506 PANDARA
Season Summary

FIRST TECH CHALLENGE:
2019-2020 "SKYSTONE"

A message to jungle explorers:

Welcome to our season summary!

I was honored to represent team 506 “Pandara” in the 2019-2020 FIRST Tech Challenge season. As Team Captain and honorary “Papa Panda”, I’ve seen phenomenal growth in every one of our members this year and loved serving as a mentor to budding roboticists. Our team is full of passionate, STEM-minded individuals that always pull through in reaching their goals. We pride ourselves on the time put into community outreach this season, with major partnership projects with St. Joseph’s Children’s Hospital and others developed continuously over the past eight months, which was recognized through the 1st place INSPIRE Award for the Gulf Coast League this year.

Perhaps the most exciting mission of our year has been foundationalizing opportunity for the next cohort of Palm Harbor robotics members and STEM scholars in our greater community—a mission dubbed the “Panda Path”. We have complimented student-focused outreach opportunities with reform and new initiatives in the Palm Harbor Robotics Club. Following a World Champion title, our community has doubled in size. Pandara has maintained a proactive role in facilitating organizational changes, creating fundraising opportunities, and forming the Path of resources that will last for years to come. We can’t wait to share it with you here!

Thank you for joining our jungle adventure. Chew, Chew, Bamboo!

—Josh “Papa Panda” Brandt, 506 Team Captain

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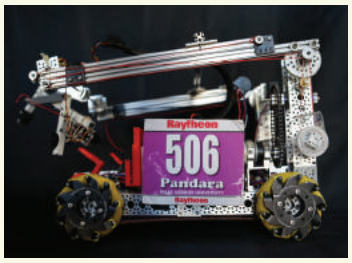
Team Summary - 506 Pandara

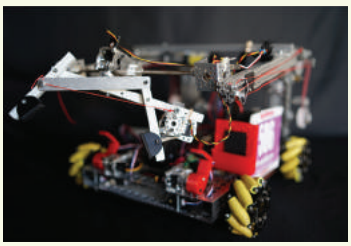
506 Pandara is the oldest team from Palm Harbor University High School, having participated in the FIRST Tech Challenge for 13 years and established as the 506th team ever created. This year has been our most successful year yet, from field successes to outreach and club impact recognized in our first place INSPIRE Award for the Gulf Coast League. We can't wait to take you on our Jungle Journey!

Recent Successes

- 1st place 2020 INSPIRE Award Gulf Coast League
- 2nd place season ranking in Gulf Coast League
- 2020 and 2019 League Compass Awards
- 2018 and 2019 League Control Awards
- 2nd place trophy Gulf Coast League Meet #2
- Former recordholder for highest FL match score
- 97th percentile worldwide by OPR, Top 15 FL

Pandara's Robot





Our Four Subsystems:

Drivetrain: Four direct-drive mecanums (GoBilda) equppied with our "any-directional strafing" method, allowing movement in any degree of direction, from any chasis orientation.

Linear/Rotational Slides (Arm): Dual cascading slides with 270˚ rotation allow us to deposit on towers nine stones tall.

Claw: With 3 degrees of freedom and a dual 20kg servo mechanism, our claw is lightweight and adapts to any field scenario.

Foundation Movers: Two custom, 3D-printed movers allow us to reposition the foundation while simultaneously placing a block.

Our Outreach Initiative: The "Panda Path"

The "Panda Path" is how we have foundationalized opportunity in our community and our FIRST family all year. Flip the page to read more! This has included:

- 3D-printed racecar design workshops, planned with President of St. Joseph's Children's Hospital
- Representation at Synapse Summit, the largest tech/business conference in Tampa!
- Robotics / STEM Summer Camp in 2020
- STEM Boy Scout and Girl Scout workshops
- Tampa International Mall event (Microsoft)
- Local fairs / workshops for middle schools
- Community events, including the famous "Third Friday" in Safety Harbor, FL

The **Palm Harbor Robotics Club** hosts 5 FTC teams, 70 members, and a number of fantastic mentors!

Pandara itself has made a direct impact on 70 FIRST members at Palm Harbor HS:

- Created Fundraising Committee to pay a $24,000 World Championship bill
- Championed club leadership change to 5-team representation, 10-person board.
- Worked with club to organize annual workshops to teach new members and promote FIRST opportunity around PHUHS.

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Meet Pandara

Team 506 Pandara is one of five teams at Palm Harbor University High School's robotics club. As 506 members, we see our team as a fantastic combination of spirit, engineering, and thoughtfulness -- characteristics that brought us far during the 2019-2020 FTC competition season. We take pride in the many endeavours and achievements we have accomplished over the season, and are thrilled to outline a summary of our success!

This season surely has not come without challenge, but something we made sure to improve upon from years prior was our robot's physical design. We spent weeks designing, and many months building our robot "Pandamonium". We iterated through multiple claw designs and explored the advantages of 3D printing to give our robot the hardware it needed to succeed. By the end of the season, our robot consisted of a well-tested linear-slide arm made of dual cascading slides that allowed us to stack a tower nine blocks high, far beyond what it was originally capable of! By no means was the arm the only notable subsystem, in fact our claw could move in all three axes with custom aluminum grips clamped by a 20 kg servo. With an extremely wide range and high maneuverability our claw set 506 Pandara apart from the rest. To move the foundation we used custom designed 3D printed hooks on our all-mecanum four wheel drive train.

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Utilizing the design of our drivetrain, Pandamonium could drive in any direction and at any angle. While hardware is important, a robot's performance is only as good as the programming that controls the hardware. On 506 Pandara, we took programming to the next level.

506 Pandara's programming team was extremely effective throughout the season due to the new structure of having two programmers working on the robot at all times. This allowed one of our senior programmers to set the foundations and work with a new coder who had fresh ideas coming out of his first year of being a builder. Our programming team implemented a variety of original features to control our robot. On the tele-op side, our robot's arm was stabilized hundreds of times a second to ensure the claw was always facing down to aid in picking up blocks quickly under the stress of competition. Autonomously, our robot could carry out complex maneuvers by taking advantage of directional strafing algorithms that allowed it to drive at any angle instantaneously. Additionally, our use of proportional driving controllers meant that our robot could slow down or speed up depending on its distance from its target, giving it smooth driving paths and lower battery usage. Our robot was also equipped with a camera running OpenCV, an open source image processing library which allowed us to detect the location of the skystones instantly upon initialization.

Even though the robot is what gets the most attention, one of Pandara's most important initiatives was our "Panda Path", a goal we set out for ourselves to work with community organizations to spread the message

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of FIRST and inspire younger kids to be involved in robotics. We held countless events, from allowing elementary school students to drive our robot in their classroom to win special 3D printed Panda prizes, to being exhibitors at Tampa Bay's largest technology convention - the Synapse Summit. We travelled to both boy scout and girl scout camps to engage with the members about STEM and even worked with St. Joseph's children's hospital to brighten up the day of young cancer patients with the inspiration of robotics. We even gave back to FIRST directly, by hosting a fundraiser with Microsoft in Tampa to give to less-funded robotics teams in our area. The members of 506 Pandara truly believe that robotics is much more than programming or building, the competition inspires us to better ourselves through hard work, which inspires all of our team members to give back and spread the message of FIRST.

Of course, the work that 506 Pandara has put into robotics and our community would not be possible without our amazing sponsors such as Raytheon, who give us the resources we need to learn and grow as the next generation of engineers, programmers, and globally minded citizens. Thank you for all that you do, because we love to CHOO CHOO BAMBOO!

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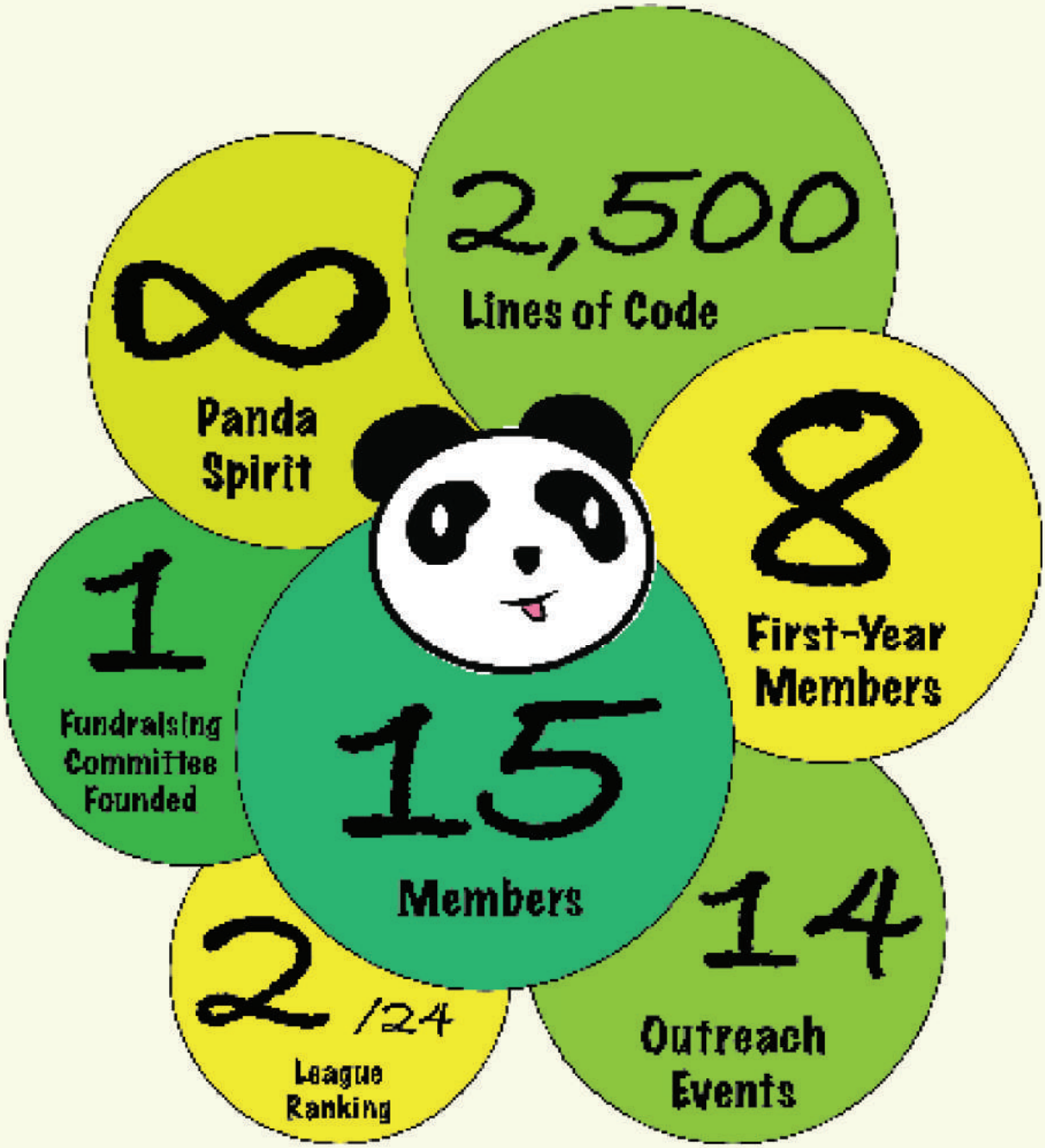
Pandara at a Glance

1st place INSPIRE Award Winners, 2020 Gulf Coast League



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COMMUNITY OUTREACH

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Outreach has been a focus for team 506 this year. We launched our previously mentioned “Panda Path” initiative to guide both our school-based and community-based outreach. This initiative is set to encourage our members to remember FIRST robotic’s core values and to foster a service mindset in the actions we take; we passed on the experience of our senior members to the new robotcists at PHUHS and brought more awareness of our projects to the community in hopes of inspiring future STEM learners!

One of the earliest outreach events our team joined was in partnership with with a local Girl Scout troop. For their Girl Scout STEM day, Pandara and other PHUHS robotics members set up a variety of STEM learning stations and ran them over a 3-4 hour period. These activities varied in skill level and age level, so we could effectively teach robotics and STEM basics to any Girl Scout that was ready to learn and have fun doing so. Across teh school year, we used the success of this event to model other Pandara-specific visit, such as to two different Boy Scout troops. At Troop 475, we ran a full Robotics Night and created unique workshops about CAD, engineering, driving and programming to give middle and high school boys a taste of everythign we do at the Robotics Club! Some of these students went to PHUHS and others were getting ready to transfer in next year, and were insterested in joining the club.

We regularly do demonstrations for community, charity and sponsor events. Recently, we visited Glazer Children’s Museum for our annual

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demonstration for elementary students. This is one of our favorite events and is organized by our awesome mentor Mr. Dan Kinzer, with all of Palm Harbor's teams coming together to enjoy our time with children that can drive our robots.

Pandara visited Raytheon for a demonstration on February 17, where we brought five of our freshmen members to learn from Raytheon mentors and show our thanks for their support as a sponsor. This is a recurring event that we enjoy, and is a great opportunity for engaging with the community and practicing outreach for when we hold there demonstration for the public.

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With the “Panda Path”, we created some specific projects to serve our goal of leaving an outreach legacy at Palm Harbor University. One of these was our outreach to St. Joseph’s Children’s Hospital, where we planned for months to make an awesome event with a demonstration for sick children. The hospital loved the idea of bringing robotics and STEM learning to them, as many of the children cannot leave the hospital and are always looking forward to fun activities to distract from other difficulties.

In April, Pandara earned our Club a presenter spot at the Synapse Summit for the first time after years of trying! The Synapse Summit was a huge opportunity for both student experience and sustainability alongside connecting with new sponsors and mentors. At the Summit, over 7,000 professionals and tech industry experts converged at the Amalie Arena across two days, and the coordinators of the event were excited to offer Pandara a space for a demonstration as well as a table for displaying our robots and work from the past year. We invited the rest of the PHUHS Robotics Club to join us, and we had a fantastic time! One 506 member even talked to a director from NASA and got his business card to follow up in the future.

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ENGINEERING/ BUILDING

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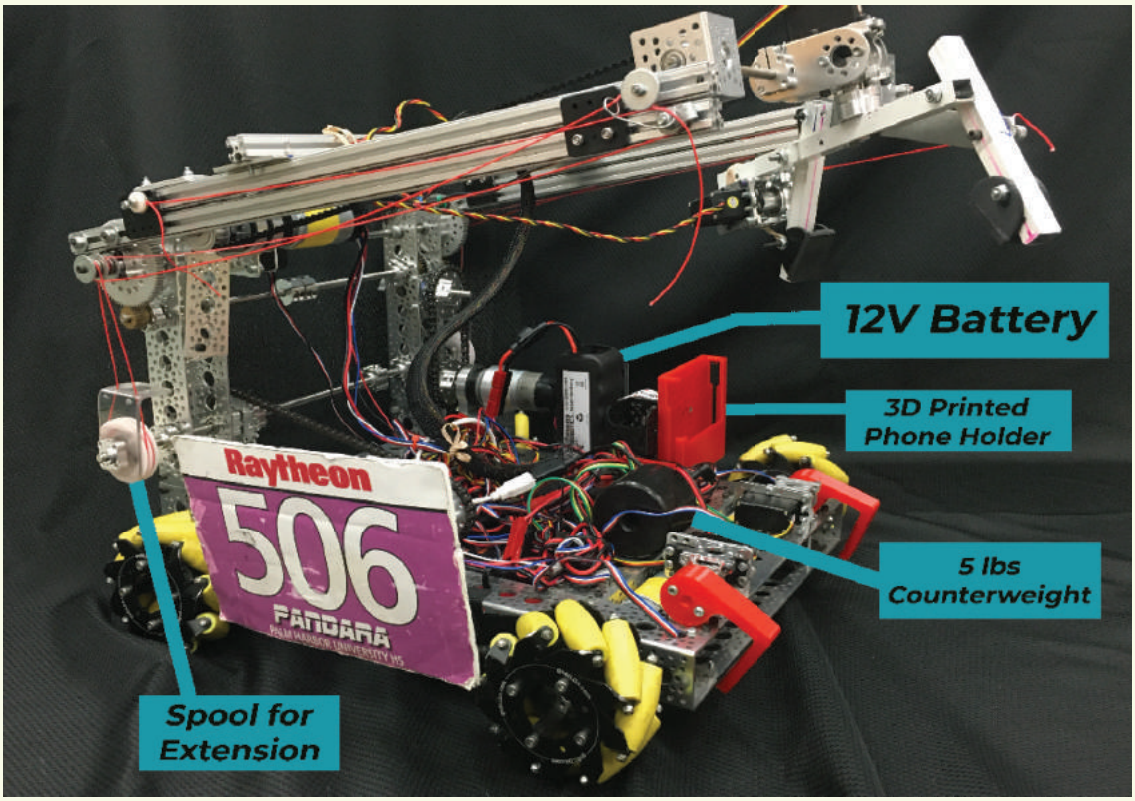
Design

This year we had to come up with a totally unique design to compete in this game. In the beginning of the year we sat down with all our members and started drawing out designs we believed would work and be efficient. We continuously iterated through many versions of our subsystems to get to a final design which we believed was most efficient. We believed in the philosophy that building never stops, you can always improve something further and make designs more efficient. Our robot relies on a few subsystems which together created an effective and efficient competition robot in this year's game:

- Drive Train
- Foundation Movers
- Claw
- Linear sliding arm



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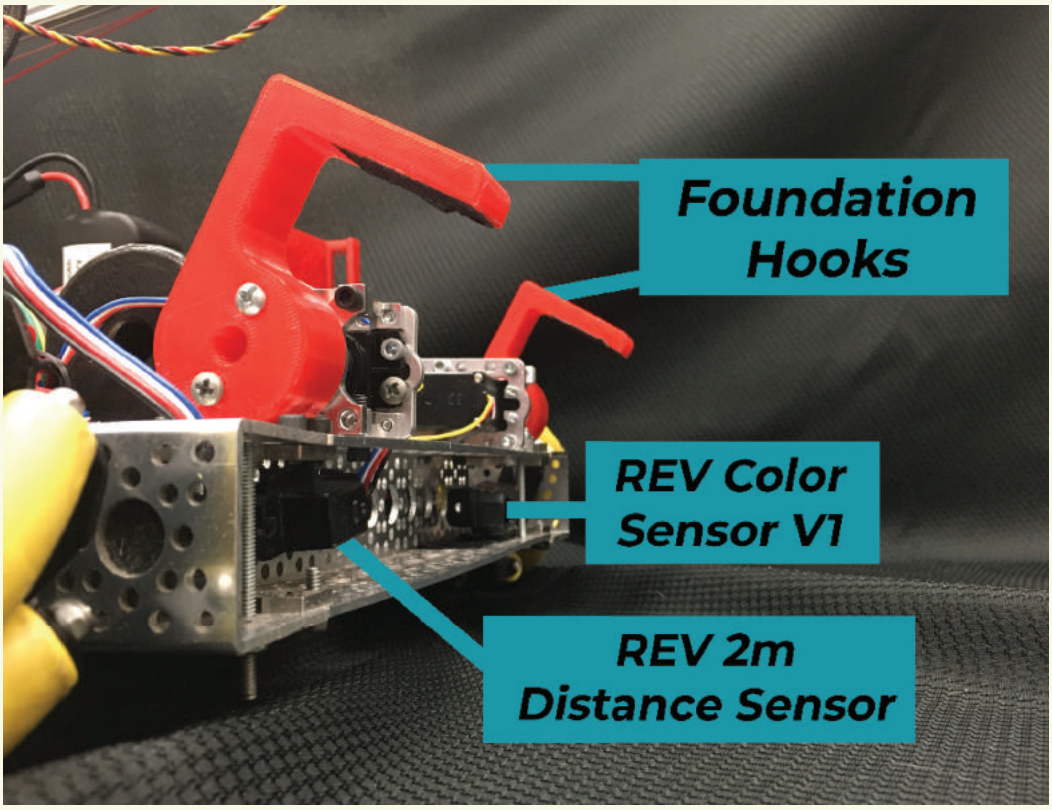
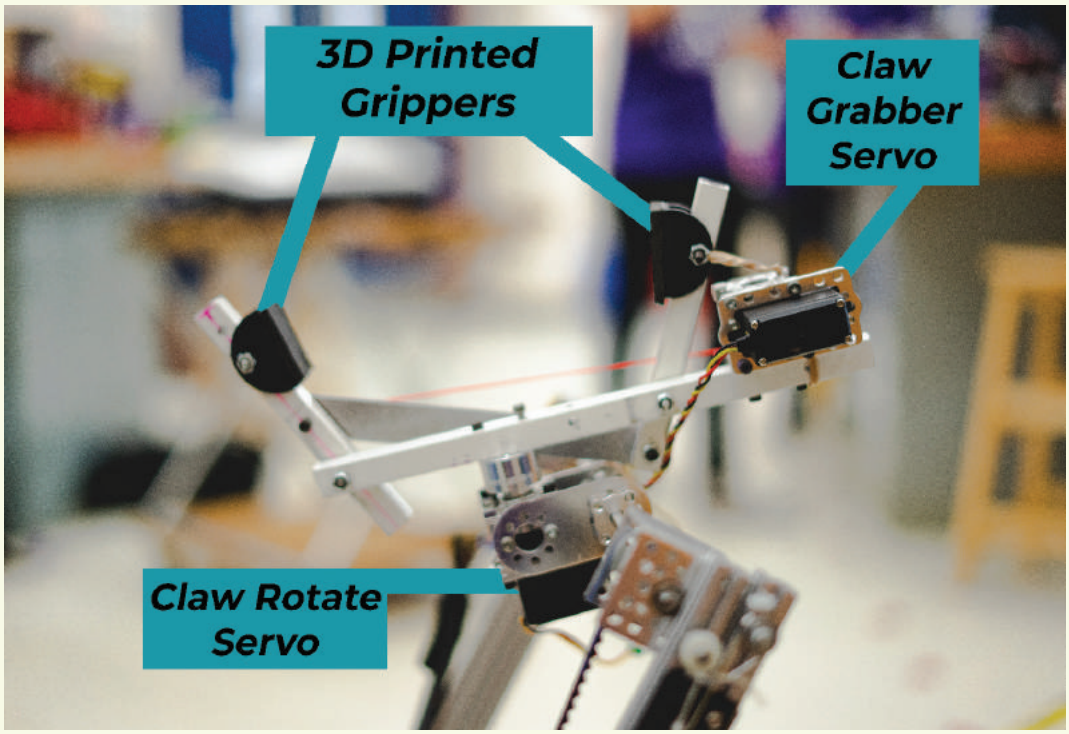

Foundation Hooks
REV Color Sensor V1
REV 2m Distance Sensor


3D Printed Grippers
Claw Grabber Servo
Claw Rotate Servo

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Drivetrain

In order to maximize points in the game, we recognized that being able to navigate under the alliance marked skybridge was important. This meant the whole robot would need to be shorter than 13 inches. The skybridge is 14 inches tall, but due to field differences, we wanted to be safe in their measurements and left room for variation. Due to our new height limit, the team knew their drivetrain had to be as low to the ground as possible. Pandora explored the possibilities of ways to have the drive train lower to the ground, and ultimately settled on utilizing 4 GoBILDA 5202 Yellow Jacket 19.1 motors. These motors have the ability to be mounted inside actobotics and GoBILDA channel, which allowed for the motors to be mounted level with the channel. This meant that when the wheels would be attached, the robot would only sit 2 inches above the ground. We throughout the season, decided that we wanted to add protection to our mecanum wheels in order to prevent them from getting stuck on a game element or another robot. We noticed often times during the autonomous period that our robot would get off track because of outside factors like the field walls or even another robot as our wheels would hit the object. In order to solve this, we decided to design our own side driving plates to minimize the amount of contact with our wheels. The plates are retrofitted from an old FRC competition robot due to the lightweight and robust aluminum used. There are slits in the sides of our plates to create a trapezoidal shape in order to decrease weight and also create a custom surface area which would cover only the spots that were necessary for our wheels. We did this in order to still retain access to the wheels, as well as to stay within sizing requirements, as the bottom piece of the plates do not need to be as long in order to cover the whole wheel base. This also created area where we would be able to customize what the plates said ourselves, we painted them green to align with our jungle theme, and we also painted our team number on the side of the plates to get rid of a big sign that would take up space on the chassis of the robot, this was a much more simple design.

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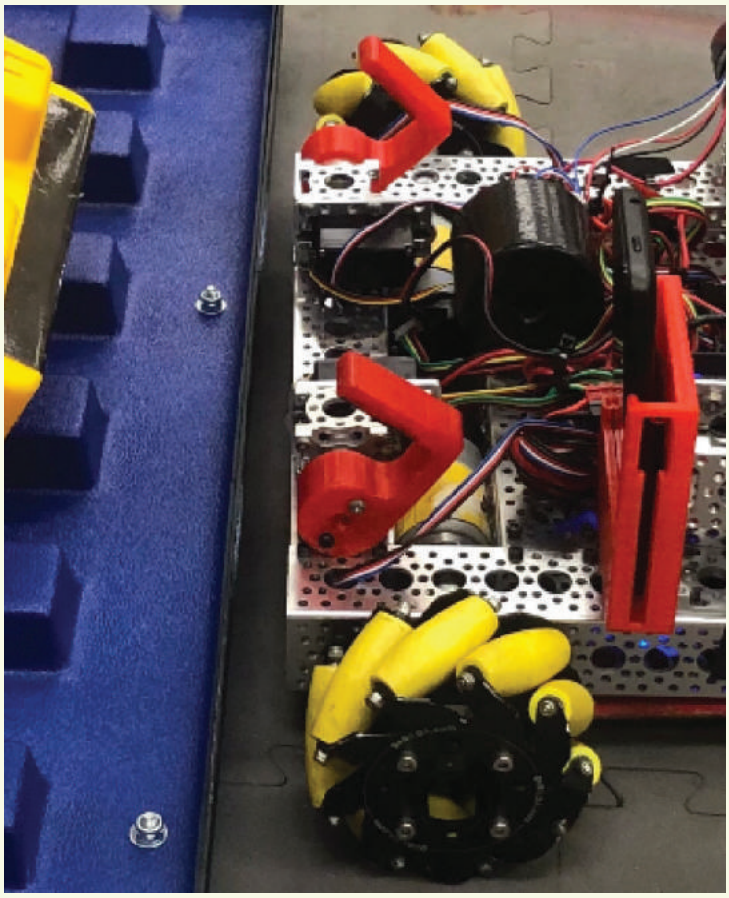
Foundation Movers



The foundation mover is an extremely essential addition to our robot. It provides the ability to score quickly and efficiently while putting a multitude of points on the scoreboard. However, much care was needed to be taken while designing this subsystem. It was extremely important to create a system that would allow us to quickly maneuver the foundation, while also being extremely careful not to knock down a tower while doing so. It was also important to create the functionality to place a block while moving the foundation during autonomous to be more efficient in scoring methods. We decided to place the moving system in the front of our robot to be able to provide full force into moving the foundation, which gave the robot more range of motion for this. We custom designed two 3d printer hooks that had a perfect curve to grip the lip of the foundation and hold tight while it was maneuvered in Tele-op and Autonomous. The hooks added two points of contact which was also more effective in moving the foundation than other systems. We also added grip tape to the ends of the hooks to assist in mitigating slippage of the hooks.

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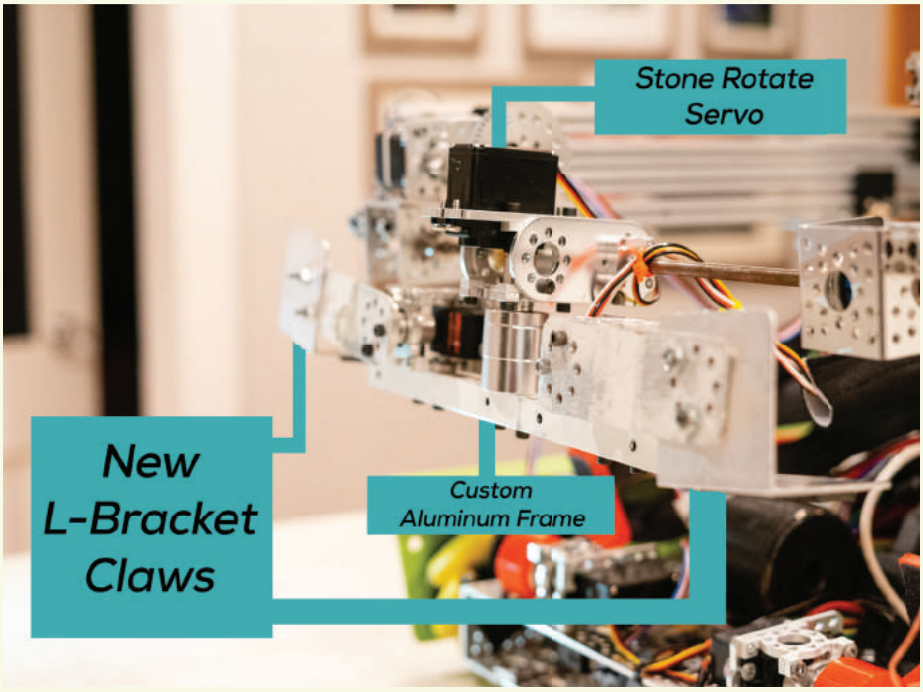
Claw

The claw subsystem was the foremost utility of our robot this year. The claw has been through 4 iterations throughout the year, each one more efficient and lighter than the last. It was important to have a quick, light, and efficient claw for this game as this was the way we would pick up stones and place them on the foundation. With our research and multiple designs, we found that a lightweight box aluminum design was perfect because of its customization potential and its compact and lightweight features. Using the aluminum as a base chassis, we created custom made aluminum claws to properly grab the stone. This bent design gave the claw a wide surface area to grab with, and it allowed for the block to shift between the claws for the best possible grip. This year we used a grippy rubber material called sorbothane which assisted us in having a strong grip on each block. With this design and from learning with each iteration we were able to create a claw that was very quick and easy to grab and place with. The claws would open and close with two powerful digital servos, and the claw could also swivel to different positions to allow for 3 degrees of freedom using a regular servo.



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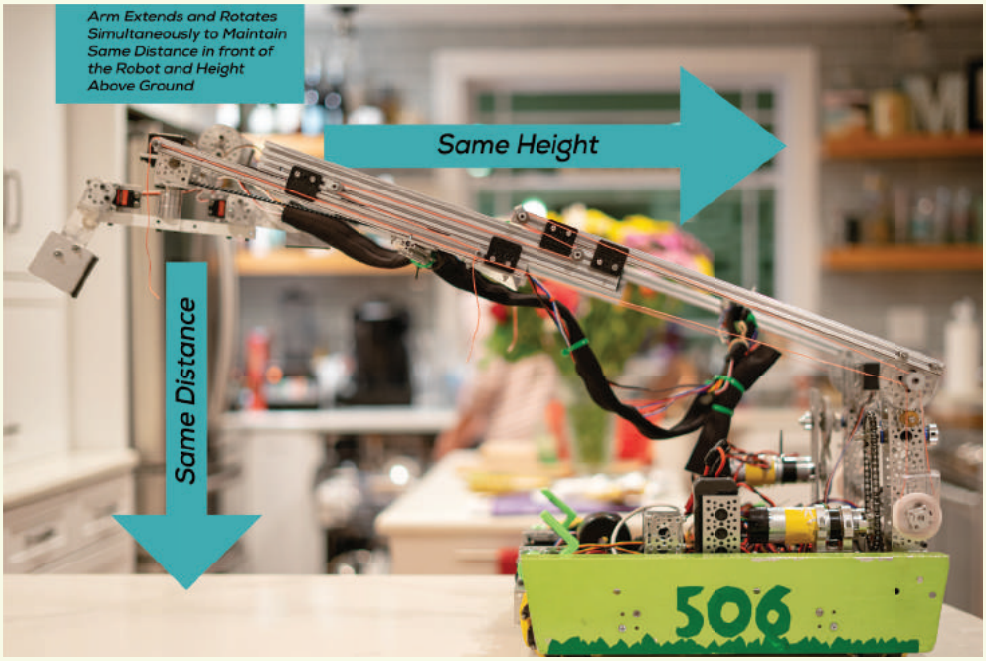
Arm

The arm has also been a very important system that we spent time working with and perfecting. In the beginning of the season we decided that the REV 15MM extrusion paired with the REV V2 slide kit was the perfect application for a cascading linear slides system. The kit comes in pieces that require assembly, we however further customized this with different lubricants and through different modifications of the slides by drilling holes and making cuts to further adapt this to our robot's design.



The slides are built in a dual, three stage system which allows the arm to extend 40 inches from the base of the robot. This allowed for a maximum reach of 9 stones stacked with a cap stone. This was very successful in competition as this was well above our average of about 7 in 2 minutes. The arm would extend in and out with a string based system powered by a motor with a 40:1 gear ratio which worked at the perfect speed to be careful enough and to be stable. The arm would rotate on an axle which allowed for the system to move up and down on a rotational axis. This was powered by two 5.2:1 gear ratio motors and attached to a 27:1 gear ratio worm gear for strength and stability.

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PROGRAMMING

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The new structure of our programming team enhanced our ability to create and implement more complex and even more efficient code. A few of the major challenges the programming team had to overcome this year consisted of optimizing our computer vision software, limited robot maneuverability and accuracy, and autonomous claw stabilization. Our programming team took our code and algorithms to the next level this year by deriving and creating trigonometric and calculus-based algorithms to heighten the capabilities of both our autonomous and teleop programs.

We started the season using computer vision software that must detect a stone itself before determining if it is a skystone or not which consisted of Vuforia and DogeCV. While these computer vision softwares are extremely popular with FTC Teams we found them to be less reliable and very sensitive to varying lighting conditions. This left our autonomous prone to misidentification of the placement of the skystone during autonomous or to time out before the stone would be identified. Correctly and consistently identifying the position of the skystone is crucial to being able to score the vast majority of a team's autonomous points. We opted for our own custom made computer vision software that simply looks at the same region of the video stream captured by our logitech webcam and based on the average RGB value of the region it can determine if it is black and hence a skystone, or not and is a regular stone. In this case simpler is better. Once the software's final version was fully developed we failed to witness another computer vision failure in the rest of our matches for the season.

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As always, time was of the essence this year with the structure of the autonomous scoring system. With only 30 seconds yet with a large ceiling for scoring points we were challenged to quicken the speed of our autonomous, and with increased speed came increased error. We spent the majority of the middle of our season developing a variety of algorithms to accomplish this challenge. The first of which was our directional strafing algorithm. By far the greatest advantage of mecanum wheels is their ability to strafe (travel in directions not parallel with the line of the wheels) and move with 360 degrees of freedom. For many teams this freedom is limited to Tele Op, with only simple left and right strafing methods being implemented in autonomous. However for our team we took full advantage of the maneuverability of mecanum wheels by deriving the equations for what we call "Directional Strafing" methods: methods that allow the robot to be programmed to strafe at any specified angle with very high precision. This now made it possible for the robot to strafe at 57 degrees northwest, or 22 degrees southeast. This method laid the foundation for our next major algorithm to improve maneuverability, our calculus-based path following algorithm. It so happens that the arctangent of the derivative of a function outputs the angle of a tangent of a point on that function. This allows our robot to maintain its orientation of facing forwards while it strafes out the path of a polynomial, trigonometric, and even logarithmic function. While this algorithm had limited use due to building restraints that would otherwise aid in its accuracy, it has laid the foundation for the next level of robot maneuverability in the 2020-2021 season for 506 Pandara's programming team. While these new algorithms allowed for more efficient and quicker autonomous paths we had to invest time into developing algorithms to increase the accuracy and consistency of the paths. A PID Controller, also known as a Proportional Integral Derivative Controller, is used to control how a motor approaches a specified tick value. We use a version which excludes the derivative portion. It functions by setting the power of a motor to a "potential constant" multiplied by the difference (referred to as the error) in the motor's current position to the position it is being specified to go to (its target position). This has the effect of making the RPM of the motor approach zero as the error approaches zero;

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Essentially decelerating the motor as it reaches its target position. However, in the occasion that motor power is unable to overcome the friction of the wheel against the ground to move the wheel enough to reach its target position we take the accumulation of the error and the larger that accumulation the larger the power being sent to the motor is multiplied. Which has the effect at overcoming any potential of a motor stalling and increasing the accuracy of our paths by decelerating to a stop.

The most important part of our design is our unique claw design which requires the claw to maintain its downright orientation autonomously. We use input from two potentiometers, one mounted to our claw and one mounted to our arm, and an algorithm which utilizes a PID to tell our motor how to adjust our claw. We decreased the systems vulnerability by using two separate potentiometers because if by chance the belt which moves the claw were to skip it would communicate that with the potentiometers and the algorithm would continue to be able to stabilize the claw correctly. Before we had run into issues where during tele op a driver would cause the claw to stabilize incorrectly by causing the belt to skip.

These are just a few of many programming projects Pandara implemented in the 2019-2020 season. To learn more we highly recommend you read our notebook to see our derivation of the equations which back our equations, programs which save text files, crash-preventing software, and more!

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CONCLUSION

As you can see, 506 Pandara has grown immensely throughout the season through our perseverance, competitive spirit and friendship. Aside from the bolts and the computers, robotics has brought the members of our team closer together as friends: building bonds that will far outlast their origins in FTC. For our team, robotics is a culmination of engineering and community service that gives us experience in the careers of the future and the importance of using your skills and inspiration for the betterment of others.

We would like to take this final opportunity to thank all of our sponsors for enabling us to do what we love while learning at the same time.

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