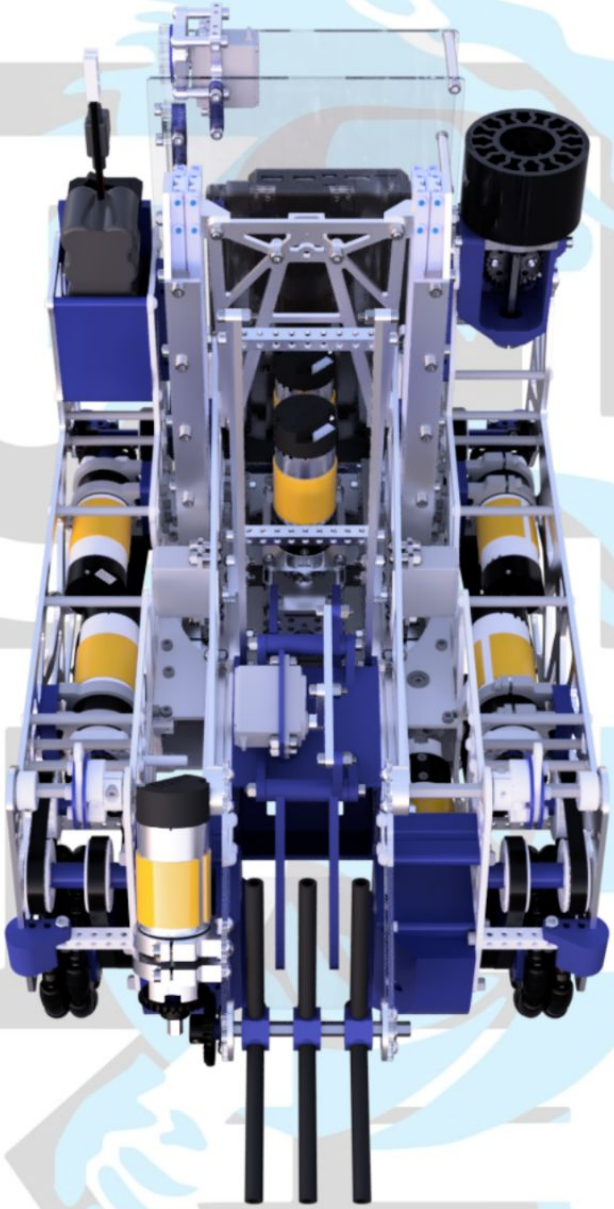
14473

FUTURE

student-run team
custom hardware

innovative outreach
adaptive software



FREIGHT FRENZY
2021-2022

ENGINEERING PORTFOLIO

TEAM PLAN

Future 14473 is a **completely student-run team** from the Bay Area consisting of 9 STEM enthusiasts. Our mission is to be the change by **bringing STEM to underrepresented communities**, both locally and around the world. We always seek to apply knowledge from our combined experiences to the world of robotics and technology.

FREIGHT FRENZY SEASON GOALS

Mechanical

1. Optimization of structure and design
2. Rapid adaptable innovative prototyping

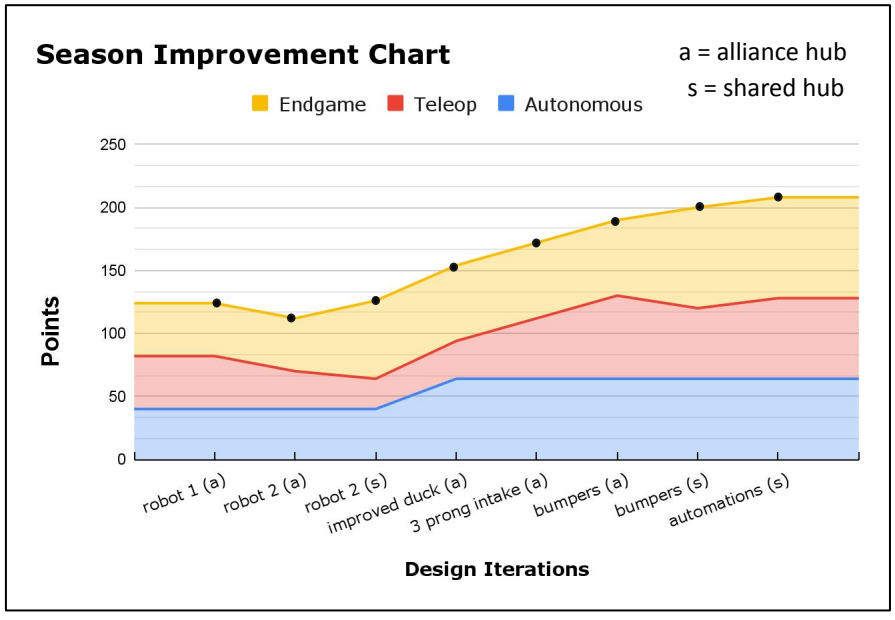
Software

1. Adaptive navigation and computer vision
2. Reliable software through evolving algorithm

Outreach

1. Introduce students around the world to STEM
2. Use STEM to create new communities

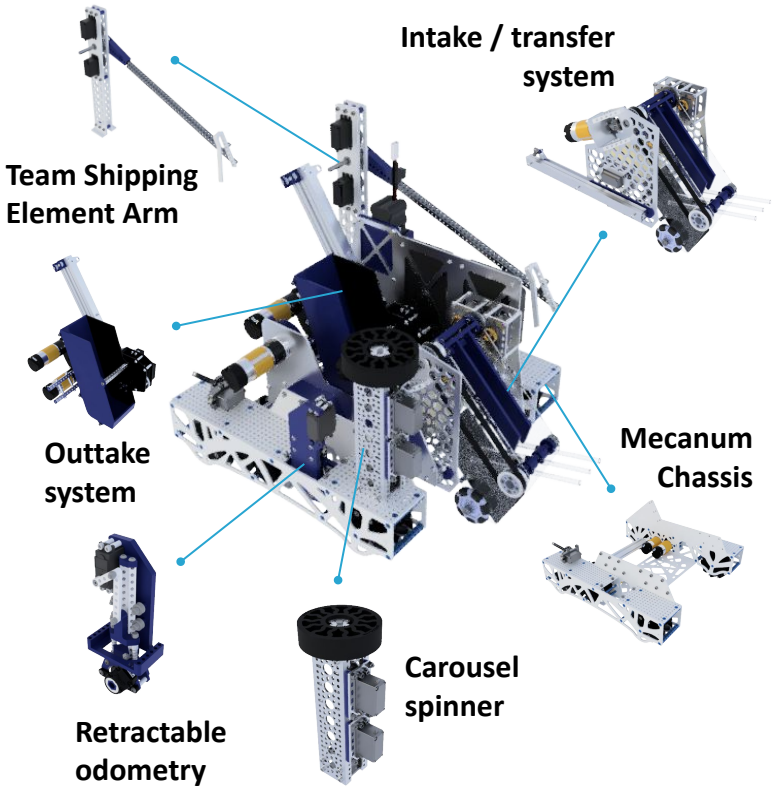
SEASON IMPROVEMENT



OUR ENGINEERING PROCESS

Identify the challenge and goals
Brainstorming and research
Basic prototyping for proof of concept
CAD and order parts
Test and analyze results
Seek advice/feedback from mentors
Iterate and improve design
Repeat!

OUR PREVIOUS ROBOT - **TSUNAMI**



What Worked	What Didn't
• Efficient intake • Fast transfer • Fast outtake • Quick and efficient duck cycling	• Can't go around barrier • Couldn't drop on shared hub • Inaccurate shipping element arm • No relocalizing

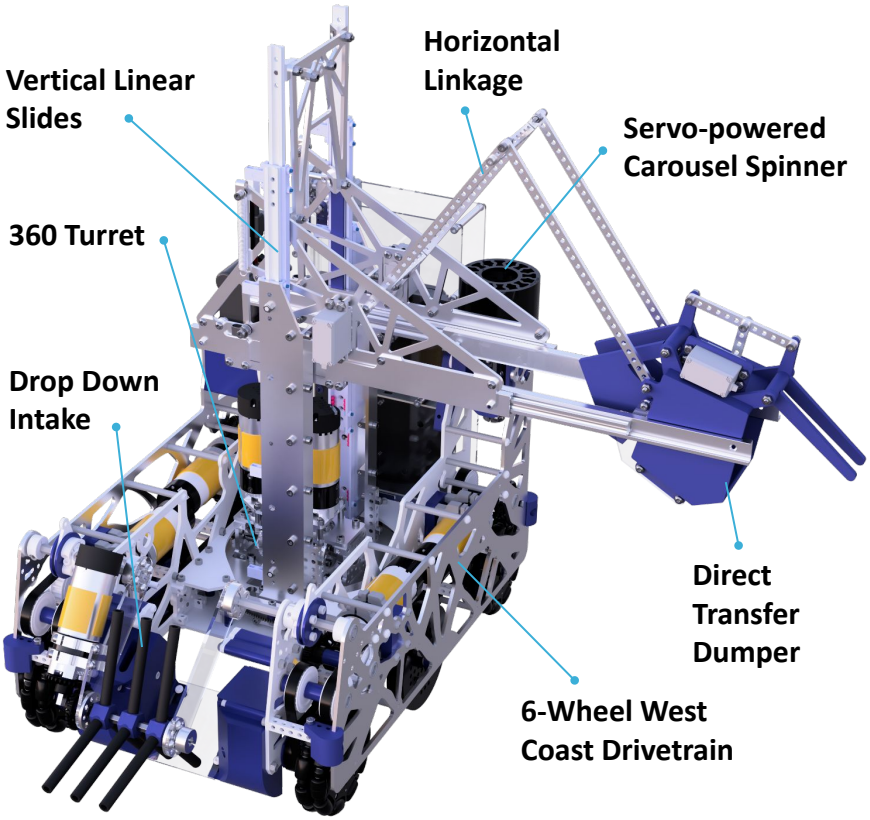
Reasons for a redesign

- Best chance for advancing is designated support bot to be a WA First Pick
  - Must be able to go around barrier
  - Must have fast Shared Hub cycles
- In-person competitions will have defense
  - Must have a strong defensive robot

Redesign goals

- **6 Wheel Drive** → more torque → defense
- **Turret** → provide 360° of outtake rotation
  - Makes shared hub cycling more efficient
  - As a support bot → more drop off positions for team shipping hub
- **AprilTags** → locate Team Shipping Element

MEET THE ROBOT, WHIRLPOOL



Autonomous	**Shared Hub: 64** • Preload + vision • Deliver duck • Collect/ score duck • Full Park	**Alliance Hub: 40** • Preload on Alliance Hub • Full Park
Teleop	**Shared Hub: 64** • 16 freight on the shared hub	**Alliance Hub: 66** • 11 freight on the alliance hub
Endgame	**Shared Hub: 80** • 9 ducks delivered • Full Park	**Alliance Hub: 34** • 4 cycles • Full park
	208 total	**140 total**

SUSTAINABILITY

FINANCE

The team uses Splitwise to manage finances and track expenses. **Sponsorships and monetary and material donations are obtained by application and contacting companies.**

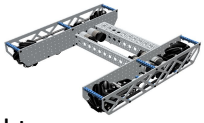
Expenses	Cost
GoBilda Robot Parts	-1,175.13
GoBilda Sponsorship	+293.78
Learning Bee 3D Printer	+350.00
Countersinking Bits	-60.53
Servo Programmer	-12.79
Team Dues	+2,250.00
Webcam	-30.86
Berbawy Soldering Kit	+35.00
Total	**+1372.2**

TEAM PHILOSOPHY

- Driven by passion: Freeform structure, members choose work and take initiative
- Unlocking potential: A **family** that pushes and drives each other through fun and compassion
- Learn by doing: **missteps are *the steps***
- Student-run collaboration: every voice is equal

RECRUITMENT/TRAINING

- Recruited **4 new members**
  1. Rolling applications contained short answers and past work
  2. Team interviewed candidates looking for fit based on personality, prowess, and potential role on team
  3. Final decisions reached through vote
- Training and onboarding:
  - Team bonding, dynamic, and communication exercises
  - Mock-participate in Ultimate Goal to practice technical skills
  - Discover new opportunities and start new outreach initiatives



SWOT ANALYSIS

Strengths
- **Completely student-run**
- Nobody has as much fun as we do
- Distribution of ages and experience levels
- Good teamwork and chemistry
- Many connections with other FTC teams (testimonials!)

Weaknesses
- Many rookies
- Time management/ communication

Counter
- Large network of teachers, mentors, alumni, and other teams for assistance
- Partner system: each senior member works closely with and mentors a rookie member
- Use Google Sheets for planning deadlines and assignments

Opportunities
- Many local tech companies and printing resources
- Online forum of FTC specialized mentors
- Abundance of incoming freshman passionate about FTC
- Several other schools without Serendipity programs

Threats
- Low funds
- Graduating members

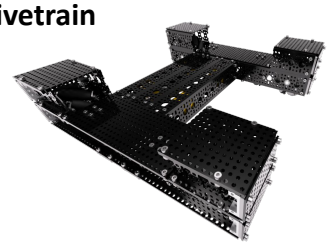
Counter
- Apply for sponsorships and grants, work with companies to get discounts and resources
- Self-sustaining outreach and training programs
- Recruiting new members

DRIVETRAIN

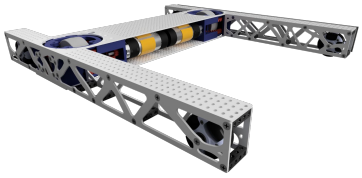
Main goals: speed, drift-resistant, defensive capabilities

1. Standard GoBilda Drivetrain

- First drivetrain, using COTS parts
- 4-wheel Mecanum drive
- Heavy and slow



2. Swerve Differential Drive, Hypoid Bevel Gears

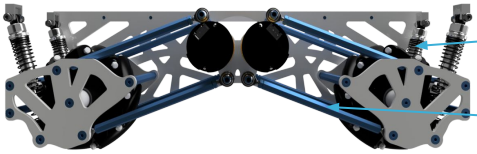


Differential Drive: 2 main differential blocks powering a wheel that spins in 2 axes

Hypoid Bevel Gears:

- Gears are offset and 2x compact
- Spiral teeth for smoother transitions between gears
- Reduces number of gears

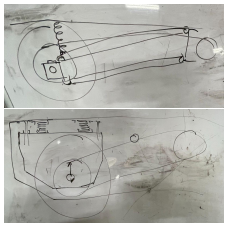
3. Suspension



Coil-over shocks

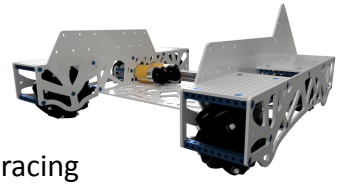
4-bar linkage

- Faster crossing over barrier
- Smoother driving
- Stronger chassis base



Initial ideation and sketches

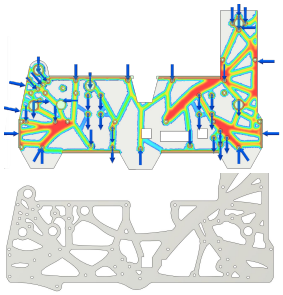
4. Banana Mecanum



- 4-wheel Mecanum drive
- Generative design sideplates + cross-bracing
- 40mm clearance arc for crossing barrier

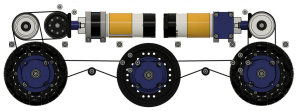
GENERATIVE DESIGN

- Computer physics simulation generate optimal plate structure based on calculable load cases
- Mathematically optimizes pocketing design - maximum strength & minimizes material used
- 48% of the original mass but 95% the strength



CURRENT 12" 6-WHEEL WEST-COAST DRIVE

- 2mm drop-center [middle Rhino wheel lowered] for turn control
- Can easily cross barrier or fit between barrier and wall



OUTTAKE

Main goals: maneuvering/scoring flexibility, minimize robot movement

VERTICAL SLIDES

BWTlink Slides

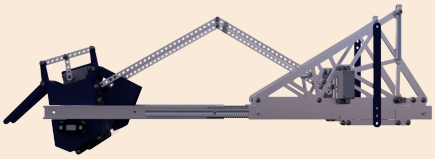
- Compact slides with vertically mounted pulleys
- Extension + retraction stringing
- Spring tensioning
- 2 stages for 1.5 feet extension

- Telephone cable wiring

HORIZONTAL SLIDES

Linkage Powering

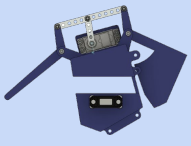
- Extends dumper to different lengths
- Powered by 2 torque servos - allows for **fast and accurate extension/retraction**



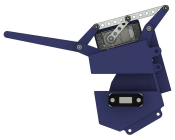
DUMPER

- Linkage system - 1 servo to control a gate as well as a flicker
- **Auto freight ejectection**
- **Direct transfer** from intake

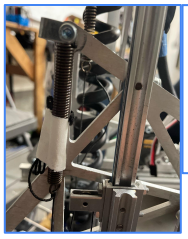
Gate Closed



Gate Open



Flicker Active



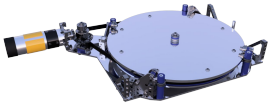
Spring Tensioning
Prevents string from tangling and cushions acceleration

Motor encoder ticks → turret degrees

TURRET

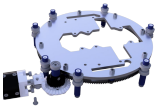
Turntable provides 360° range of motion for output

Iteration 1



- 254mm Diameter main turret plate
- Belt powered

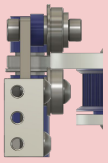
Iteration 2 (Final)



- 184mm Diameter main turret plate
- Gear powered

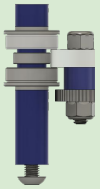
Issue

Radial-load Bearing Constraints
Complex and over-designed for necessary load case



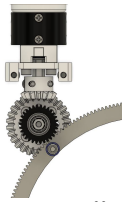
Solution

Bearing Stack Constraints
Compact (allows us to add more), more reliable and easy to maintain



Current Design Gear Train

Custom Laser-Cut 225 tooth Stainless Steel gear → 15:1 gear ratio

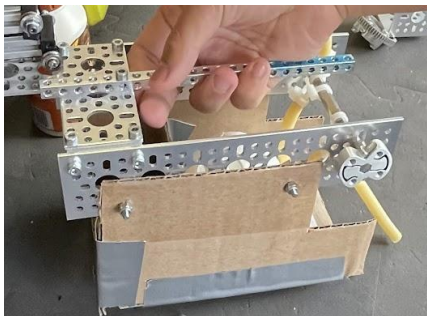


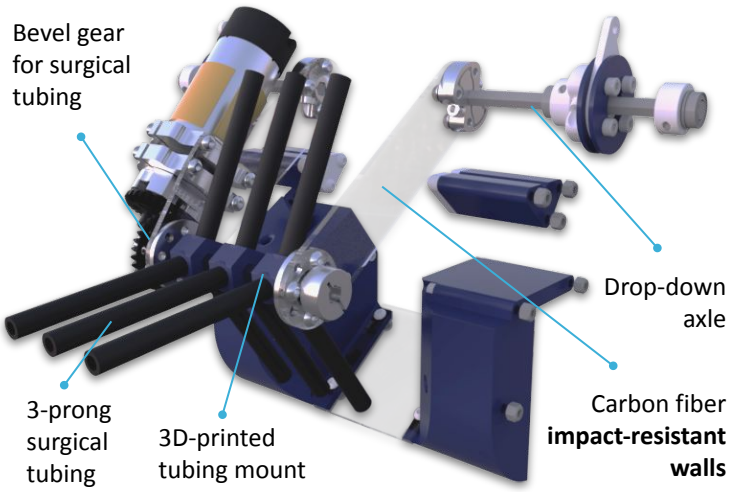
Horizontally mounted motor powers 1 set 1:2 bevel gears + 1 set 30:225 spur gears

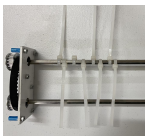
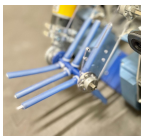
INTAKE

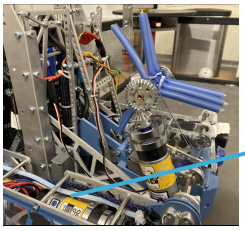
Main goals: compact, impact-absorbent, instantaneous intaking

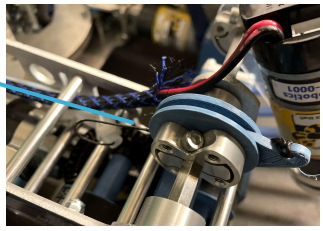
Cardboard Prototype
- 2-prong surgical tubing
- Beam to prevent freight from flying out
- Direct transfer





Zip ties	Compliant wheels	2-prong tubing	3-prong tubing
			
Intake time: **2.40 s** Couldn't grip cubes well	Intake time: **1.59 s** Unable to collect freight near each other	Intake time: **0.87 s** Struggles with heavy freight	Intake time: **0.63 s** Efficient, struggles with ducks

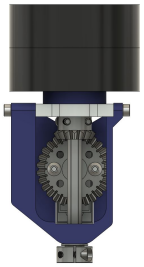


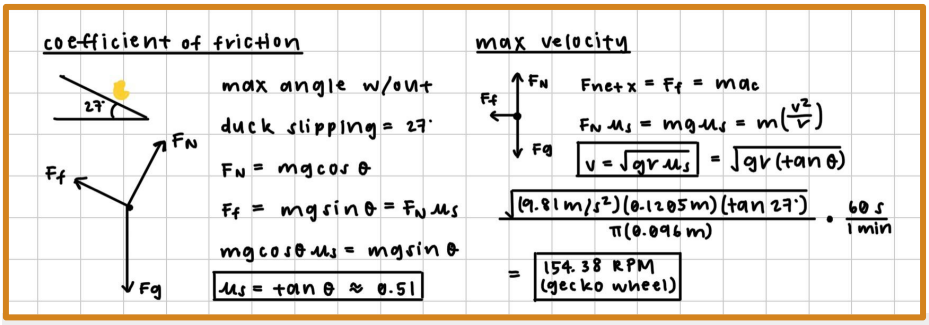


CAROUSEL + BACKPLATE + TSE

CAROUSEL SPINNER

- Powered by a super-speed **servo geared 2:1**
- Modular design
- **Optimized cycle time** by gradually increasing wheel speed

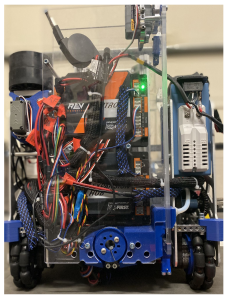




Physics calculation for max carousel spinner velocity → **increase efficiency**

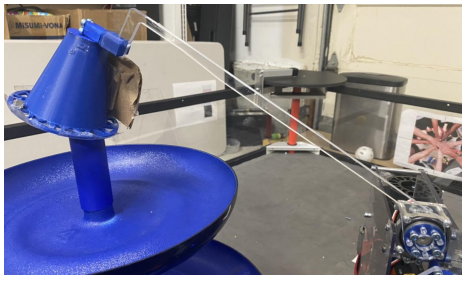
BACKPLATE & WIRING

Contains expansion hub mounting plate, intake drop down servo system, TSE arm, wiring, and protective polycarbonate outer plate



TEAM SHIPPING ELEMENT (TSE)

- Cone-shaped with tungsten base for easy capping and stability
- **Magnetic top** for lifting
- **Integrated Apriltag**
- Polycarbonate servo-powered arm
- Configurable into hook



NAVIGATION

Main goals: simplicity, accuracy, speed, consistency

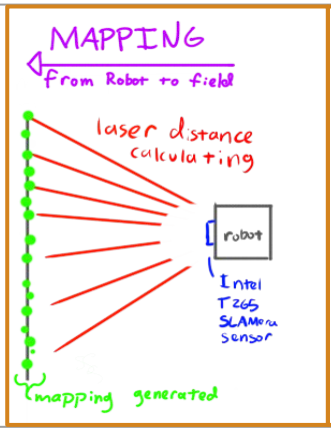
INTEL T265 SLAMera

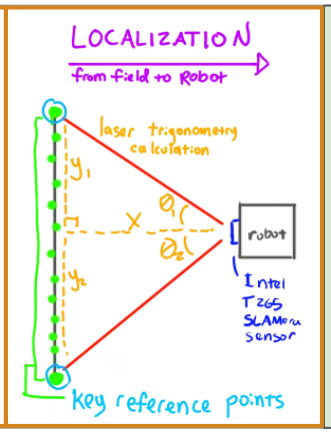
SLAM → Simultaneous Localization And Mapping

Binocular Vision Algorithm: 2 cameras to track environment objects + make a 3D Field Map

Mapping: Uses lidar to create 3D map of points from field [left]

Localization: Robot finds position in relation to waypoints [right]





Advantages:

Full field coverage object tracking
Built-in acceleration localization

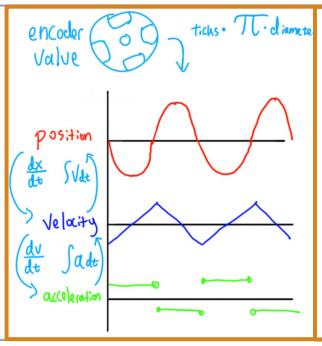
Problems:

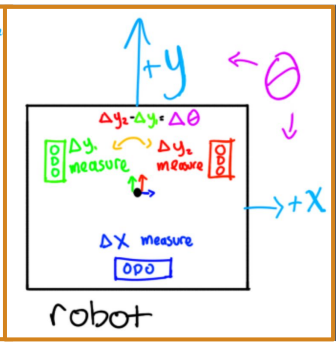
Movement of other robots not accounted

ODOMETRY

Advanced software algorithm transforming wheel rotations into robot field position [right]

Finds velocity and acceleration from position using calculus [left]





Advantages:

Fast
Accurate position for relative movement

Problems:

Prone to drift over time

ROADRUNNER

What is Roadrunner? *SLAM* library & built-in Motion Profiling: automatic path trajectory + velocity constraints

Velocity Controllers

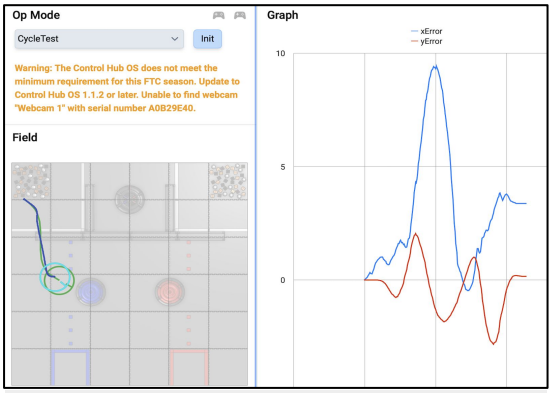
- Built in Roadrunner Tool
- Uses *Motor.setVelocity()*
  - Method to accurately maximize motor's speed
- Smooth Acceleration
- Use Drive Velocity PID: velocity loss minimized using PID

FEEDFORWARD	DRIVE VELOCITY PID
• Open Loop: no real-time tuning • Dead-wheel encoders pods • Easier to manage • Less accurate	• Closed loop: uses real-time tuning • Drive Encoders • Harder to tune • More accurate

RAMSETE

What is Ramsete Follower?

- Industry Standard Tank Drive Follower
- **Increase reliability** and accuracy
- Compensate for inability to strafe
  - kBeta → Proportional Convergence
  - kZeta → Dampen horizontal loss

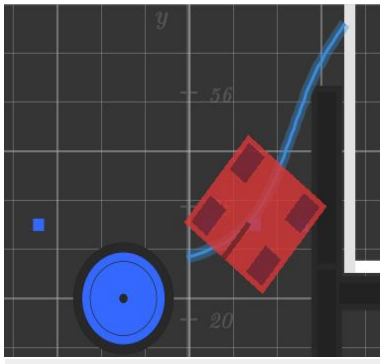


Live tuning of kBeta and kZeta to minimize drift. Decrease errors to **increase consistency** of spline paths

Advantages

No additional mechanics
Full field coverage
Optimized path creation
Speedy path following
Consistent velocity across different batteries

Turn PID Controller: Heading error eliminated with PID algorithm



PID **enhances functionality** of drivetrain trajectories

COMPUTER VISION

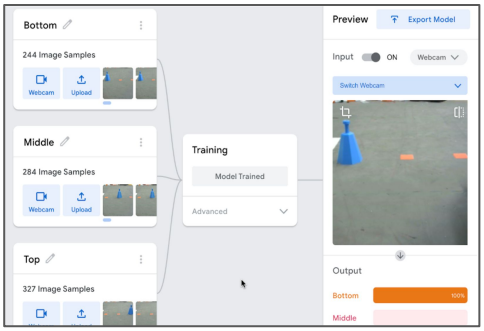
Main goals: reliability, accuracy

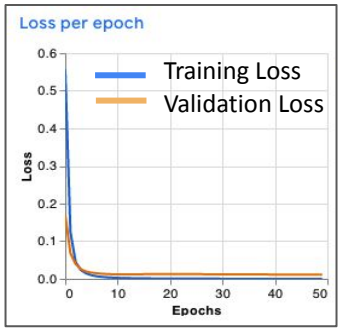
TEACHABLE MACHINE

Cloud-based Tensorflow neural network training

[Left] Cloud-based Training

[Right] 50 epochs (iterations) loss = $1.7 \times 10^{-4} \approx 0$





Problems

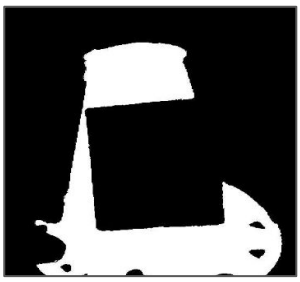
No FTC SDK support

Overfits (only detects specific orientation)

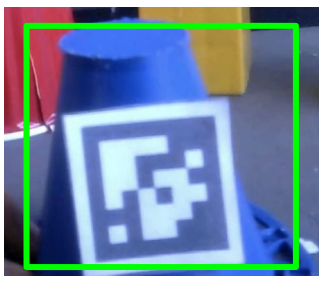
OPENCV

Hue Saturation Value (HSV) color filter algorithm

1. Crop camera input to increase process speed



2. Filter for blue color, ignore background



3. If % blue is above threshold → detect

Problems

Different lighting conditions can vary accuracy

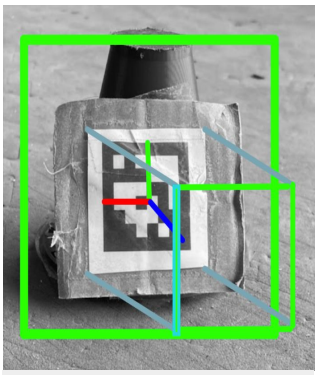
Area based detection algorithm

APRILTAGS

Visual-fiducial system that locates the position of a QR code called an *AprilTag*

1. Set high decimation (remove every 10th pixel), increase process speed

2. Grayscale image, detect white and black transition border



3. Identify AprilTag, draw fiducial marker, detect position

Advantages

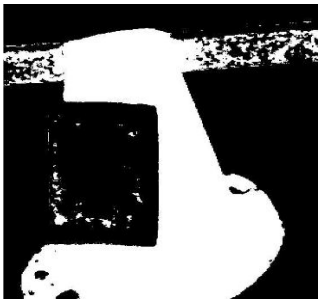
Accurate under all lighting conditions

Built-in SLAM for XYZ position

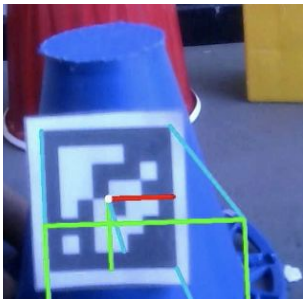
Adaptable: easily attached to alliance partner design

DUAL CV

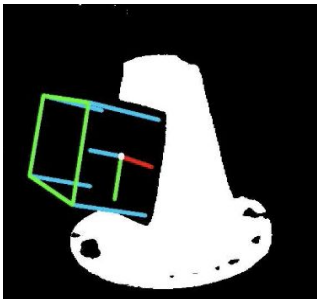
Double check AprilTag detector with OpenCV color filter



1. Color Filter using OpenCV 1st check



2. AprilTag 2nd check



3. Combined OpenCV + AprilTag Dual CV

Advantages

Double checks detectors

Helps drivers visualize and adjust camera prematch

OPTIMIZATIONS

Main goals: efficiency, simplicity

PID and PID REGRESSION (PID-RE)

PID REGRESSION (PID-RE)

1. Run **PID** test
2. Calculate error loss function
3. Determine change in loss from previous round
4. Adjust variables based on change in loss results
5. Repeat!

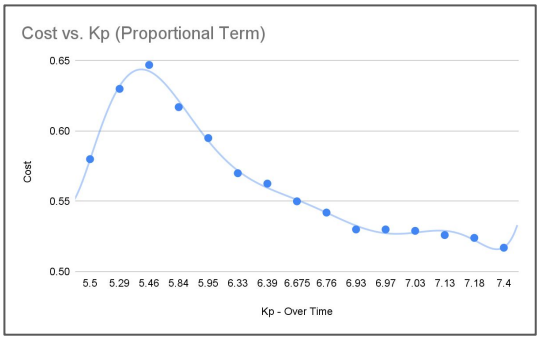
PID regression is the automation of PID tuning; a code for PID regression allows anything to be tuned by PID without human input.

PID is a **feedback loop** defined by 3 measurements:

- *proportional* [the absolute distance from the actual value to the target value]
- *integral* [the sum of error over time]
- *derivative* [rate of change of actual value]

We use PID tuning for:

- Turret angle adjustment
- Drivetrain velocity / path



Graph shows decreases in error over time through tweaking PID coefficients

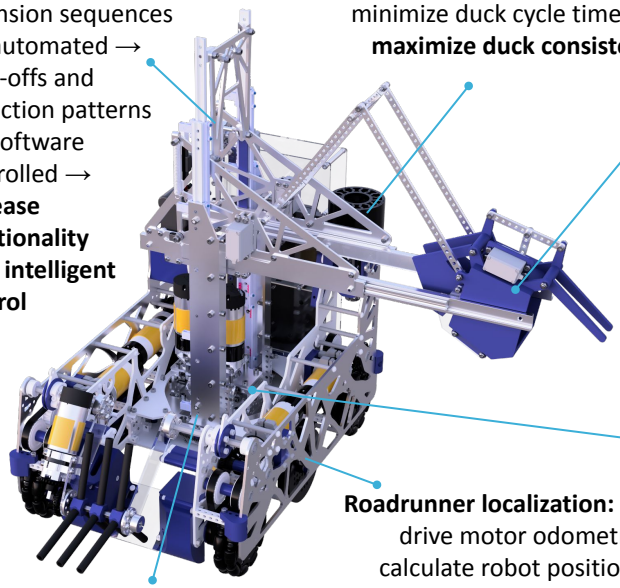
Gradient Descent: an iterative **optimization algorithm** to find local minimum of any function

- Finds highest accuracy → used to decrease error of PID
- Constantly tweak PID coefficients until lowest error is found

Root Mean Squared optimization: a machine learning tactic used to make gradient descent faster by decreasing variance

Smart Slide Extension: all slide extension sequences are automated → drop-offs and retraction patterns are software controlled → **increase functionality with intelligent control**

Duck Spinner Automation: varies servo speed [slow → fast] to minimize duck cycle time and **maximize duck consistency**

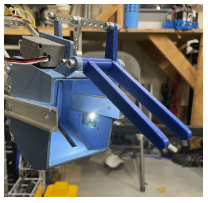


Turret tuning: Always turns the shortest distance to the target angle → **faster cycles**

Roadrunner localization: uses drive motor odometry to calculate robot position on field → 6 wheel robot has minimal slippage/drift and therefore **high reliability**

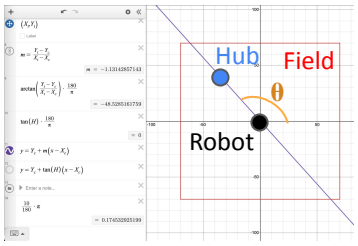
INTAKE SENSOR

- Detects the presence of freight
- As soon as freight is collected, the dumper closes, intake reverses, and the slides extend
- **Increase cycling efficiency**
- Prevents penalties from possessing multiple freight



SMART ALLIANCE HUB TRACKING

- Turret always points towards Alliance Hub
- Calculates angle from current to target position using trig
  - Max speed → faster cycles
  - **Enhance robot functionality**



OUTREACH: "HELLO WORLD" INITIATIVE

OVERARCHING OUTREACH INITIATIVE

- Goal: **Embrace culture of FIRST and be a strong ambassador**
- Strive to use their outreach projects to **introduce students (say "Hello!" to STEM)** in various ways
- Goal: help **underrepresented communities** gain access to STEM

660+ Teaching hours

5.1k+ People reached

2825+ Man hours

1. "Hello World" to students from **international** countries (pg. 10)
2. "Hello World" to **special education** students (pg. 11-12)
3. "Hello World" to **FIRST** robotics teams and **Industry Professionals** (pg. 13-14)
4. "Hello World" to **FIRST community** (pg. 14-15)

TAIWAN OUTREACH PROJECT (TOP)

100+ Man-hours

150+ Students taught

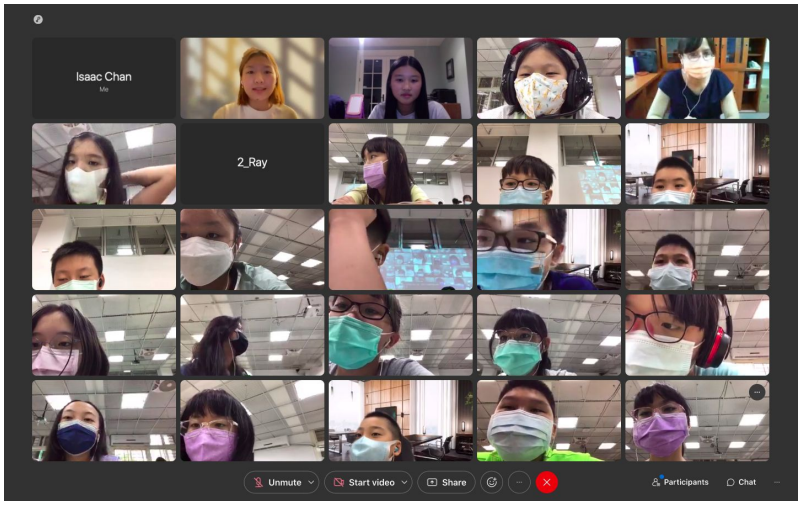
International ambassador for FIRST

- 150 students in Kang Ning Elementary, Taiwan
- 9 different classes → robotics crash course
- Sparking joy for engineering

Community Engagement

- Met through volunteer English teaching program at Chinese school
- Importance of international outreach: limited FIRST presence in Taiwan compared to US

taiwan outreach project.



3 Week Class Timeline

1. Robotics and FIRST (taught by Team Future)

- Introduction to the team and curriculum
- Introduction to FIRST, FTC, and robots
- Brainstorming activities
- Real-world application of robotics
- Robot demonstrations
- Question and Answer Session

2. Hardware (taught by Team Future)

- Basics of FTC Hardware
  - Different types of chassis
  - Types of wheels demo
  - Motors/Servos demo
  - Gears and torque demo
  - Fusion 360 demo
- Kahoot Quiz
- Q and A Session

3. Software (taught by Team RoboForce with Future curriculum)

- Introduction to block coding
- Scratch brainstorming and activity
  - Based off **Serendipity curriculum**
- Question and Answer Session

HWI: SERENDIPITY

WHAT IS SERENDIPITY?

- **Community** of FTC teams dedicated to providing ***Special Education students*** from all walks of life with STEM opportunities
- **Sparking enthusiasm** for FIRST and STEM through engaging weekly classes
  - Catalyst to share the **culture of FIRST** to students and nonprofits

OPEN-SOURCE FOCUS

- One of FIRST's only **sustainable inter-team** outreach projects
- **Collective effort** of 6 local FTC teams
- Open-sourcing every step of outreach process
  - Provide curriculum and teaching guidelines
- **Accessibility**, low barrier to join and learn
  - Lasting **legacy** and maximum impact on local community with multiple branches
  - **Easy for rookie teams to start** outreach
- Coded **Serendipity Backpack** full-stack web app to **open source 30+ weeks of curriculum**

CURRICULUM

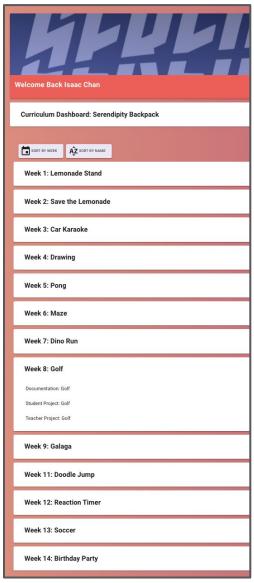
- 5-level curriculum aligned with *Next Generation Science Standards (NGSS)*
- Repeated concepts to reinforce logic-based thinking
- Modular and hand-tailored to each student

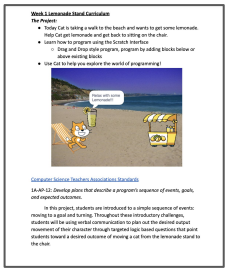
460+ hours

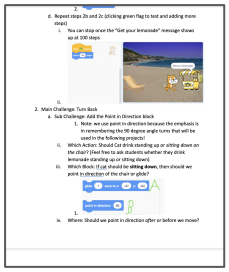
170+ classes taught

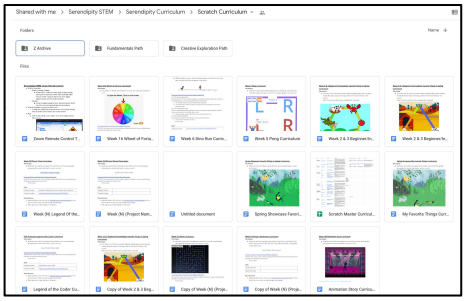
150+ students

600+ pages of curriculum written









WEEKLY CLASSES

- Maintain a 3:1 student to teacher ratio
- Bring special education community to FIRST community through introduction to FLL Jr. and FLL
- Friends of Childrens With Special Needs
  - **Weekly after-school robotics classes** at East Bay location
  - 2 week summer camp
- Fremont Unified School District
  - **Weekly Scratch programming** classes at Irvington High School during advisory
  - 4 week summer camp at Horner Middle School

HWI: SERENDIPITY (cont.)

COMMUNITY SHOWCASES

- **Generate enthusiasm for FIRST** during annual student demonstrations
- Help students and **local teachers identify with FIRST**
- Celebrate Special Education students with supportive community

Summer Camp Finale: celebrating student's final projects at the end of summer camp

FUNDRAISING: SUMMER CAMPS

Partnered with Learning Bee (local after school) to teach summer coding classes

- **72 camp classes to 60 total students**
- **Sustainable funding**: **$3.1K raised** for in-person LEGO Robotics kits
- **Leaders of the collective effort** involving FTC Teams 13345 Polaris, 17390 Techno G.O.A.T.s, 18767 Techarinos, 13223 Endgame

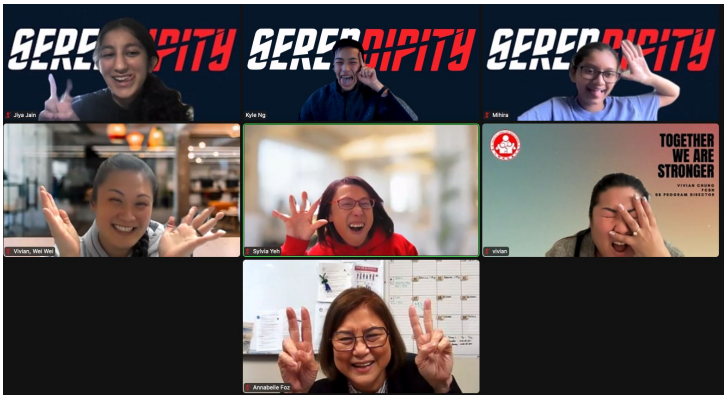
FTC TRAIN THE TRAINERS (TTP)

- 3-week *Train the Trainers* programs for FTC teams to learn how to teach
- Weekly 2-hour class of paired-teaching with Future teacher
  - Covers curriculum writing, teaching, class management
- Ensures **sustainability** and **growth** of Serendipity

Teacher reflection meeting of TTP week 3

COMMUNITY TRAIN THE TRAINERS

- **Bridge the STEM gap** by teaching non-STEM FCSN staff how to teach coding
- **Improve team knowledge base and skills** by getting feedback from nonprofit executives
  - Weekly meeting with Sylvia Yeh, Executive Business Director at *Friends of Children with Special Needs* (FCSN)
  - Met at FCSN Volunteer recruitment event



8 Week Training Timeline: Teach Coding, Graphic Design, & Curriculum

Train the Trainers Program with Friends of Children with Special Needs (FCSN)

Week	Skills	Synchronous Activities	Asynchronous Activities	Project Name
1	Creating Scratch Accounts Introduction to Scratch blocks	Scratch Accounts Introduce each block section Teach Student/Teacher Version	Create Own Project Version	Save the Lemonade
2	Scratch Basics	Teach Student/Teacher Version	Create Own Project Version	Pong
3	Introduction to Creating Curriculum	Introduce Curriculum Teach Student/Teacher Version Step by Step Curriculum Making	Create Own Curriculum Version	Maze
4	Introduction to Video Recording with Zoom	Introduce Video Teach Student/Teacher Version Step by Step Video Making	Create Own Curriculum Version Record Curriculum Lecture	Golf
5	Introduction to Teaching Coding	Practice Teaching Golf Teach Student/Teacher Version	Create Own Curriculum Version Record Curriculum Lecture	Galaga
6	Showcase: Fliers, Slideshow design with Canva QR code Design	Teach Student/Teacher Version Introduce Canva Showcase Skills	Start Showcase Slideshow Create Own Curriculum Version Optional Record Lecture	Reaction Timer
7	Showcase: Certificate Award design with Canva Bit.ly Link Shortening	Teach Student/Teacher Version Introduce Canva Award Design	Create Sample Certificates Create Own Project	Doodle Jump
8	Showcase: Certificate Award design with Canva	Present Canna Slideshow: Teacher/Student/Curriculum Certificate/Flier	N/A	Showcase and Make Own Project MOP

HWI: FIRST AMBASSADORSHIP

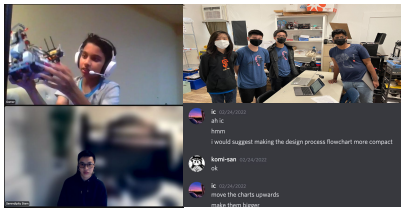
OVERVIEW

Give back to the FIRST community through

- *Learn*ing from **Industry Professionals** and **local mentors**
- *Teach*ing **rookie FTC** and **FLL** teams with the knowledge we gain from *learning*
- *Help*ing the whole FIRST community through creating **community resources**

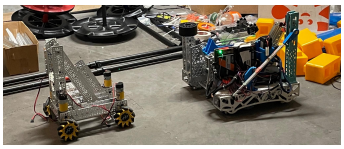
FIRST MENTORSHIP

Future emphasizes passing knowledge to other teams. Future mentors 4 FIRST teams, and assisted dozens more.



ASSISTED 20+ TEAMS, SUCH AS:

- **16374 MEAF:** portfolio layout & strategy, adapting to goBILDA, team organization (HI)
- **14318 Biobots:** Fusion 360, tournament preparation and scouting (CA)
- **13345 Polaris:** autonomous pathing, judging practice, team organization (CA)
- **11468 Ohm Raiders:** design process, engineering section of portfolio (TN)



MENTORED 4 TEAMS

- **FLL Jumping Jelly Beans:** CAD, tournament preparation
- **FLL Cargo Coolies:** Python implementation
- **FLL Mind Bloomers:** innovation project, 3D printing
- **FTC Nuts & Volts:** hardware, judging presentation, software, team logistics, driving

INDUSTRY CONNECTIONS: OUR MENTORS

The team connects with various mentors (**industry professionals**, teachers, and other FTC teams) to **grow team member skills** and **expand knowledge base**.

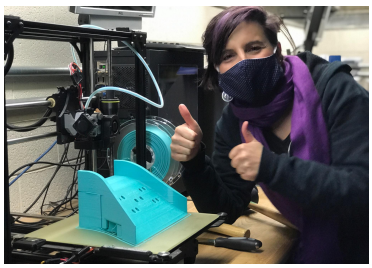
APRILTAGS EXPERTS

To better understand AprilTags and open-source documentation (**no FTC AprilTag documentation**), the team met with two AprilTag experts:

- **Dr. Edwin Olsen (UMich Professor):** inventor of AprilTags
  - Taught technical deepdive about AprilTags library
  - **Improved** team's accuracy by **95%**, fix false negative
- **Mr. Michael Windwoes:** wrote AprilTag plugin for FTC
  - Taught how to tune camera homography
  - Open source contribution for null pointer error

BERBAWY MAKERS

- Met through **local high school**
- Taught the team how to use 3d printers, laser cutters
- Provides acrylic, wood, and MakerSpace tools
- Manufactured Onyx Fiberglass intake plates



LEARN FROM FTC TEAMS

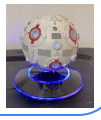
The team is able to discover new concepts by reaching out to other FTC teams through connections from the discord community, competitions, emails, and more.

- **4345 Aragon:** notebook, presentation
- **4150 Dark Matter:** differential swerve, SLAMera
- **6165 MSET Cuttlefish:** 6wd Ramsete follower
- **6547 Cobalt Colts:** Slamera, documentation
- **7172 Technical Difficulties:** team philosophy, connections, sustainability
- **11311 Paragon:** CNC and machining
- **11970 Titanium Talons:** portfolio, driver strategy
- **15173 Robotic Eagles:** Teachable Machine CV

DISNEY

Mr. Ferreira (Disney Imagineer & Project Manager):

- Met through FIRST in Alabama
- Deepen knowledge about generative design
- **Explored real world opportunities** with animatronics, robotics in the workforce



HWI: FIRST AMBASSADORSHIP (cont.)

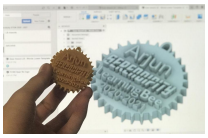
INDUSTRY OUTREACH

The team has more meetings scheduled with STEM technical experts to **connect the dots between industry and FTC**.

- **Google:** future improvements in detection, automation, and optimizations
- **Bay Area Compliance Labs:** materials science and usage of different parts
- **Finisar:** fuses, disconnections, batteries
- **John Deere:** drivetrain usage and optimization
- **Northrop Grumman:** sensor technologies and false positives

LEARNING BEE

- **Teaching:** taught the team how to teach young students
- **Fundraising:** provided venue for Python-Robotics course
- **3D Printing:** gave the team access to 3D printers

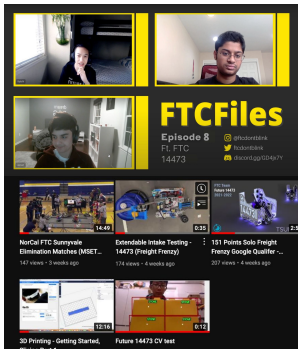


EMBRACING CULTURE OF FIRST

In the Help category, Future gives back to the community by offering free resources, including tutorials, open-sourced designs, lessons and advice, parts, and time.

YOUTUBE

On YouTube, Future produces weekly videos with lessons on a wide range of FIRST topics.



Tutorials
- 3D printing and slicing
- OREO Assembly

Podcasts + Talkshows
- Featured on FTC Top 25
- FTC Files: open sourced notebook, fundraising tips, outreach planning

Gameplay
- Vlogs and match videos

SCRIMMAGE

The team hosted a 5 team **scrimmage** that gave FTC teams Quixilver, RoboForce, Aragon, and CRABS a way to practice in-person play.

KICKOFF WORKSHOP

Presented **Community Outreach 101** - taught about venues, Curriculum, and teaching students STEM during the Kickoff

IRVINGTON MAKERSPACE

Future assisted Irvington High School with implementing new engineering curriculum.

- QR codes to tutorial courses on makerspace machines: **Learn Laser Cutter**
- Operating 3D-printers to teach students about safe manufacturing
- Implementing FIRST Robotics into AP Computer Science curriculum

QUALIFIER VOLUNTEERING

40+ hours volunteering, **game announcing**, and **livestreaming** at Burlingame and Sunnyvale

DONATING PARTS

Donated many parts to: 5773 Ink & Metal, 7303 RoboAvatars, 12635 Kuriosity Robotics, 14318 Biobots, 14663 Killabytes, 17759 Mind, 19982 Nuts & Volts, and more!

FTC DISCORD COMMUNITY

The FTC Discord is a community of **10.5K students** and engineers. Not only a social hub, it's a place for teams to learn, collaborate, and grow. Future serves as **active contributors** on the NorCal and FTC server always lending a helping hand, participating in over **20K messages**.

OPEN-SOURCED PROJECTS

OREO

Open Source Retractable Encoder Odometry

- Designed custom odometry pod for crossing barrier → allow rookie teams to use localization even with no expertise
- **Engaging and enabling FTC community**

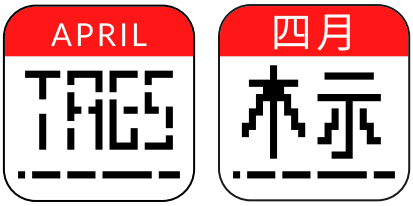
700+ interactions with the FIRST community

20+ teams nationwide use OREO

LEARN APRILTAGS

Created **step-by-step documentation of AprilTags:**

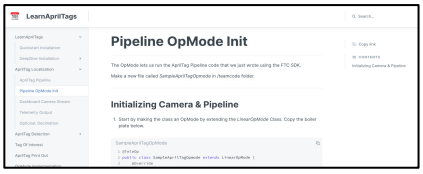
- Installation
- Localization
- Detection
- Debugging
- Community Involvement

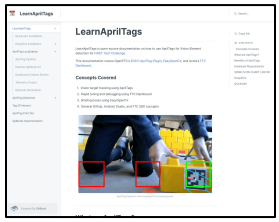


Why create Learn AprilTags

- AprilTags is the most reliable detection method
- No existing documentation at all
- **Engaging in community knowledgebase**

Not only will the documentation be in English for most teams, but it'll also be the **first Chinese AprilTag documentation** for Asian teams.





CONCLUSION

The team plans to continue improving upon the robot mechanisms and software for upcoming events, in addition to advancing nontechnical skills and sustainability of the team. Some of our future goals and plans include:

1. Obtain **sustainable funding**
2. Implement Serendipity in **new school districts**
3. Recruit and train new members
4. Update Learn April Tags with more tutorials in new languages
5. Connect with more companies
6. Contribute outreach resources to Game Manual Zero
7. Moderate FTC Discord server
8. Reach new communities like the blind and foster children

TESTIMONIALS

”

I love their **activeness in the community** and how they are helping not only the technical side, but also **providing platforms for other teams** to help with outreach and sustainability.

- FTC 14481 Don't Blink

”

When our team started the season this year, we were really worried about how we would fare with our lack of experience. Future gave us the **help and advice** we needed to do well in our rookie season.

- FTC 19982 Nuts & Volts

”

Every Lego and Robotics class **engages each student** at every level and provide them with hands-on experience and promote **creativity, collaboration, critical thinking, and communication**.

- FCSN Afterschool Program Teacher