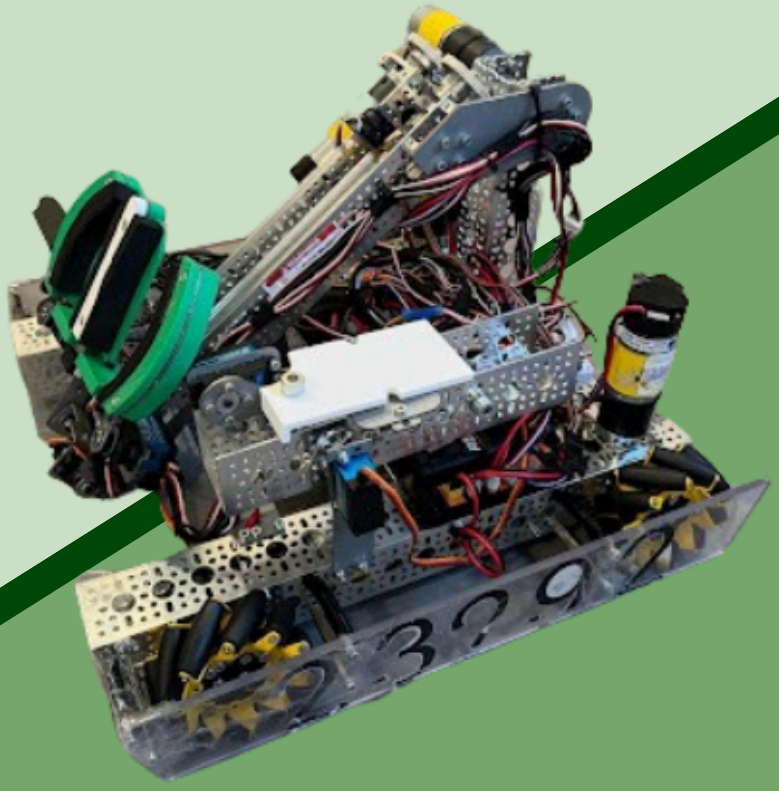
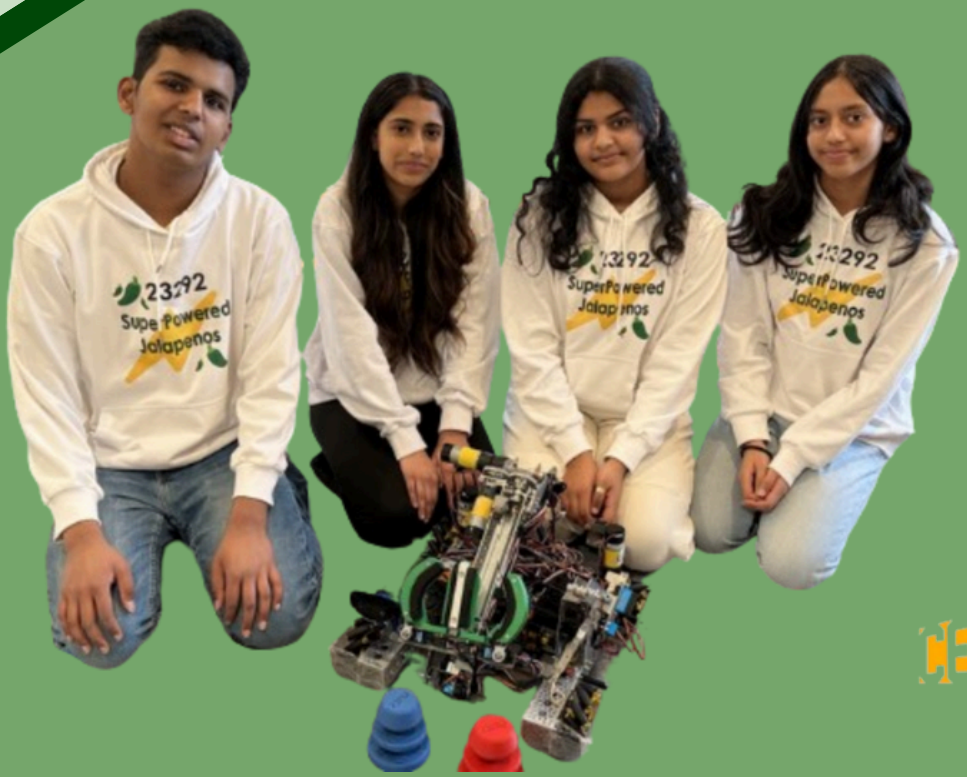
ENGINEERING PORTFOLIO

23292

FTC 2023-2024

SuperPowered Jalapeños





CENTERSTAGE

PRESENTED BY RTX

INTRODUCTION

MEET THE TEAM:

Akshara Rex (Team Captain + Hardware + Outreach)

Saachi Todur (Software + Outeach)

Nitya Payyavula (Hardware + Outreach)

Aarush Rex (Software + Outreach)

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TEAM ACHIEVEMENTS

- **Inspire Award and Winning Alliance** in FTC Peninsula League this season
- **FLL Razorback '23- Core Values Finalist Award**
- FLL NorCal **Regional Championship** '23 - **2nd place Champions Award**
- **Jacobs Teen Innovation Competition** - '23 **Photonics Award** for solar powered GPS tracker/phone charger: **Donated prize money ($1000)** to Pratham - organization that supports education for underprivileged children in India - support 1.2 million children
- FLL - 2022 Innovation Project reusable lunch boxes - **worked with Santa Clara School District** to create a plan to implement reusable lunch boxes for students
- **FLL Championships for two years** ('22, '23)

DEVELOPEMENT PLANS

We divided the team based on individual interest into software and hardware. The Hardware team learned using CAD, 3D printing, CNC and water jet cutting. The Software team focused on the basics of Java, Github, Android Studio, RoadRunner and machine learning. Everyone worked together for outreach.

TEAM SCHEDULING

Subteam	M	Tu	W	Th	F	Sat	Sun
Hardware (5:00-6:30)	✓	✓	✓	✓	✓	✓	✓
Software (3:00-5:00)	✓	✓	✓	✓	✓	✓	✓
Outreach (2:00-3:00)						✓	✓

MISSION TEAM PLAN

	Goals	Outcome
Robot	• Design robot entirely in Fusion 360 CAD software • Suspend from rigging and drone mechanism by 2nd league • Use Road Runner in autonomous • Maintain a detailed engineering journal throughout the season • Learn tools and machinery to help build the robot	We successfully designed a robot in Fusion 360 that is able to rig and has a drone mechanism. We were also able to use Road Runner. We also learned how to use a waterjet cutter, CNC machine and sheet metal brake for bending.
Outreach	• Reach 1000+ people • Mentor at least 2 teams • Interact with over 20 FTC teams • Host scrimmage • Apply for grants • Reach out to FTC teams for help and scrimmage • Participate in showcase hosted by FIRST • Opportunities to teach students robotics	We empowered over 1000 people around the world by reaching out to many different teams, holding scrimmages, mentoring younger kids and donating to organizations. We also applied for 3 grants.
Sustainability	• Add more members next season. • Reach out to more schools to teach robotics • Do workshops at our local library • Host more scrimmages with other teams.	We have been participating in FIRST together for 8 years. We added 2 members this season and we plan to add more next season. We also hosted many scrimmages. Additionally, we reached out to libraries to hold workshops.

General Expenses

ITEM	COST
Registration	900
Control Hub/Driver Hub	539.04
Macanum wheels kit from gobilda	458.98
Perimeter Kit	876.24
Rev robotics battery, led controller, etc	239.04

Estimated Income

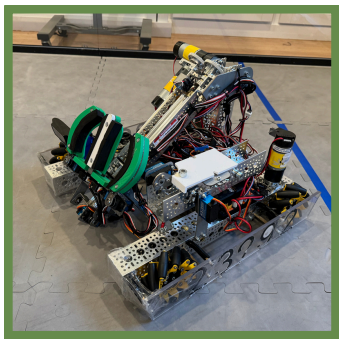
ITEM	COST
Google	6,000
Intuitive	3,000
Total Team Funds	9,000

DESIGN THE PROCESS

ROBOT REQUIREMENTS

- Pickup 2 pixels from human player or from stacks
- Drop 2 pixels on backdrop and create a mosaic
- Stack pixels up to the second line on back-drop
- Suspend on rigging for at least 20 seconds
- Launch drone reliably to zone 1 or 2

OUR DESIGN PROCESS



Brainstorming: Team members propose ideas which are discussed based on merits

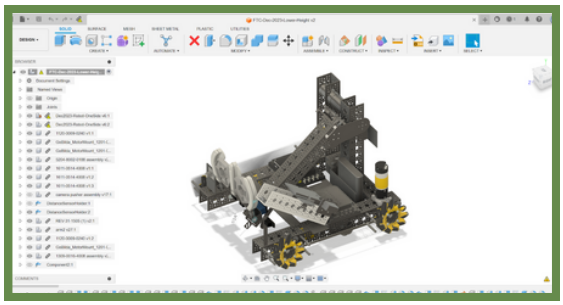
Prototypes: We model our designs using foam boards

CAD: We use Fusion 360 to model our designs and check for interference between parts and arrive at bill of materials.

Build and Test: We manufacture our parts, test them and make improvements.

FOAM MODEL

FUSION 360 - ROBOT MODEL



MATERIALS USED

Materials	Reasons for Choosing	Robot Component
Aluminum 5052	Aluminum 5052 is good for bending, as we use our Sheet Metal brake really often	Drone Mechanism
PLA Plastic	Lightweight- Used as 3D printer filament.	Claw
A653/A924 Galvanized Steel 1/16in	Galvanized Steel does not rust and is very strong.	Backbone of Claw, Hooks for suspension, Spring lock for drone mechanism
Polycarbonate	Highly resistant to impact	Side Wall
Foam	We used foam because it was lightweight and was able to grip onto pixels	Claw

MANUFACTURING PROCESS OVERVIEW

Waterjet Cutter

3D Printer

Sheet Metal Brake

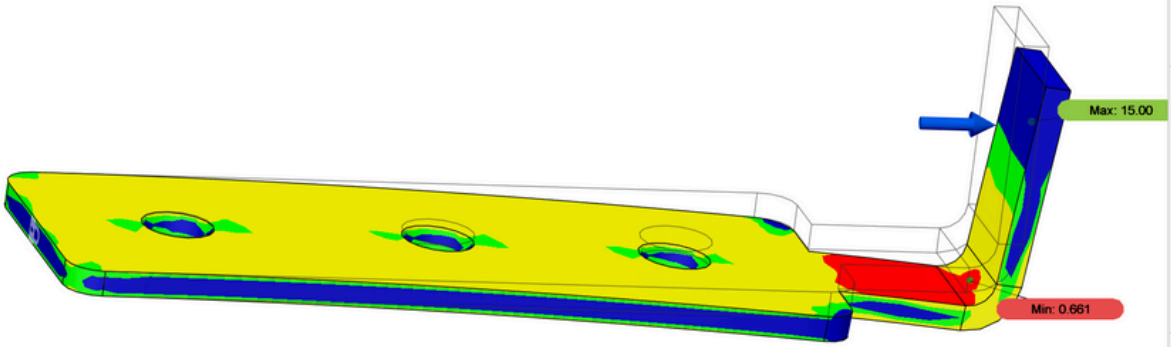
Fusion 360: Used to Design and Model Parts → **Water Jet Cutter, CNC Machine, 3D printer: To Create Parts** → **Install Component on Robot, Test, Iterate**

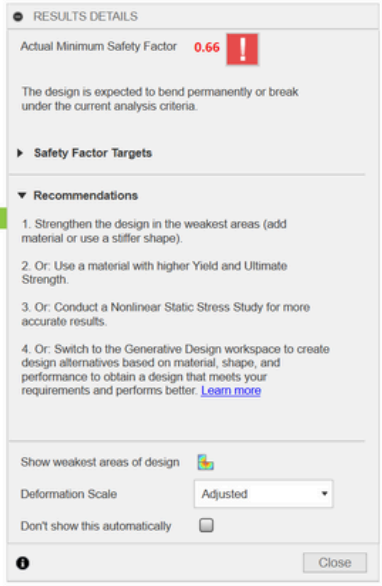
DESIGN

STATIC ANALYSIS

We used **Static Analysis Simulation** feature in Fusion 360 to determine if critical parts will be able to withstand required loads.

Below example shows the drone spring locking part in Aluminum being static stress simulation tested. Simulation result showed that it will not withstand the loads and will fail. We then switched to using steel to get a part that will withstand the 8 lb load from the spring.

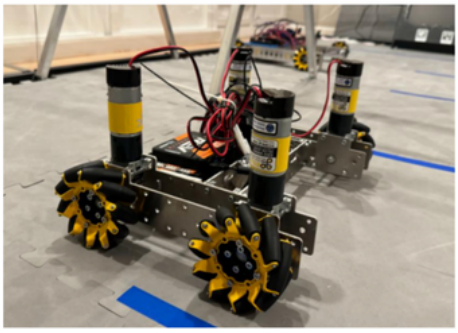




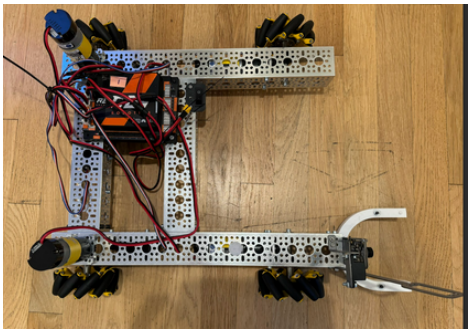
DRIVE TRAIN

Our first iteration was a fully custom built drive train. We faced issues with the bearing failing due to incorrect alignment. We then switched to GoBilda Strafer Chassis. We used 3-wheel odometry with 2 dead wheels on X axis and 1 dead wheel on Y axis to improve localization accuracy

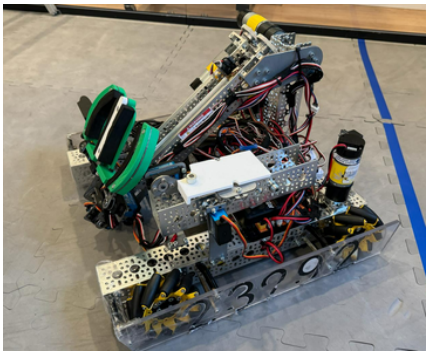
PROTOTYPE 1



PROTOTYPE 2



PROTOTYPE 3

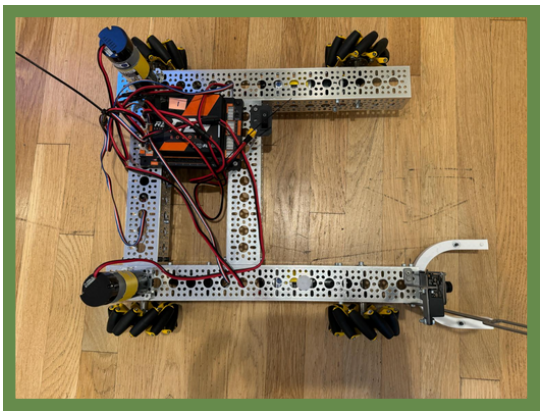


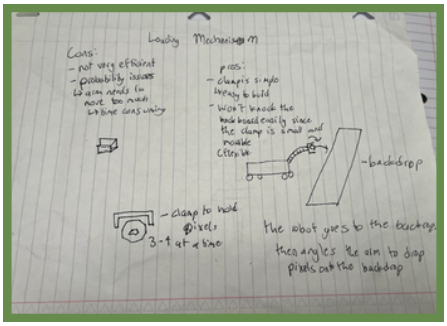
DESIGN

INTAKE MECHANISM

PROTOTYPE 1:

Our first prototype was a push bot with no arm. It pushed two stacked pixels from the human player area to the backstage. It was not able to place the pixels on the backdrop. Used For 1st League meet.

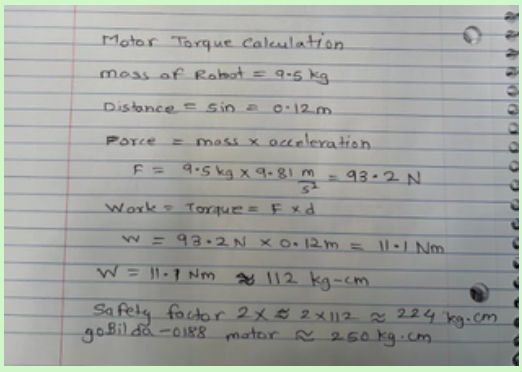




PROTOTYPE 2:

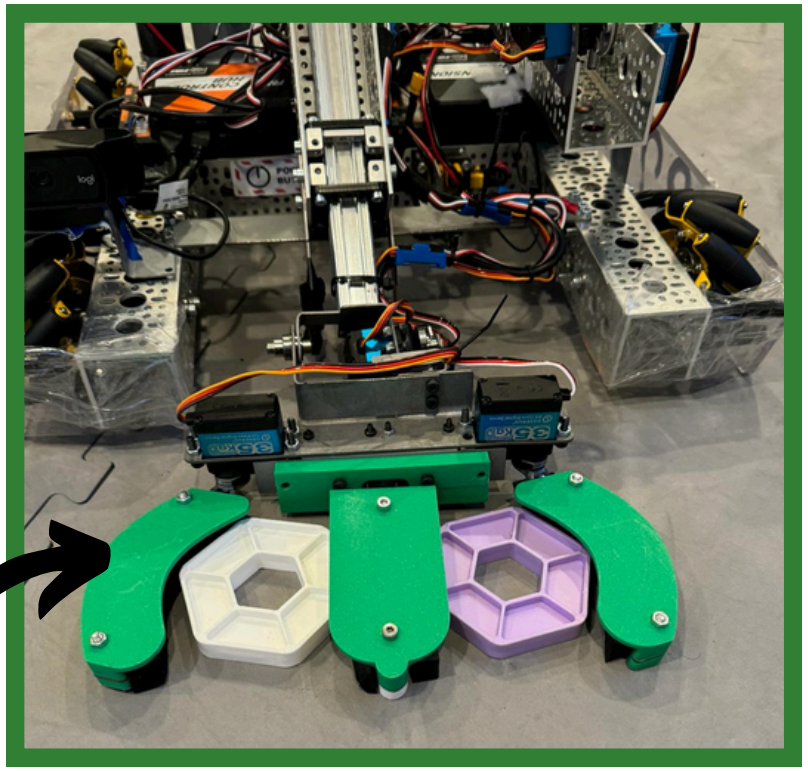
Our second prototype was a custom built intake mechanism that was able to pull pixels and place it on the backdrop using rollers. The design looked really cool but it was too slow.

MOTOR TORQUE CALCULATION



FINAL DESIGN

Our third and final prototype was a claw mechanism attached to a linear slide (arm). It collected 2 pixels simultaneously and can drop them onto the backdrop. The arm is also used for suspension from rigging.

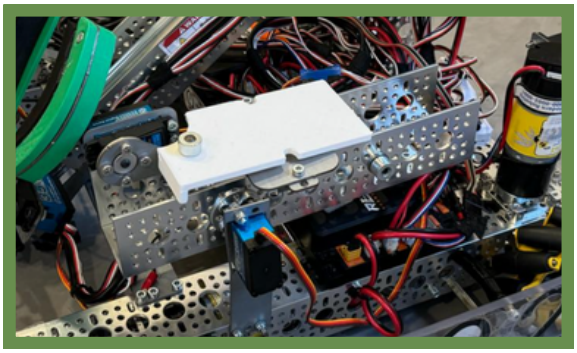


DESIGN

DRONE+RIGGING

PROTOTYPE 1:

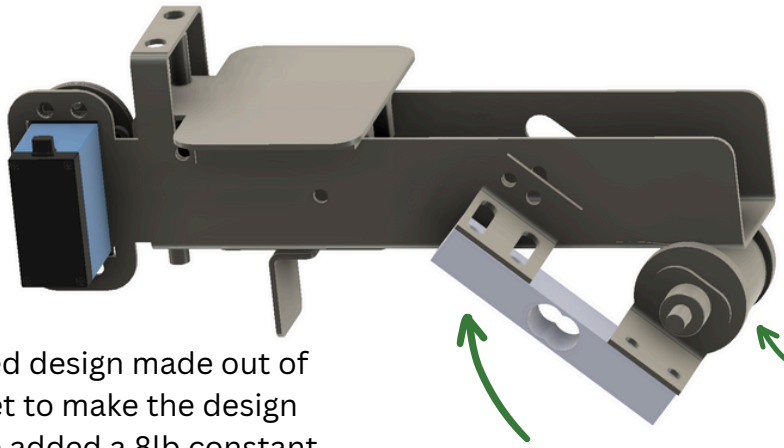
Our first prototype used two servos: one to adjust the resistance and the second to release the rubber band.
What went wrong: The mechanism was unreliable because the rubber band wouldn't rotate properly



PROTOTYPE 2:

Prototype 2: We used a screw and nut then adjust the length of the rubber band, which would impact the resistance. Added a 2nd servo to change the angle.
What went wrong: Flimsy, bulky, and reliability issues- the drone would go in different directions as the rubber band wouldn't launch the drone at the right angle.

FINAL PROTOTYPE:



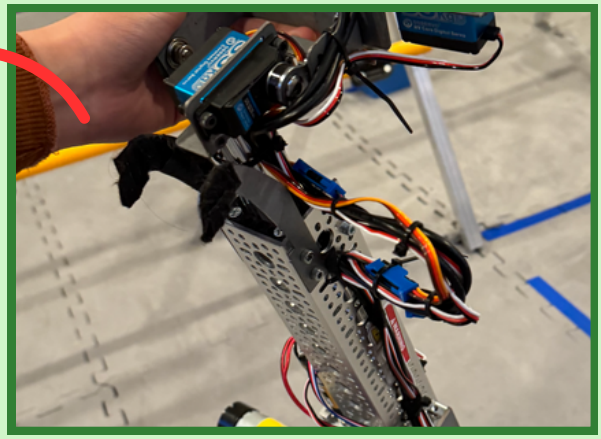
Final Prototype: A Customized design made out of aluminum and cut in waterjet to make the design smaller and more reliable. We added a 8lb constant force spring and a loadcell to accurately launch the drone in either zone 1 or 2.

Constant Force Spring provide reliable drone launches and is much better design than rubber band.

We use a Load Cell sensor to measure tension of the spring. Our software algorithm computes a running average of tension measurement to detemine if tension is within range. It lights up a RED warning LED if the tension is out of range.

SUSPENSION FROM RIGGING

Steel Hooks

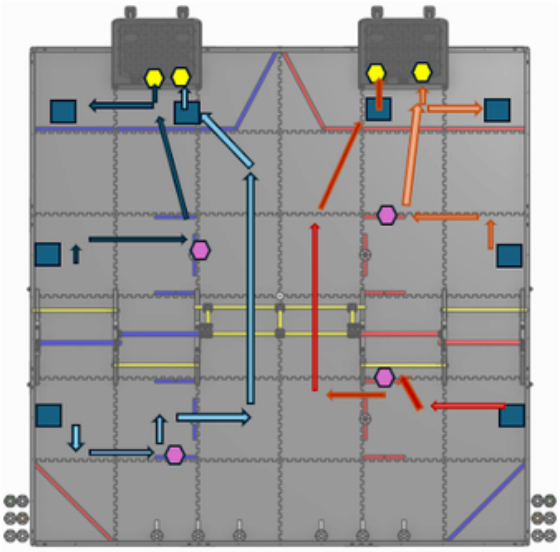


Our mechanism uses two custom-made steel hooks using waterjet cutter and when the arm moves down it grasps on to the truss to rig.

PROGRAMMING AUTONOMOUS

AUTONOMOUS RELIABLY GETS 50 POINTS

Rigorous testing to drop Yellow Pixel reliably with or without alliance pixel present in either slot.



1. Score 1 **Purple Pixel** onto the randomized spike mark with the team prop on it. **(20 points)**
2. Drop the **yellow pixel** onto the defined April Tag marker on the Backdrop. We also score points for having a pixel on the backdrop (**25 points)**
3. **Park in the backstage** area - **(5 points)**
4. Altogether, the total points received during these 30 seconds are**(50 points).**

SOFTWARE ITERATIONS:

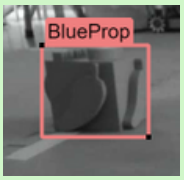
1

We used the **distance sensor** to **detect** the location of the **prop** to drop the pixel.

What went wrong?
Most of the time, we **failed** to **detect** the distance accurately. We were able to score **5-10 points** on average.

Things we learned
Distance sensors are very sensitive to the angle of obstacle and **failed** to **detect** objects when angle is slightly off

2



We used the **Arducam black and white camera** and **machine learning** to **detect** the **prop**. We **implemented** the **road runner trajectory** for moving accurately to specific coordinates to **drop** the **purple** and **yellow** pixels. (**25 points**)

What went wrong?
The camera **detected** the **wrong** object as a **prop**.

Things we learned:.
Arducam cameras are **hard** to **calibrate**. We need to **detect** the **prop** in any **location** by **controlling gain** and **exposure** during **initialization**.

3

We decided to use a **Logitech C920** colored camera to **train** the models. The reliability **increased** due to this to 100% for **prop detection**.

We implemented code to do **Prop detection** during **init that also can control gain** and **exposure** of the **camera to adjust for different room lighting.**.

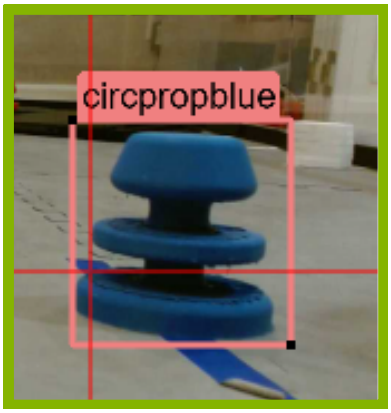
Create Trajectory to **drop purple pixel** on **randomzied spike mark**. Use **pose** of **apriltag** to **drop** the **yellow pixel accurately** on **spike mark indicator**.

Consistently scoring **50 points.**

PROGRAMMING AUTONOMOUS

TENSORFLOW

We used a machine learning library called **TensorFlow Lite** that **allowed** us to **train** model to detect our **custom prop.**



APRIL TAG DETECTION

Our arducam camera is used to detect the **desired Apriltag** to **align the robot** accurately with **pose values** (x,y,z) and to drop the yellow pixel on the appropriate slot on the backdrop.

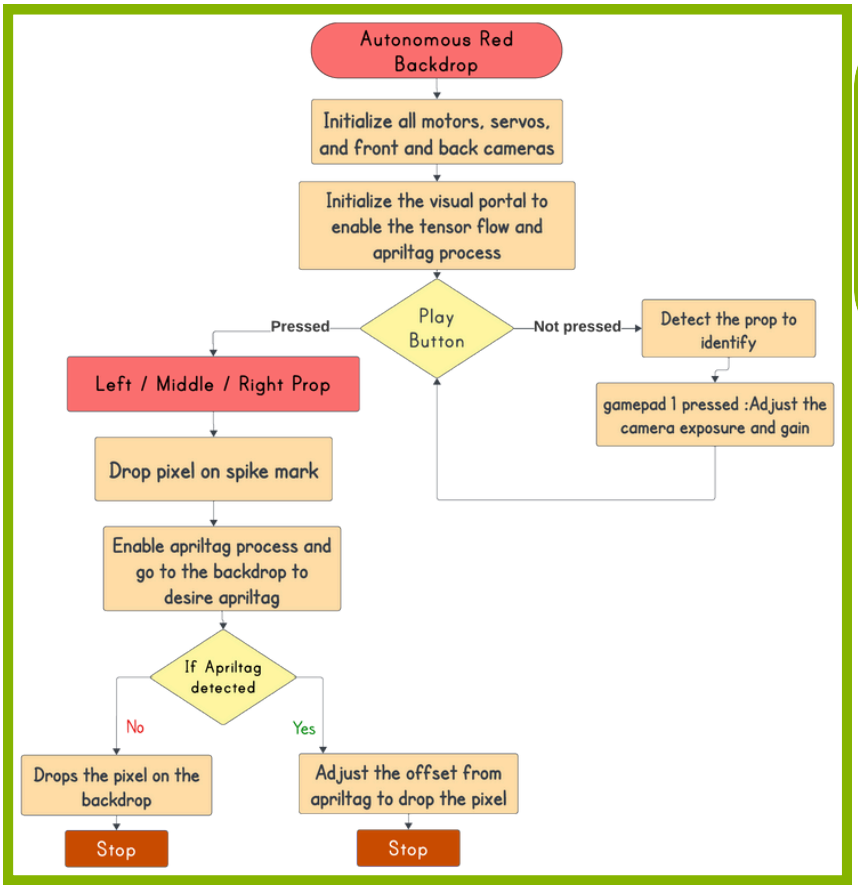
MACHINE LEARNING

We used the FTC machine learning tool chain to train a model to **detect** our **custom prop**. We converted the frame rate to **2 fps** so we only had around **30 frames** to train the model. 20% of these frames are used for object evaluation, and 80% is used for prop detection. The file size was around **5 MB.**

ROAD RUNNER

We used Road Runner to build complex paths using **Trajectories** to move in the coordinate plane accurately while controlling **velocity** and **acceleration**. We could even lift or lower arm using **parallel programming** when robot was moving to required position.

AUTONOMOUS FLOW CHART



ROAD RUNNER TESTS:

ForwardPushTest

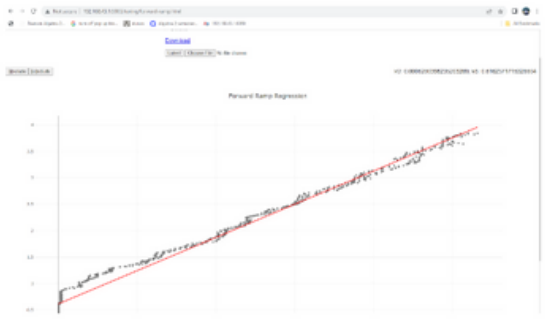
24 inch - 8112	8112/24	338 per inch
24 inch - 8030	8030/24	334 per inch
24 inch - 8074	8074/24	336.42 per inch

Avarage reading tick per inch = 336.14

Inch per tick = 1/ 336.14 = 0.002975

ForwardRampLoggerTest

```
public double kS =  0.6162371715326604;
public double kV = 0.0006280398235203289;
```



GAME STRATEGY TELE OP

SCOUTING STRATEGY

By scouting other teams we can create strategies to maximize the points we can earn in our alliance rounds.

We usually record information such as:

- Amount of points scored
- Their reliability in the autonomous period
- Their scoring strategy

We also get to know all the teams in our league, and all of our team members are included. It is also fun to watch other teams' rounds and see their robots and mechanisms.

TEAMWORK

For **autonomous**:

- We discuss with alliances which side is comfortable.
- How many points they score
- How much time it takes
- If we are in the audience side, add a delay in our code if needed

For **tele-op**:

- We come up with a pixel picking-up strategy during the Tele-op mode based on the cycle time to maximize the scoring, as well as communicating that scoring a yellow mosaic is our priority

For the **End game**:

- We check if the alliance has a drone mechanism and from where they shoot the drone
- We check if they are comfortable rigging either inside or outside

GAME STRATEGY

Our game strategy:

- scoring 50 points in autonomous either in backdrop or audience on the red and blue sides
- parking in the backstage
- driving through the truss or stage door
- making a mosaic
- picking up pixels from the human player or at any other place on the field
- launching drones and suspending from rigging In the end-game
- based on each of our teams' pixel pickup cycles, we determine which team has priority for the human player area.

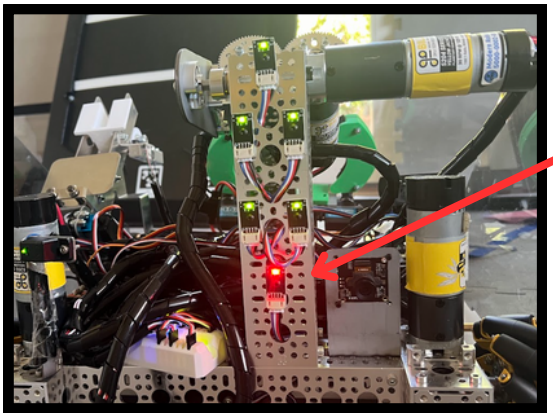
USER 1

USER 2

GAME STRATEGY SAFETY

FAULT DIAGNOSTIC USING CURRENT MEASUREMENT

We measure current consumption of all motors to determine if there are any faults in the motor or associated mechanism parts like bearings. Current consumption increases if there are mechanical issues. We display the current information using RED/GREEN LEDs on the back of the robot as visual indication if there is something faulty with the robot.

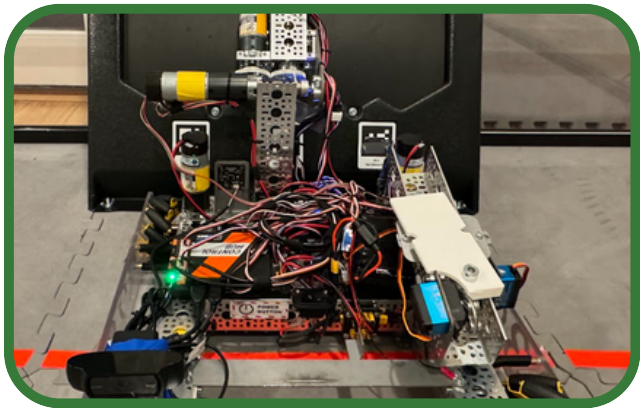


We also detect Drone spring tension using the load cell for accurate drone launching
RED LED: Not Accurate Tension
GREEN LED: Accurate Tension (4-7 mV)

LIMIT SWITCH

We use this sensor to determine the starting position of the linear Slide. This helps us because it ensures that the linear slide doesn't retract beyond its limit during the round and damages the mechanism.

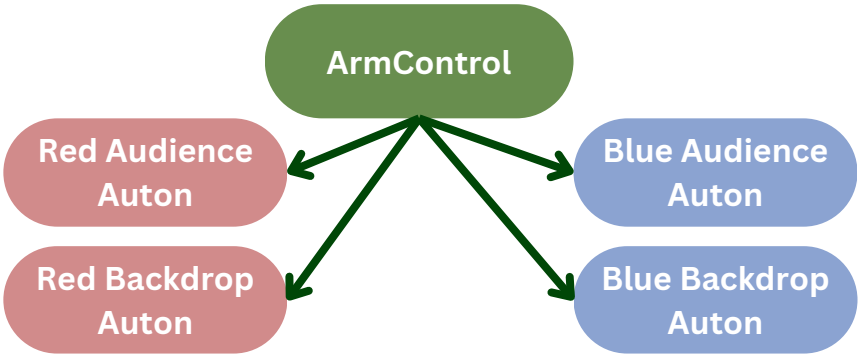
APRIL TAG POSE VALUE



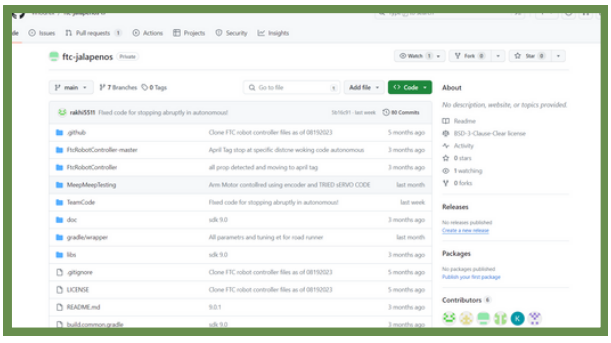
We use the April tag's pose values to align safely to the backdrop so that we are at a good distance to put down our arm on the backdrop. We control this feature by pressing the left bumper on our User 1 Gamepad.

CODE STRUCTURE

We organized our code by putting all the arm and servo control variables and functions in a separate class called ArmControl, which we could easily implement into all 4 autonomous codes. We used Andriod Studio and Github for version control.



GITHUB

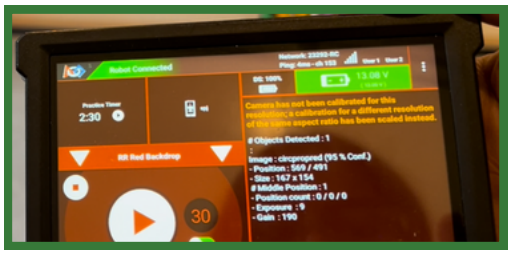


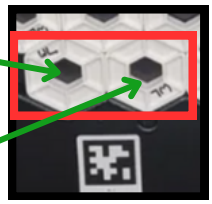
REFLECTION

TESTING / GOALS

Meet	What went well	What didn't go well	Next Step
Meet 1	• Won 4/5 games • Met many teams • 3rd place	• Autonomous code didn't work well with distance sensor. • Robot is very basic, need more functionality like rigging, drone etc.	• build intake mechanism to put pixel on backdrop • Use roadrunner • Prop detection with Camera • Develop rigging mechanism • Develop drone lunching mechanism
Meet 2	Rigging worked reliably	• Drone was unreliable • In Auto, Camera didn't detect prop well • Robot switched off after hitting another robot in the round • Human Player area was blocked	• Work on prop detction • Change camera • Solve static issue
Meet 3	• Autonomous was accurate • Highest combined autonomous score • 3rd place	• Field setup was wrong • Drone didn't work well	Always check if backdrop set up for Apriltag is not switched.

PROP DETECTION





Position 1

Position 2

CODE RELIABILITY TEST

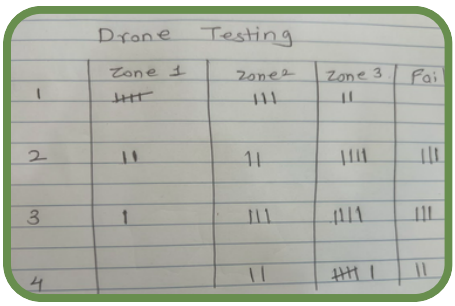
Red backdrop testing

Spike Mark	1			2			3			4			5		
Left	✓	✓	✓	✓	x	✓	x	x	x	x	✓	✓	x	✓	✓
Middle	✓	✓	✓	x	✓	✓	x	x	✓	x	x	x	✓	✓	✓
Right	✓	✓	✓	✓	x	✓	x	x	✓	x	✓	✓	✓	✓	✓

Blue Alliance Audience side Testing

Spike Mark	No Alliance Pixel			Alliance Yellow Pixel in Position 1 of 2			Alliance Pixel Yellow in position 2 of 2		
Iterations	1	2	3	1	2	3	1	2	3
Left	✓	✓	✓	✓	✓	✓	x	✓	✓
Middle	✓	✓	x	✓	✓	x	✓	✓	✓
Right	✓	✓	✓	✓	✓	✓	✓	✓	x

DRONE TESTING



ELECTROSTATIC DISCHARGE(ESD) TEST

GROUNDING WIRE

We grounded our robot wiring to the robot frame. We also protected all metal-exposed parts from coming in contact with other robots or the metal truss. We tested by crashing the robot into metal frame and other robots to ensure there are no ESD issues.

EMPOWERED 1000 + KIDS

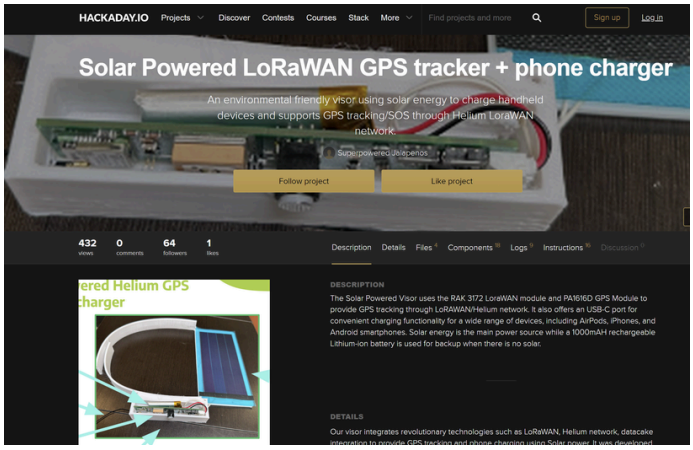
PRATHAM

JACOB'S TEEN INNOVATION:

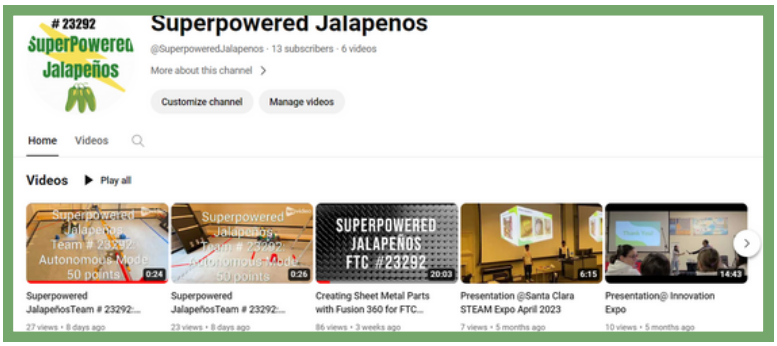
We won the **Photonics Award in the Jacobs Teen Innovation Competition** and donated the prize money **($1000)** to Pratham, an organization that supports education for over **1.2 million underprivileged children** in India.

HACKADAY

We submitted our Solar Powered LoRaWAN GPS tracker with phone charger for the Hackaday Prize 2023. Although we didn't win, we were able to connect with over 400 people through the Hackaday Website.



YOUTUBE CHANNEL



We post videos on our team's YouTube channel so we can support other teams and share the skills we acquired through our ongoing journey on FTC!

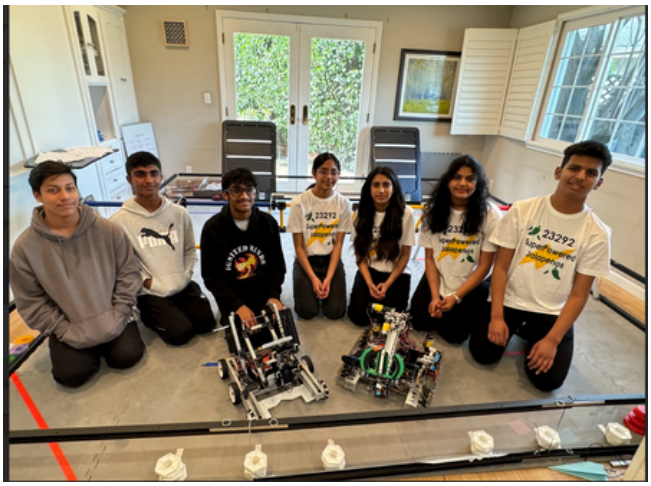
OUTREACH CONNECT

VOLUNTEERING AT FIRST

We volunteered at FLL Explorer FESTIVAL at Oakland to promote FIRST and answer questions about programs offered by FIRST.

CONNECTING WITH OTHER TEAMS:

We hosted a scrimmage with a FTC Team; Codo Dragons. We also learned Java together.



We hosted a scrimmage with another FTC Team; Ignited Minds.

THE MOMENT MAKERS

We met The Moment Makers at the Razorback Invitational when we participated in FLL. They loved our enthusiasm and motivated us to do FTC. Throughout our journey, they have been wonderful mentors.

OUTREACH COMMUNITY

YOUTH ACTIVITY CENTER VOLUNTEERING 75 + STUDENTS

Over the summer and season, we volunteered at the **Youth Activity Center**. We taught students in grades **K-8** how to build and program robots using the **SPIKE PRIME kit** and software. These **bi-weekly workshop**s helped us spread our **love for STEM**. Some students were inspired to start their own **FIRST Lego League Team.**

MENTORED 14 STUDENTS DURING THE SEASON!

MENTORING CODE CRASHERZ:

We got the amazing opportunity to mentor the FLL team Code Crasherz #60642, and they advanced to the Championships. We taught them the basics of coding and building in Spike Prime and helped them with their Innovation Project and Core Values.

MASTER CRAFT LEGO BUILDER (FLL EXPLORER MENTORING):

We are mentoring an FLL Explorer team Master Craft Lego Builder #26753. We have been teaching them how to program with Spike Prime and use sensors.