ensure everything is well-coordinated.
- Discussing Progress in Meetings: During each meeting, we discuss what has been done, what needs to be done, and what is still pending.
- Documenting Progress: We document all progress in the form of photos and videos. These are later shared on social media to showcase our work.
- Fairly Distributing Roles: We assign multiple people to roles rather than relying on just one person to ensure a fair distribution of workload.
- Using Custom Materials: By using custom materials, we can create more effective designs and have greater freedom in our creative process.

Our Approach on Designing the Robot

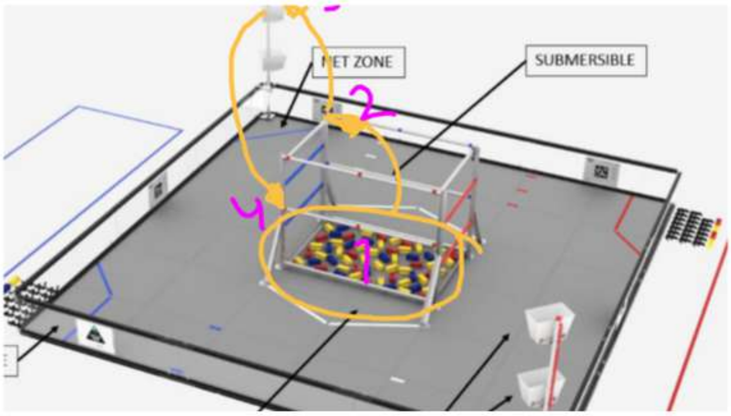
- ***Don't Get Greedy.*** From last season in Centerstage we learned that it is best to **narrow our focus on the robot to only doing a single job only, consistently**. Rather than focusing on every other task that eventually will not be done optimally by the robot.

- ***Reliability Is First.*** Our design choices for the mechanism we are using in our robot is based on **how reliable it will work in the worst or unexpected scenario possible**. Because usually that's what we are going to end up in competitions, and we need to counteract without going into panic mode.

- ***Eazy.*** Compact is one thing, but easy to repair and oversight problems are top tier. We try to create a design which is fairly **modular, easy to fix, and not too hard to build**. Complexity is unavoidable, but we try to reduce it as much as possible after the build/assembly process.

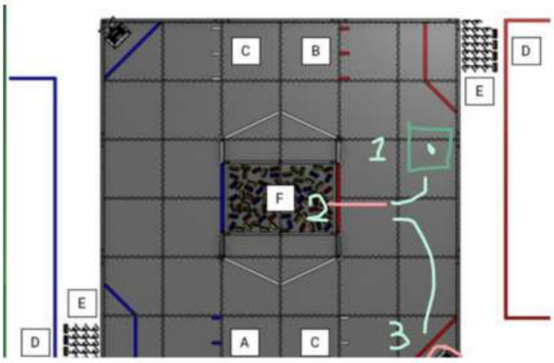
- ***Programmer ~~Nightmare~~ Dream.*** Our team are a fan of simple controls. We love to create **system that is controlled mechanically**, rather than creating a nightmare for the programmer. This also create less hassle when errors happened.

General Game Strategy



Basket Cycle, Controlling The Submersible

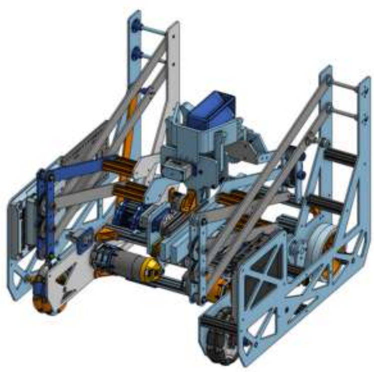
With this year's season, Into The Deep, We notice that **whoever control the submersible, won**. To control it, the most effective method is to **cycle the high basket**, as it require the least action todo and keep the submersible busy because its very fast cycle. We also see many potentials within this cycle, as it **provide lots of room to play with**. Any playstyle suits this cycle. Playing defend, attack, and other, is very possible.



Design Process - CAD's First!

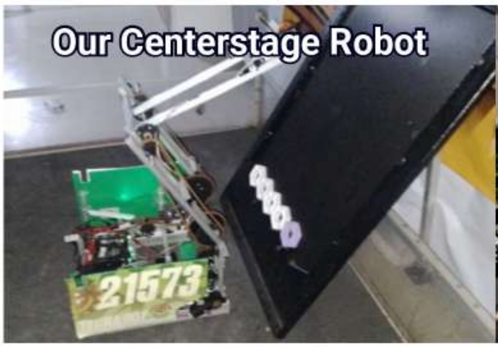
What we learn from previous years is, **CAD is number 1**. While that sound obvious, for the last two years of our team founding, **we are used to the build oriented culture-**–of constant real-world prototyping, without any clear visualized goal on what we want the robot going to be, everything depends on how we made our prototypes.

So, in this year, we really prioritize the brainstorming and design process, by **spending 1 month solely on it**, to be more thoughtful in our design choices. This change really brought many improvement for us, such as **faster prototyping**, **less error** in the build process, opportunities for more **3d printed parts** and other **custom manufactured parts**



Our robot full CAD, finished 1+ month after kickoff

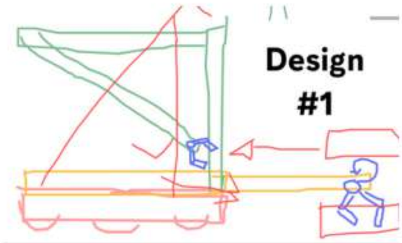
#1, Searching for Inspirations

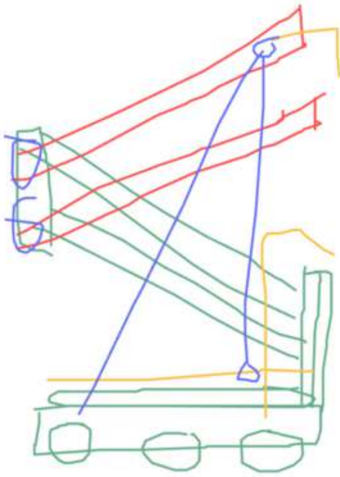


FTC Discord Server

In our design process, we first lookout for inspiration from other teams robots. What we are looking for, is a mechanism that **could intake and outtake reliably with minimal usage of actuators**, two mechanism we are interested in is the **boxtube elevator by #16379** and the **DR4B linkage by #11115**. We lookout for inspiration by searching through youtubes and prominently the Unofficial FTC Discord server, where we also connect with other teams.

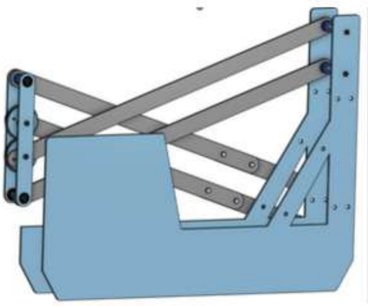
#2, Basic Sketches / Brainstorming

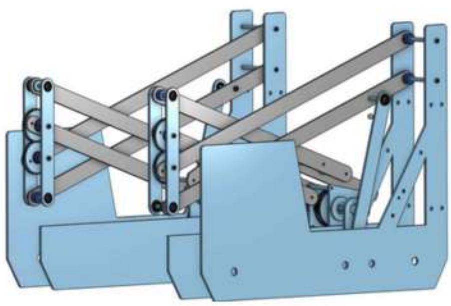


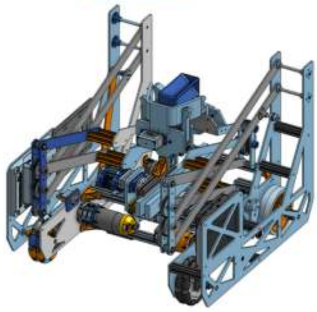


We then made concept sketches on our main ideas, to further visualize our ideas and see what fits best for our needs. With three main ideas, we chose the DR4B linkage + a linear slide, as its fits our criteria the best (as in our approach of design). The linkage only uses 1 motor and also allows for other mechanism to fit inside it (eg. ascent pulley).

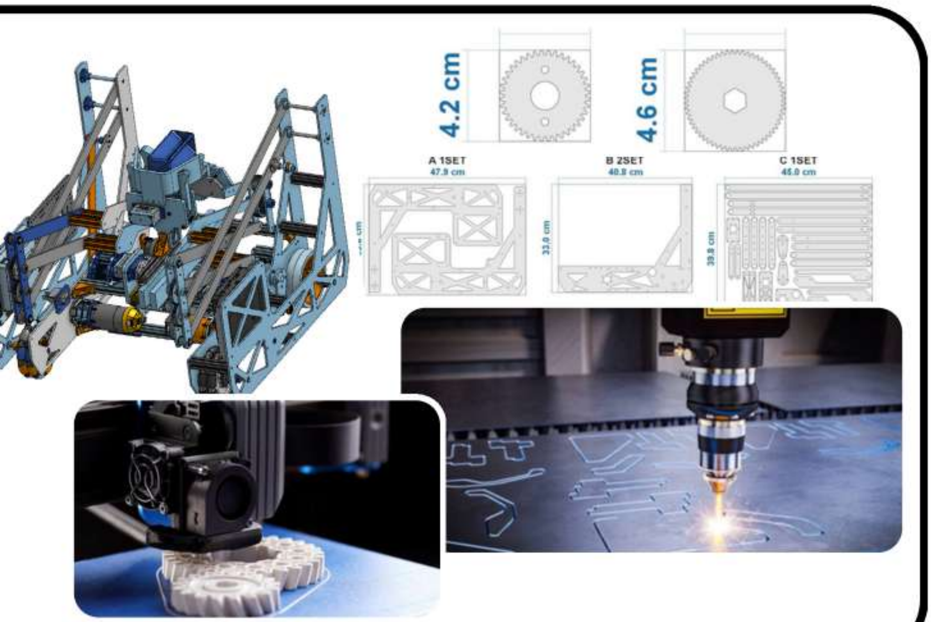
#3, CAD Evolution







After deciding on what main mechanism to use with, we then moved on the CAD process, which what we learn to be the most important process by far. With CAD, we could made design faster than ever, and minimize the time to build real life prototypes. Also with CAD, we know with exact what parts to build with, to the minute precise detail.



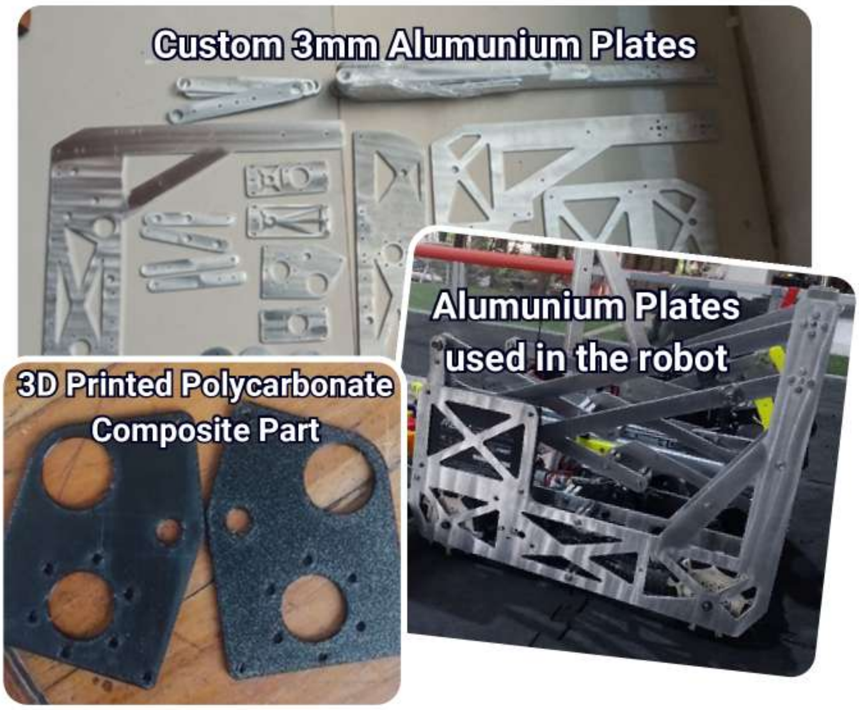
Custom Manufactured Parts

We decided for this year, to build our robot with custom manufactured parts, for most of its mechanism. We try to reduce the use of the pre-made REV Robotic parts (that our school provided) as low as possible. By creating custom manufactured parts, 3d prints, and using off-brand parts, we could maximalize the space, efficiency, and provide us with unmatched flexibility to play with. Besides all of that, this could expand our horizon of knowledge.

The parts fit us, not us fitting into what REV's provide

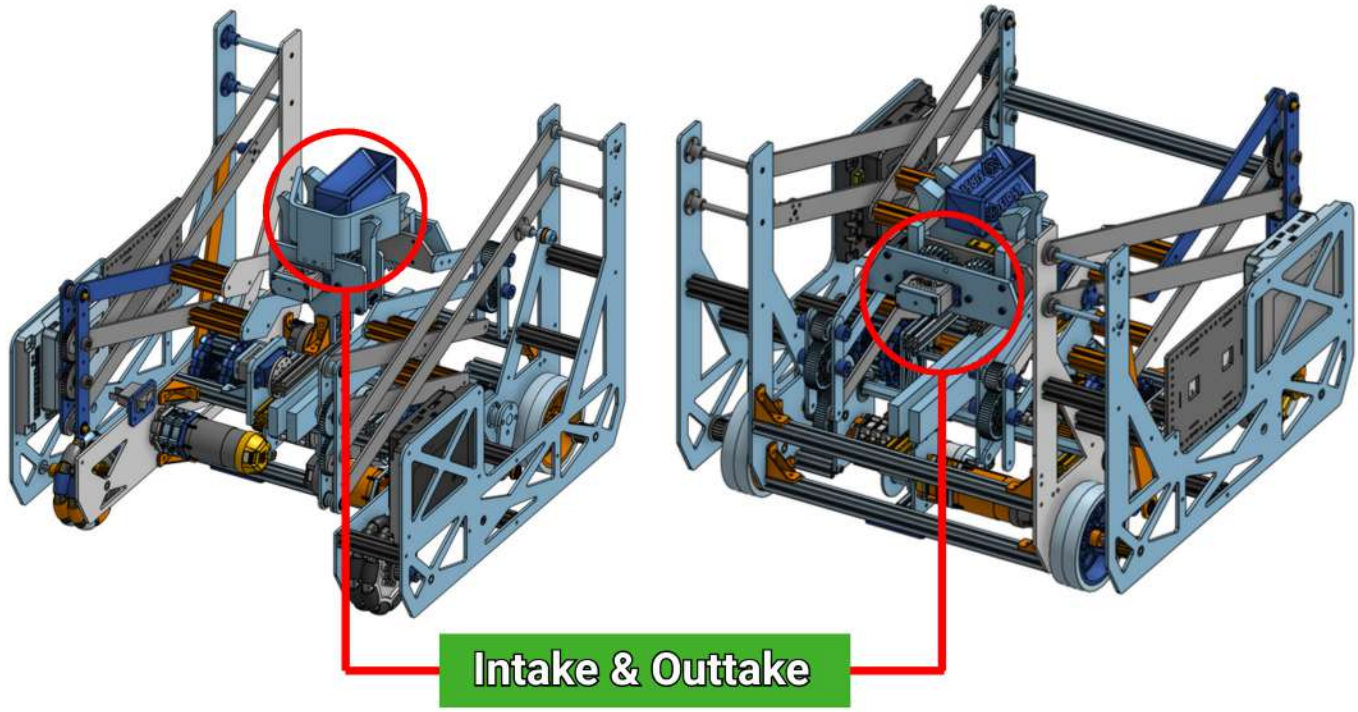
For off brand parts (which cant be replace or made with custom manufacturing), we choose MISUMI as our suppliers. As they have a large selection of parts that fits our needs. MISUMI also provide an online quoting system which made buying niche part so much easier

For our 3D Prints we had many vendors that provide us, but the most prominent one and the one we partnered up with is Filamen.co.id. They provide us with unmatched print quality and large selection of material and printing techniques to choose with.

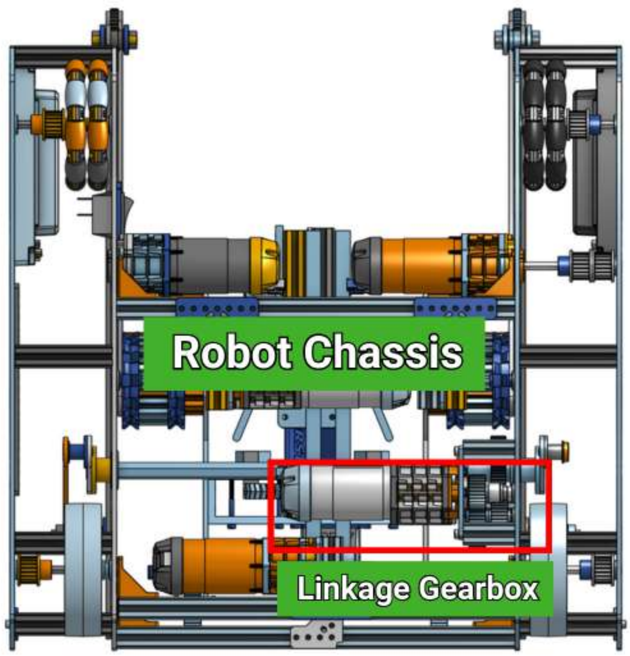


After really using the custom manufactured parts in our robot, it really change the game for us. When we had errors or change in our design, we could easily fix it in fly, as it easy to drill, cut, and etc.

Also, this season really expand our horizon on 3D Printing. As we have made 3d printed plates that support the gearbox with very high load. We use a Polycarbonate composite as its material. We thought something like this would not be possible with 3d printing.

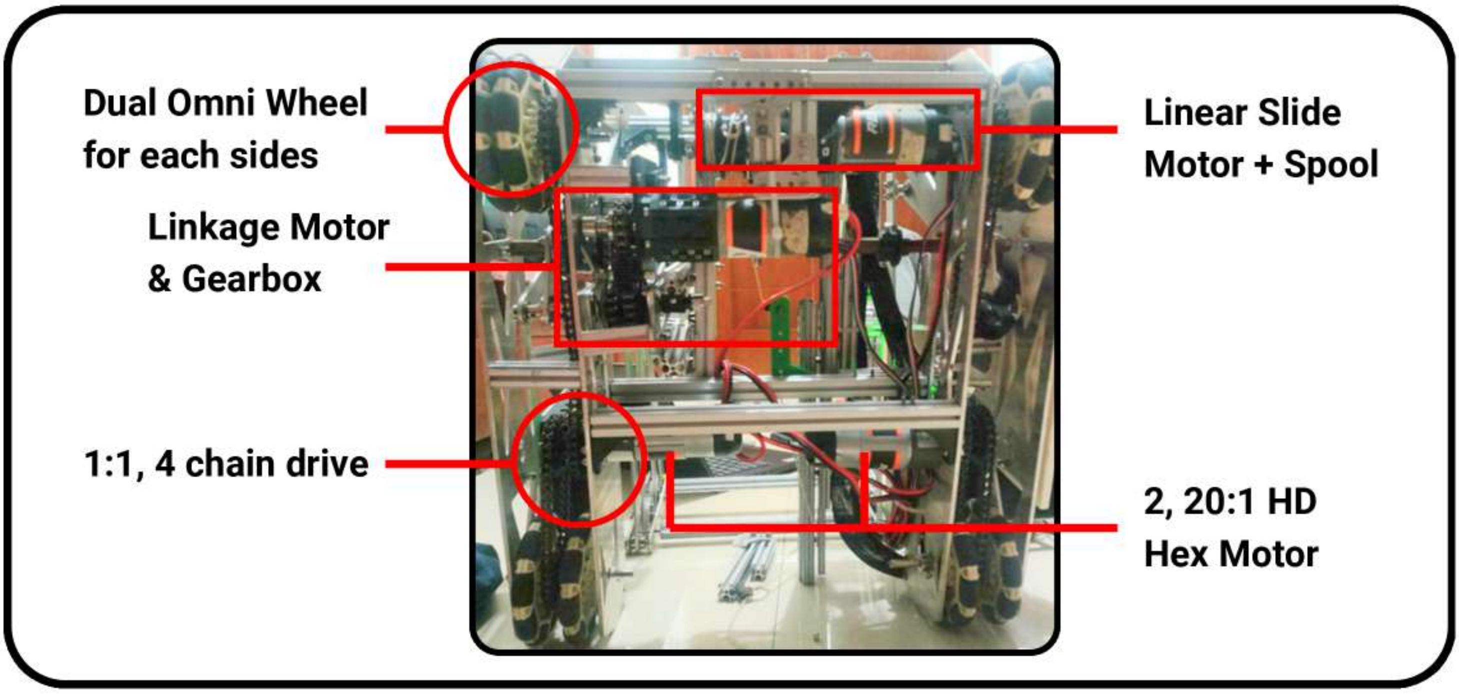


Our robot had 5 main mechanism in it. There is the double reverse 4 bar linkage that provide us with fast lateral lifts and reliable function. There is the linear slide wich could greatly reach far into the submersible. There are also the intake and outtake system, which is basically the same set of claw, just with a slightly modified mount. There is also the robot chasis which house every single mechanism reliably with it custom made plates.



Robot Overview

- Quick lateral raise by the DR4B linkage, which range around 2 secs in optimal condition)
- Intake that could rotate itself to the orientation of the samples
- Linear slide which extend the reach of the robot by 40 - 50 cm
- Fast high basket cycle, which is below 10 seconds

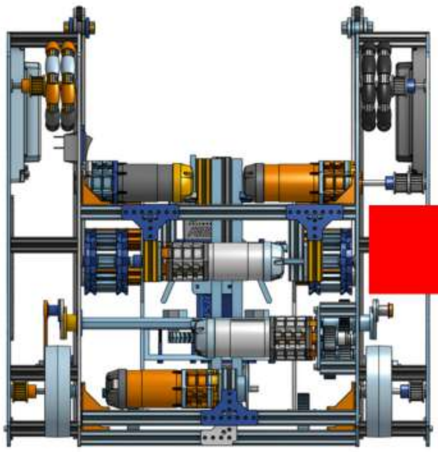


Key Features

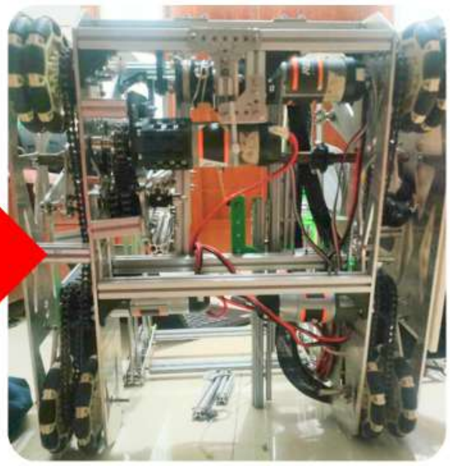
- **Fit in 40 x 40 form factor**, not max size, but not compact, as to improve the accessebilty when fixing or changing things, which really helped us when tweaking the linkage gearbox.
- **4x2 Tank Drive**, which uses dual omni wheel for each drive. While increase the chance to be easily moved by oppenent, this wheel configuration made our robot more agile and stable.
- **Fast speed**. By using 20:1 HD Hex motor with 300 rpm, and a direct chain drive to each wheel, this robot is very agile. (speed are not calculated, as we had use this configuration for years).

Why Tank Drive?

Initially, we wanted to use holonomic drives such as X-Drive and mecanum. But after some considerations, Tank drive is more suitable for our robot mechanism. By using only 2 motors, we can optimize all the mechanisms on our robot. On top of that, our driver already used to tank drive for years,



CAD Version



Finished Version

We had quite some change to our drivebase from its initial CAD design to the current version. At first our drivebase uses a belt drive with 4 omni wheel at the front and 2 grip wheel at the back, we thought this configuration could give better traction and manuevarability, but after some times using it, the belt easily slips (because its hard to tension them properly), and the grip wheel doesnt improve anything by a single bit, and made turning worse. A couple of iterations later, and we had the finished version

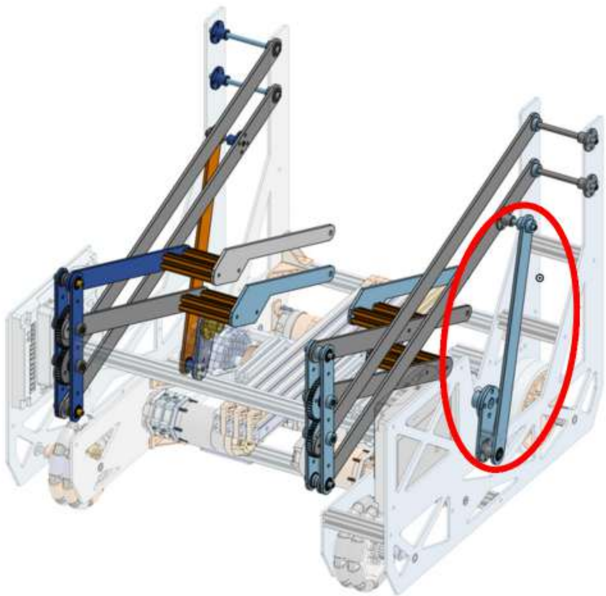
Key Features

- ***Fast lateral raise.*** Our double reverse four bar linkage can raise from its neutral point to its max height of 110cm in around 2 second.

- ***Customizable Gearbox.*** The linkage mechanism is powered by a HD Hex Motor with a builtin 4x5x5 ration and a customizable gearbox (which currently had 2.6:1 ratio). This provide sufficient amount of torque and flexibility of change on the fly.

Why Linkage?

- Linkage is way more favourable for us because of its flexibility of design. We could make it as complex, or as simple, as fast, or as slow, and as strong as we wanted it to be. The true cons is in how much space it takes, besides that it excel at every other metrics (compared to others).
- Above all, we just love any linkage mechanism, as we had been using it since last year.

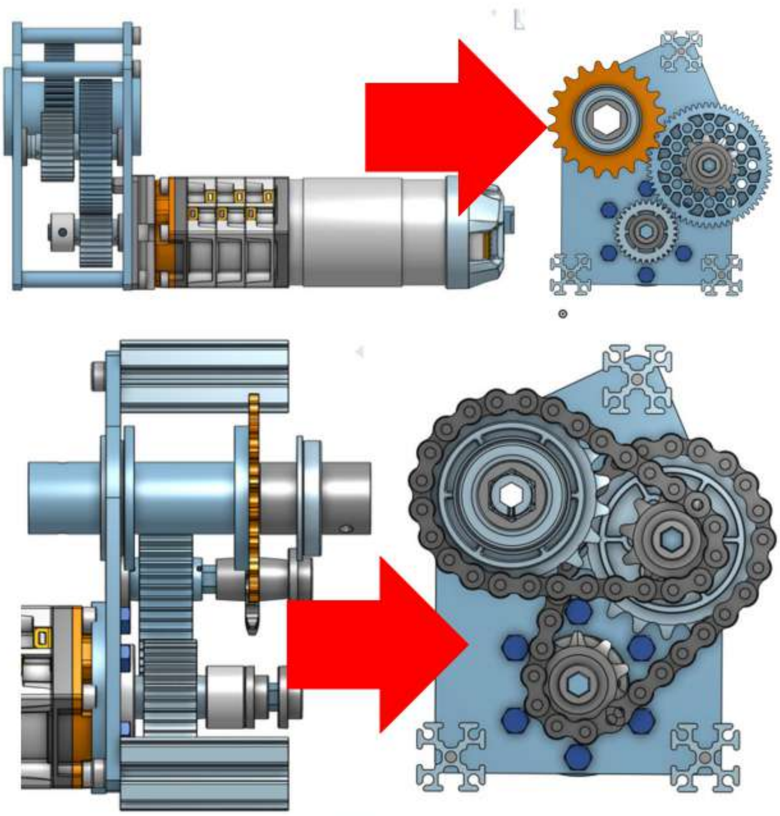


The key to being fast

So instead of plugging in the motor directly to the linkage shafts to rotate it, we use another linkage, which is a rotaty/linear one, that can provide faster rotation to the linkage and more robust support, this also means that the motor only need to rotate by less than 180 degree (not full rotation). So the heavy

Calculator we made to design the linkage

\We made our own gearbox calculator using python (which we later realize could be easily done in a spreadsheet). This calculator could give us what gearbox configuration we need according to the linkage design.



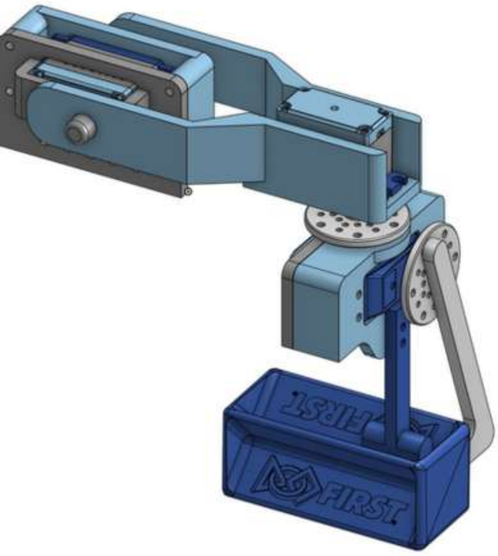
Design Iteration

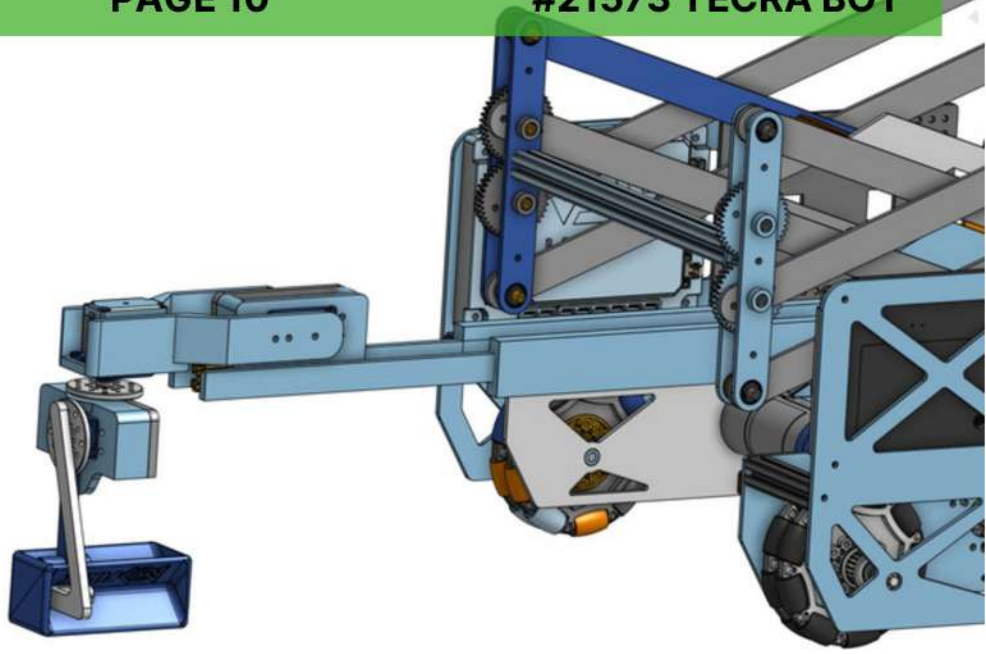
Our gearbox went alot of design iterations, from using gears to now using sprocket (chain drive). Moving to chain help us reduce gear slips and better mantain the overall health of the gearbox. We also fabricate custom metal sprocket so that it is strong and fit our 10mm hex shaft that drive the rotary linkage.

We also uses quite a few maths (built in calculators) in our gearbox to ensure the spacing between sprockets are correct, and etc.

Lesson Learned

Gearbox teach us the most out of every other mechanism. As it teaches us why precison is important and why design should be more thoughtful, thought about more than just the functionalities, but also the building comoplexity, material choice, and playing with real -world tolerances.



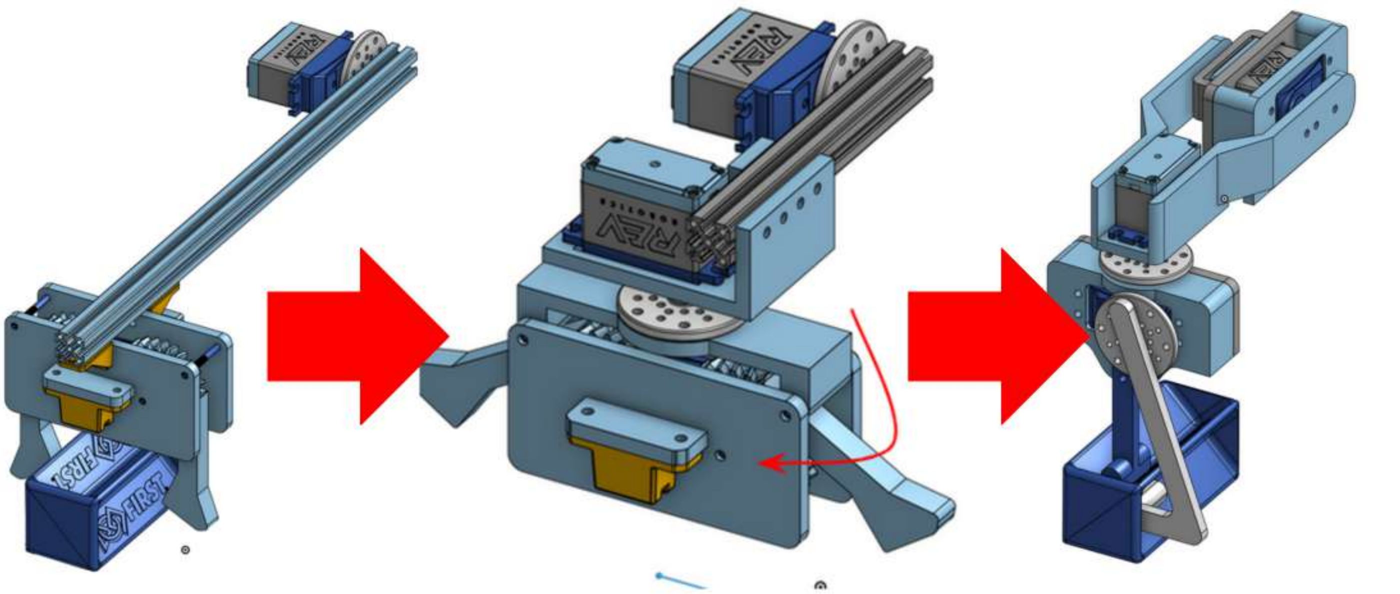


Key Features

- **Automatic Orientation:** Effortlessly adjusts its position to ensure optimal alignment and usability.
- **Pivot:** Enables fluid and precise rotation for enhanced control and versatility.
- **Wrist Fit:** Tailored to naturally adapt to the wrist, offering superior stability, efficiency, and freedom of movement.
- **Perfect Fit:** Seamlessly integrates to deliver a flawless and secure fit.

"Chopstick" Intake

We utilize a "chopstick intake" design to ensure easy fitting to the sample. Its slim shape enhances visibility from the driver's point of view and minimizes movement for precise alignment with the sample.



CAD Version, Claw + Arm **First Version, Pivot Claw** **Second Version, Chopstick**

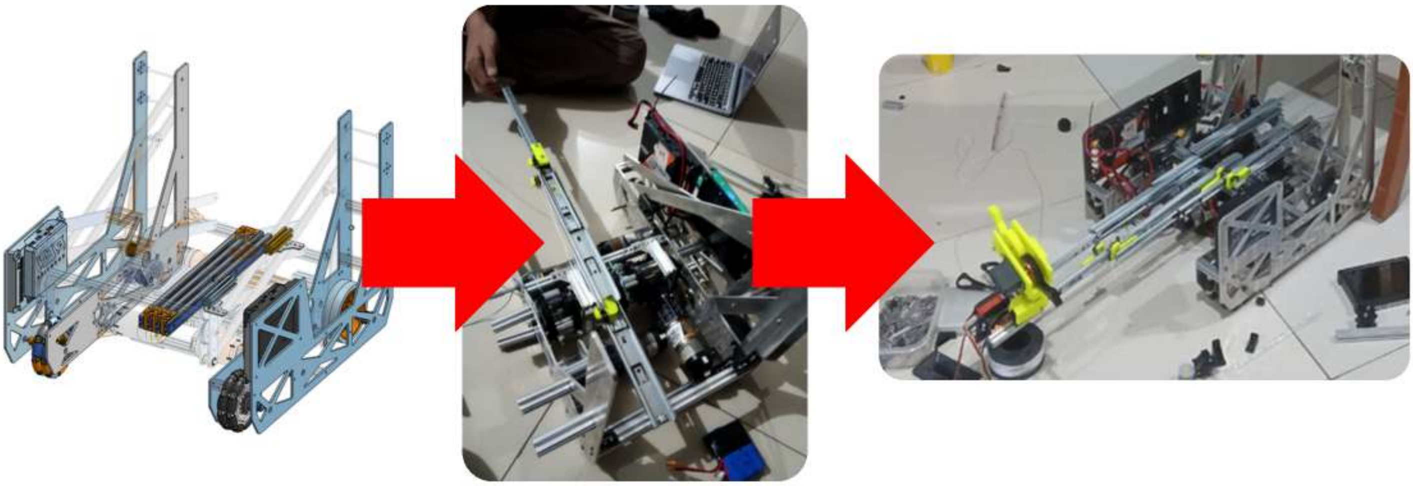
In the first design, we used one servo for the claw and another servo for the wrist/arm. In the second design, we added a pivot with an additional servo to make sample retrieval easier. For our final design, we implemented a "chopstick claw" to reduce the overall size and weight. Its slimmer shape focuses the control on a single point, making it more efficient and lightweight.

Key Features

- Fast Extension: The linear slide is engineered to fully extend in under 1 second, providing rapid and efficient performance for time-sensitive operations.
- Enhanced Stability: Featuring a dual-slider structure, the design ensures maximum stability and minimizes flex or wobble during movement, even under load.
- Custom Slider Bracket: A specially designed bracket enhances the slide's overall structure, offering a clean, organized, and polished appearance while ensuring precise alignment and secure functionality.

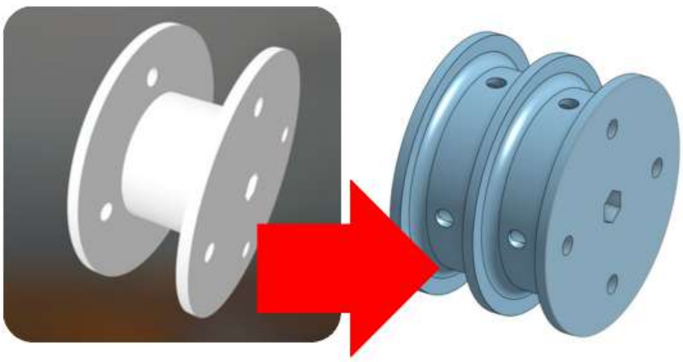
Drawer Slides

We decided for this season we experiment using drawer slides. Initially we wanted to use the MiSUMi slides as its the FTC golden standard for slides, but after alot of consideration and looking for other option, we opted to a cheap local Huben slides, which is already robust enough for our needs. As we had a lot more room for modification.



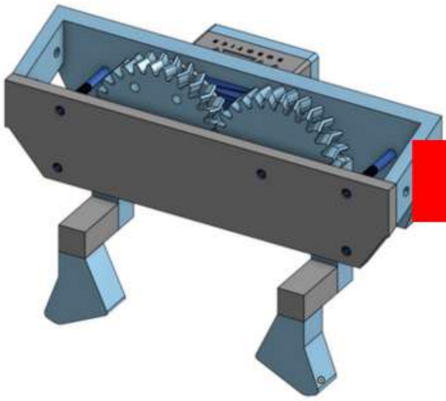
Spool Design

In our initial spool design, we used a single large side. However, in the second design, we upgraded to a dual-sided spool to ensure the cord moves forward and backward more smoothly and stays neatly organized.



Promising mechanisms which we fail to deliver

Claw Outtake



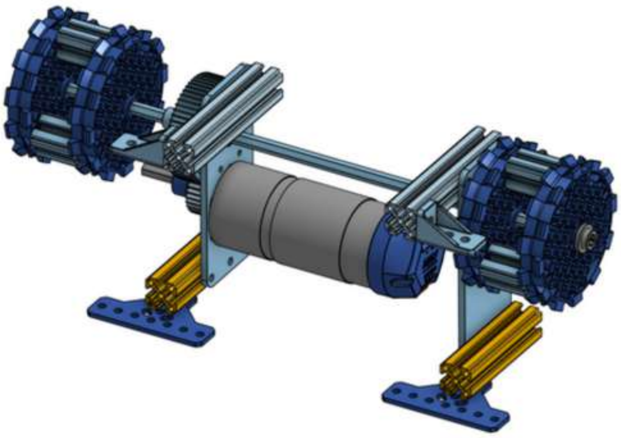
Bucket Outtake

Unfinished Version

We actually have another version ongoing, but fail to deliver it on time. This version is a bucket + claw hybrid which not only could score sample on high basket, but also high chamber for specimen.

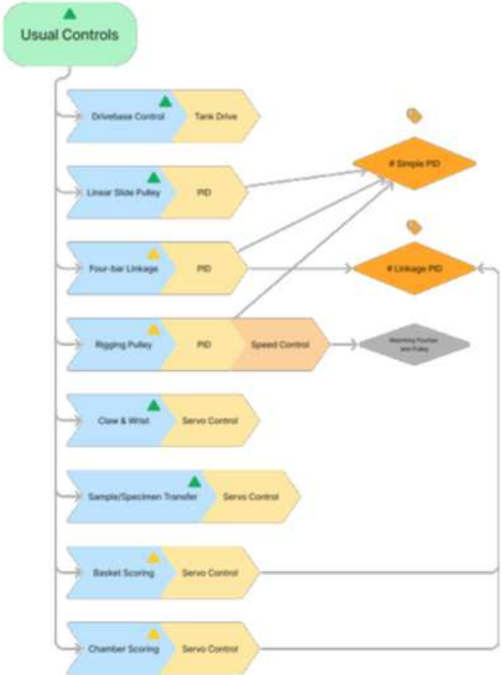
We had significantly less time to develop and test the outtake compared to other mechanisms, hence the claw outtake is very early in its design phase and quite inefficient. In contrast, the bucket design, though developed at the last minute, has shown to be a simpler and more efficient alternative. It definitely had lots of drawbacks, but at the very least still could do its job pretty well compared to the claw design.

Ascent Pulley, the reason we ditched it



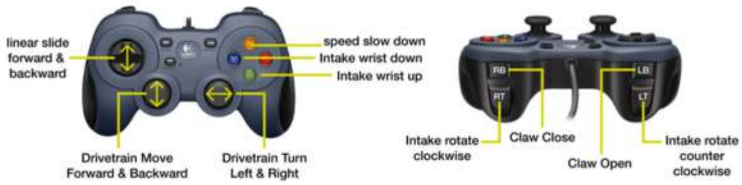
We decided not to use the ascent pulley because scoring samples proved to be a more efficient approach. Additionally, we repurposed the motor for a more practical application by integrating it into the linkage system. The pulley system also posed space constraints and raised concerns about its pulling power, as it relied on gears instead of a chain. Lastly, time limitations prevented us from fully developing and optimizing the whole system.

The ascent pulley and the outtake mechanism really teach us a lesson on how to deliver on time and what to do best in times where clock is ticking fast.

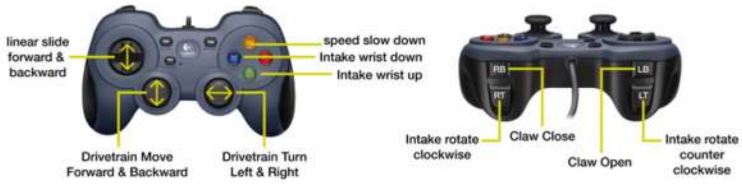


CONTROLS

Player 1 (Movement, Intake, (claw, wrist & pivot), Linear slide)

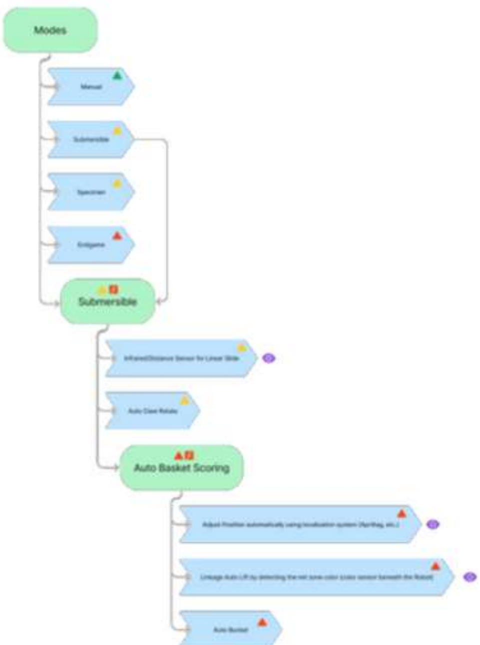


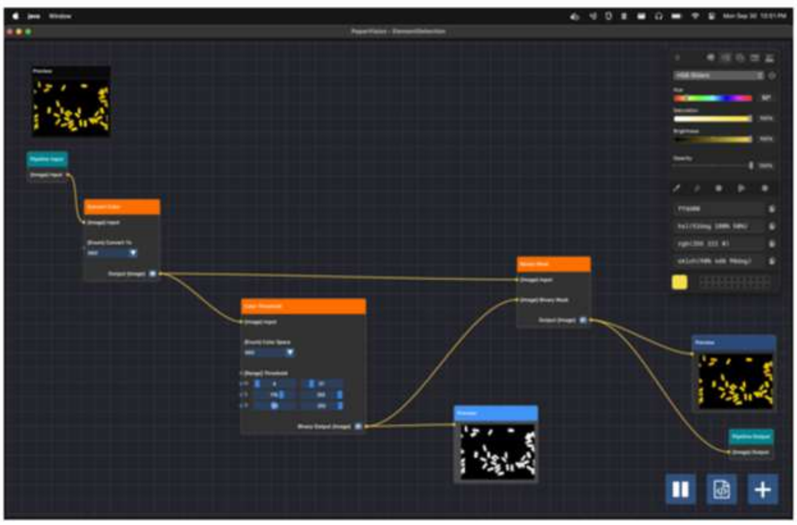
Player 2 Linkage, Outtake, Rigging



The workflow is composed of Controls, Modes, and Functions utilized within the Program. Each green node represents a specific function of the robot's control mechanism, such as the Rigging Pulley, which features both PID Control and Speed Control.

The triangle markers within the workflow serve to indicate the difficulty or priority of each task: a green triangle denotes an Easy/Main Priority Function, a yellow triangle signifies a Medium/Secondary Priority Function, and a red triangle indicates a Hard/Tertiary Priority Function. This Programming Workflow is designed to help the programmer prioritize tasks in a flowchart format, clearly outlining the order of operations.





DRIVEBASE & LINEAR SLIDE B.O.M

Name	Codename	Cost of unit (Rp)	QTY	Total	Link	Ongkir
Drivebase Plate 3mm	None	1,280,000.00	1	1,280,000.00	https://www.toko	0.00
HTD3M 24T ID 8 OD 26 - Pulley	None	36,900.00	8	295,200.00	https://www.toko	16,000.00
HTD3M Belt 396 mm	C-HTBN264H3M	30,754.00	2	61,508.00	https://id.misumi	0.00
HTD3M Belt 483mm	C-HTBN483H3M	49,129.00	2	98,258.00	c.com/vona2/det	0.00
Misumi SAR230 Drawer Slide	SAR230	267,733.00	4	1,070,932.00	https://id.misumi	0.00
V623ZZ V Groove Ball Bearing	V623ZZ	8,500.00	5	42,500.00	https://www.toko	7,000.00
TOTAL COST FOR DRIVEBASE & LINEAR SLIDE				Rp2,848,398		Rp23,000

Linkage B.O.M

Name	Codename	Cost of unit (Rp)	QTY	Total	Link	Ongkir
Laser Cutting - Bars & Plate 3mm	None	700,000.00	1	700,000.00	https://www.toko	0
Laser Cutting - Pinions 5mm	None	55,000.00	4	220,000.00	https://www.toko	0
Laser Cutting - Gear 10mm	None	90,000.00	1	90,000.00	https://www.toko	0
3D Prints	None	Free	1		Rafi & Yodha	0
Rod S45C (/100mm)	RDOC5-100	24,862.00	8	198,896.00	https://id.misumi	0
Ball Bearing flange ID 5 OD 13	F695 ZZ	9,000.00	20	180,000.00	https://www.toko	7000
Flange Ball bearing ID 15 OD 24	C-EFL6802ZZ	30,370.00	2	60,740.00	https://id.misumi	0
Drive Shaft (Misumi-S45C)	RDRC10-350	65,021.00	1	65,021.00	https://id.misumi	0
Drive Shaft coupling ID 12	None	32,000.00	2	64,000.00	https://www.toko	14500
Shaft coupling ID 5	None	10,000.00	6	60,000.00	https://www.toko	16000
Shaft Collar ID 7mm	None	5,000.00	20	100,000.00	https://www.toko	14500
M3 Screw (from school/buy)	None	0.00	26	0.00		0
Nyloc Nut (school)	None	0.00	42	0.00		0
M4 Screw	None	500.00	10	5,000.00	https://www.toko	8000
M2.5 Screw (for coupling)	None	600.00	24	14,400.00	https://www.toko	10000
TOTAL COST FOR LINKAGE				Rp1,758,057		Rp70,000
TOTAL COST FOR ENTIRE ROBOT				Rp4,606,455		

Budgeting

With a robot almost full of custom fabricated parts, budgeting is important for us, as it allow us to project how much we will spend and see what could be replaced to reduce cost. Such as when we initially wanted to use MiSUMi slides, which fit our budget but left very small cap space for emergency/unexpected cost. Our decision to ditch it turn out to be the best, because we ended up spending 1.25x our plan.

Our main source of funds

Prominently, we are funded by ourselves. Almost all of our budget comes from parent, friends, and families, especially for our fabricated parts. The reason for this self-fund is because we didnt really have any intention to get sponsorship as the window of time is very tight.

Our school funds

Besides self funding, all of our REV's robotic parts are thankfully funded by our school. As our school had been competing years in FIRST (not only FTC, but also FGC and FRC). This really reduced our cost too.

Connect & Collaborate with Others

Our school organized an FTC (First Tech Challenge) scrimmage with teams from Depok and Jogja. This scrimmage provided a valuable opportunity for us to practice, exchange ideas, and improve our skills together. During the event, each team tested their robots, explored new strategies, and received constructive feedback from others.

We also connected with people from other countries, discussing robot designs, exchanging strategies, and giving recommendations. These conversations helped us learn new perspectives and improve together.

Figure 1. Team Jersey

Figure 2. X-Banner (robot mechanism

Figure 3. X-Banner (about us)

Figure 4. Sticker pack

Figure 5. Mascot Render

Figure 6. Team Flyer

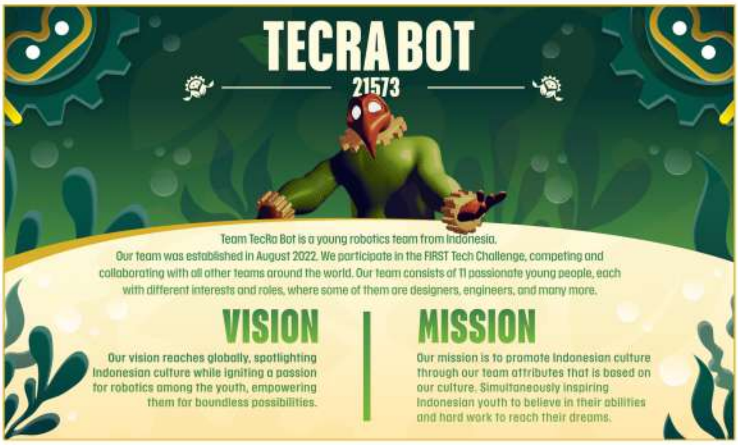


Figure 8. Backdrop Banner

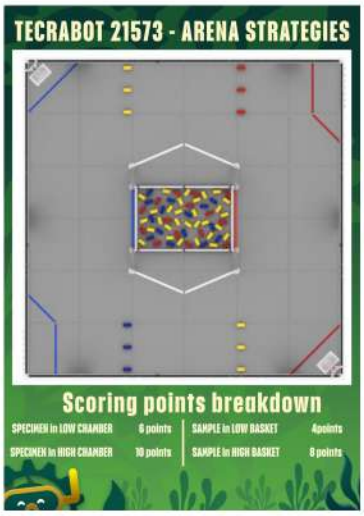


Figure 8. Arena map

Figure 7. Qr Code Scanner

Figure 9. Backdrop Banner

THANK YOU!