Team Igutech

6964

Engineering Portfolio

Game Strategy

Autonomous

- We always challenge ourselves to get the maximum number of points realistically possible in autonomous
- We prioritize reliability over the max possible score in autonomous
- We deliver the preloaded freight based on our vision target, cycle two additional pieces of freight into the high goal, and park completely in the warehouse.

Driver Controlled Period

- Our robot design revolves around a narrow frame for easy access to the Warehouse, as well as a fast and effective intake and delivery.
- Our main priority is to quickly cycle balls and blocks onto the Alliance Shipping Hub
- During End Game, we have a simple reliable mechanism to spin the carousel.
- With the remaining time, we score more freight on the alliance shipping hub and park in the warehouse

Robot Requirements

- Withstand defense without a structural failure
- Complete all major game tasks for maximum scoring potential
- Use driver automation to decrease driver workload and increase point potential

Design Process

Prototyping

- Create rudimentary prototypes that are fast and effective for the main mechanism that is highly adaptable (bucket, intake, etc.)
- CAD a more permanent solution that adapts with other prototyped mechanisms.

CAD

- Model full mechanisms and integrate them with other mechanisms

Testing and Rebuild

- Test built mechanisms as soon as possible and redesign where necessary.

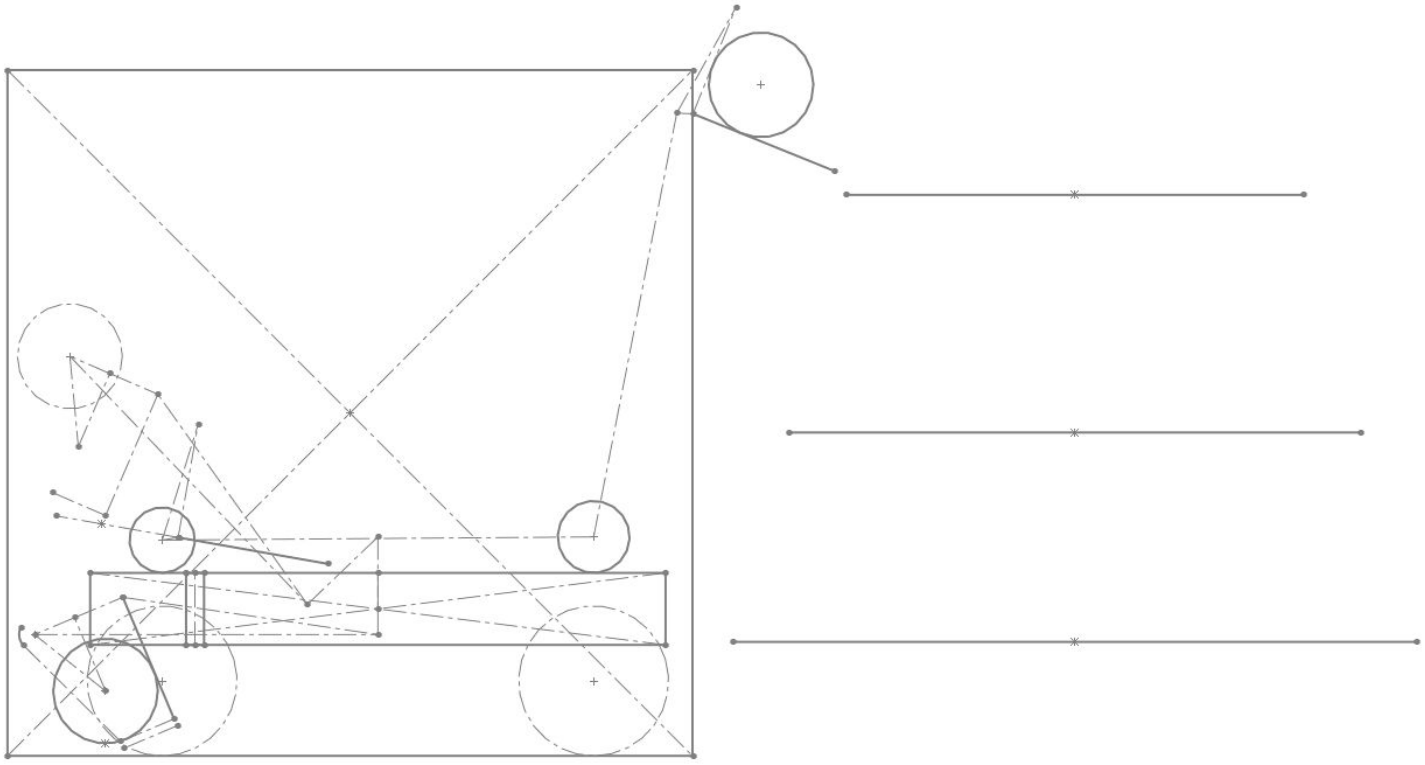
Auxiliary Mechanisms

- After the main mechanism enters the design freeze point, focus on getting end-game mechanisms ready. This year our end game mechanism was the carousel spinner.

Software Development

- Using Git for version control
- Whenever we test new features, we use a branch which creates a copy of our current code. This allows us to modify and test while being able to revert to old code quickly
- When we are satisfied with the new feature, we can merge it back with the old code.

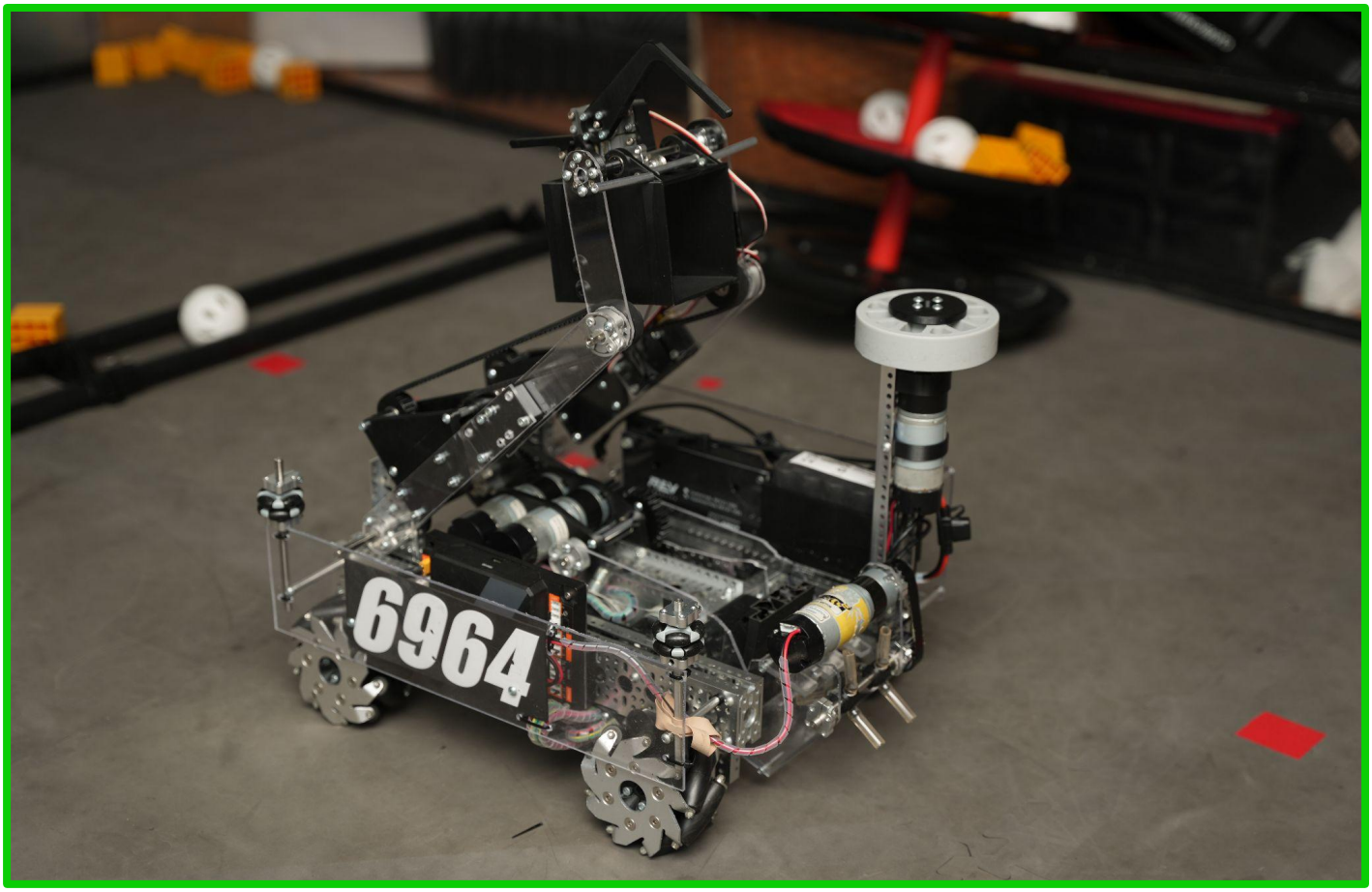
Design Process - CAD



Our robots main layout sketch. All changes to the overall robot construction are made in this sketch

- We use parametric equations and a parametric design philosophy to easily adapt our designs
- We use a few sketches throughout the entire robot design, which allows for any member to make design changes
- Changing an intake dimension or any other variable automatically recalculates and dimensions parts for every other relevant section of the robot
- Priority is put on redimensioning 3D printed parts, as they are easier to manufacture than polycarbonate plates

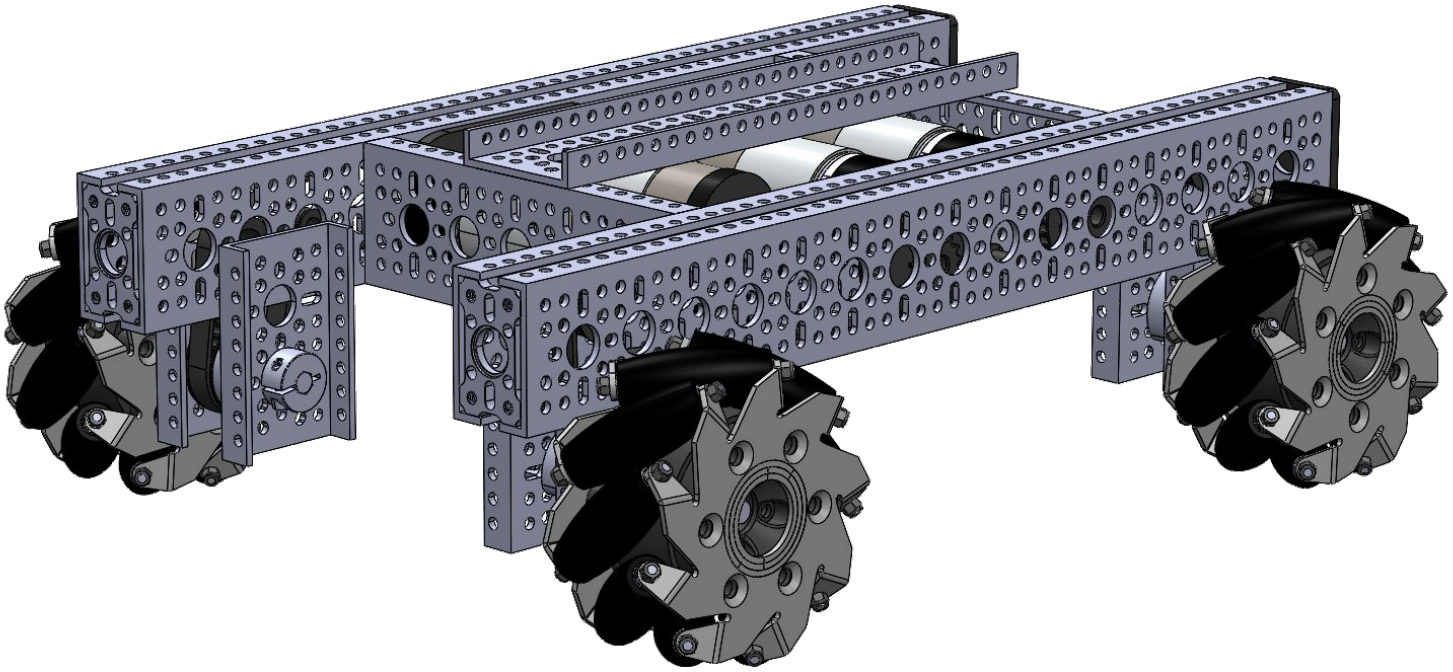
Robot Design - I

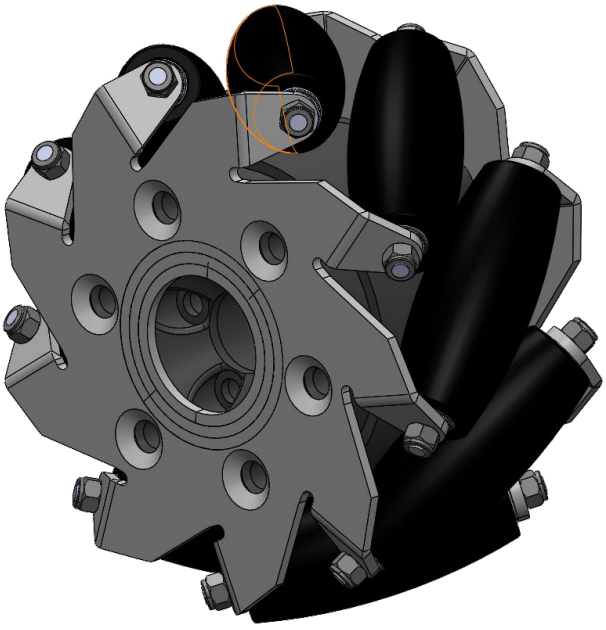


- Strong 3D-printed and aluminum channel construction
- Custom designed in Solidworks
- High Clearance Drivetrain
- 1150RPM spinning surgical tube intake
- Motor driven V4B Arm
- Motor driven intake pivot
- 3D Printed angled delivery bucket
- Motor driven carousel spinner
- High speed 17.2:1 drivetrain
- Over 200 3D-printed parts

Subassembly Design - I

Drivetrain

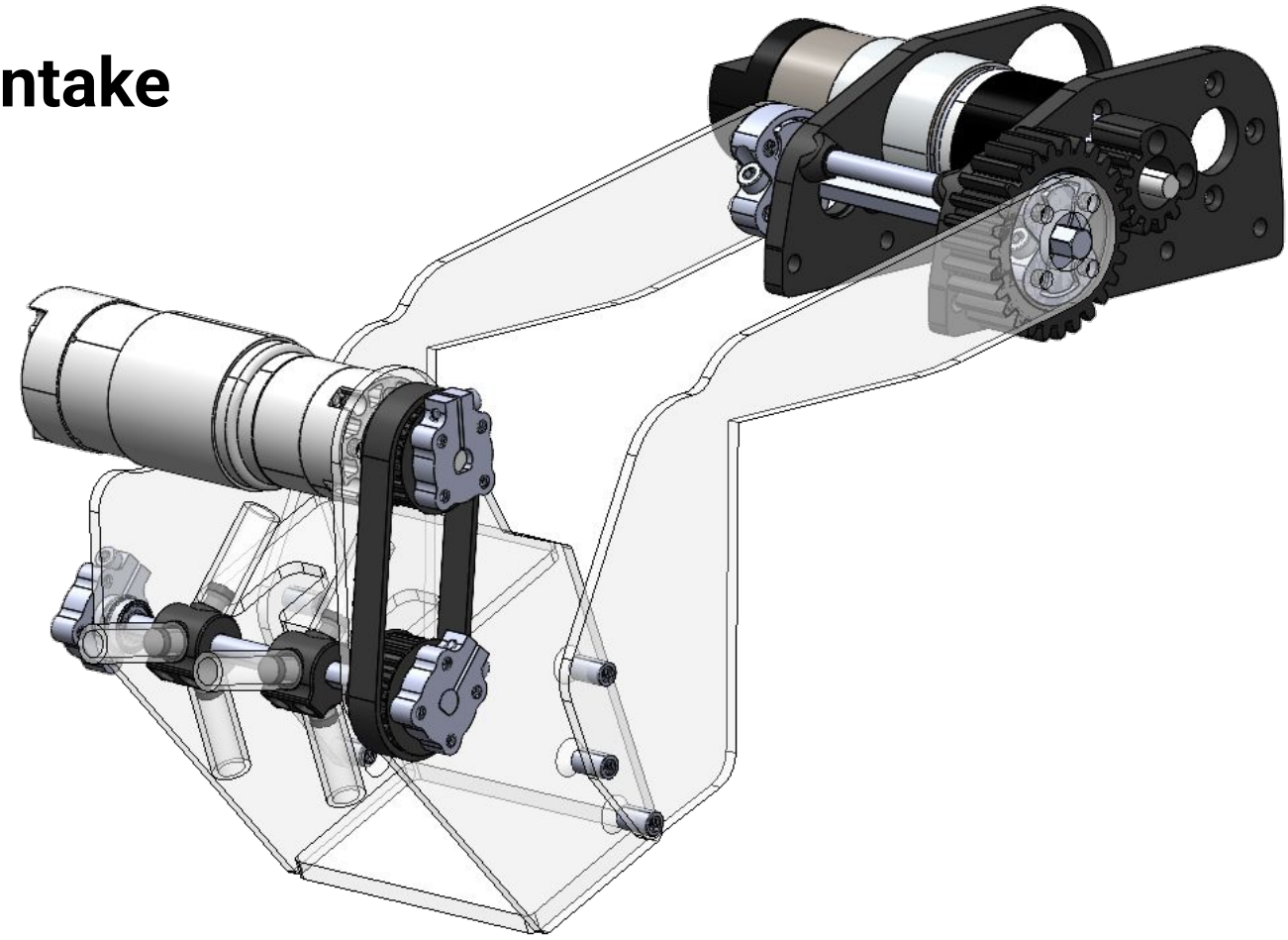




- Thin Custom-Core Mecanum wheels allow for easy maneuverability
- Narrow Drivetrain to easily access the warehouse without the need to climb the dividing rails
- Lowered Mecanum wheels to allow for clearance over warehouse pipes in the event of defense during traditional events.
- 17.2:1 gear ratio improves acceleration and top speed for quicker cycles

Subassembly Design - II

Intake



- Surgical Tubes attached to spokes to sweep elements into intake box
- Single motor to spin tubes at 1150 RPM
- Almost instant collection speed
- Intake box is strategically sized to allow for only one element to be held at a time
- Polycarb box holds game elements and allows driver to see if anything is currently held.
- Gear assembly lifts intake up in order to push collected element into the delivery bucket

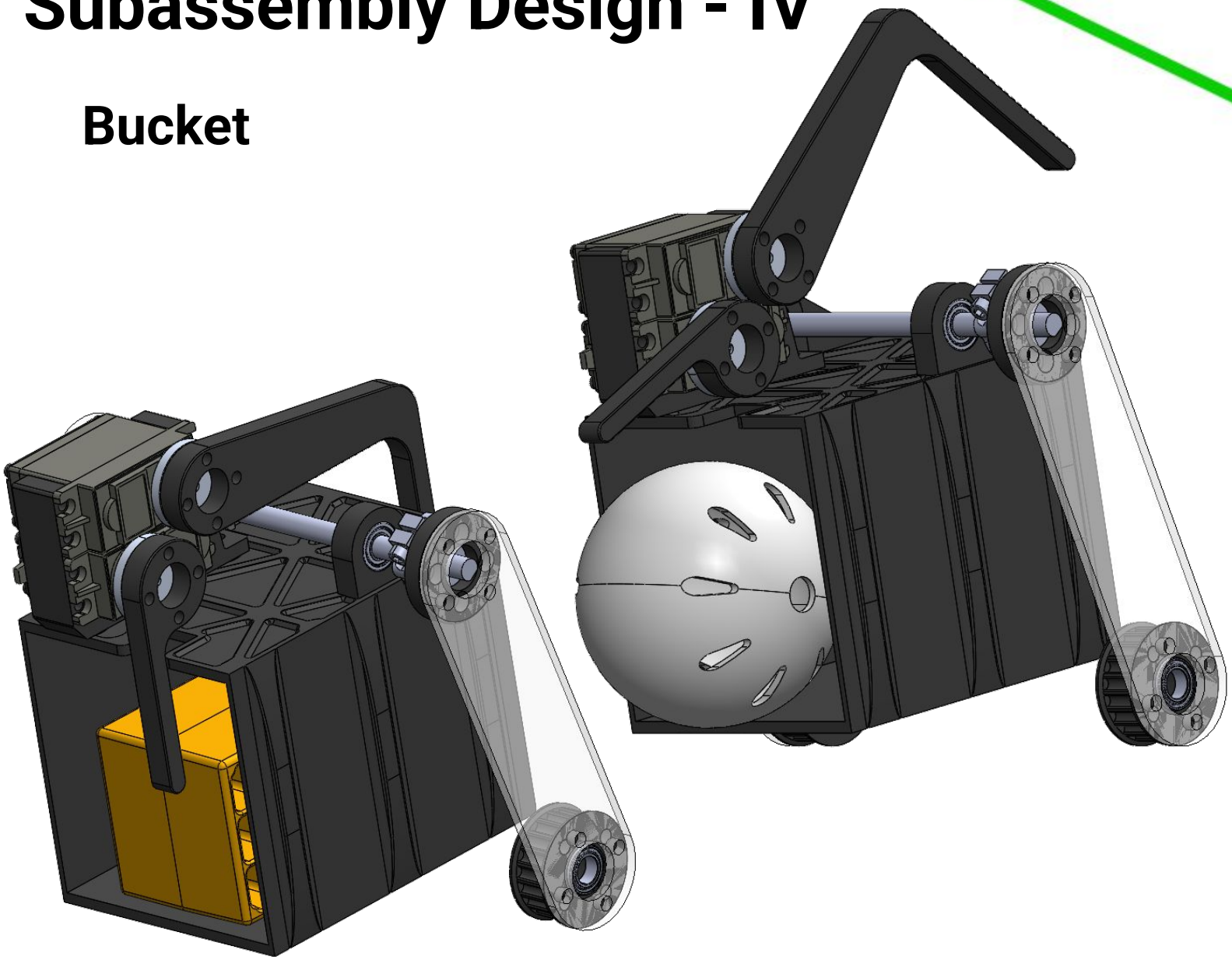
Subassembly Design - III

Delivery Arm

- Utilizes a 5:4 ratio pulley system to extend the arm with enough clearance to score in the high goal
- Fast raising and lowering speed
- Consistent positioning for each Alliance Shipping Hub level
- Specific mounting angle for bucket to allow gravity to deposit elements
- Double lexan plate construction increases subassembly rigidity

Subassembly Design - IV

Bucket

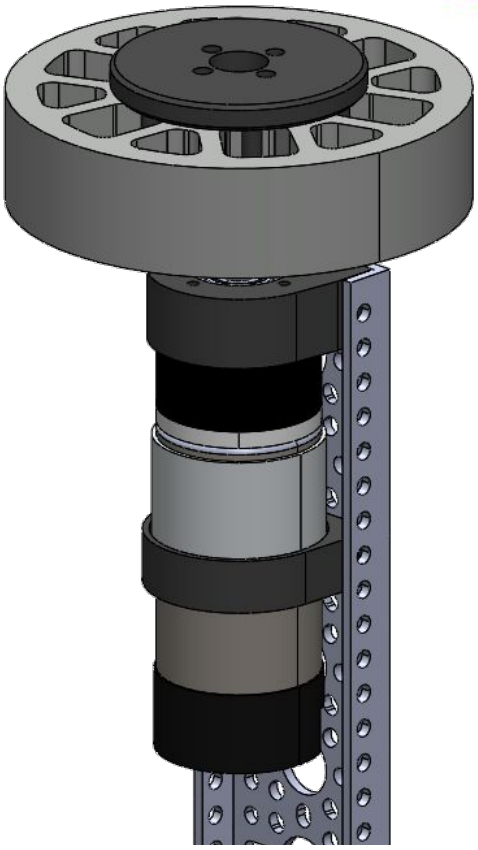


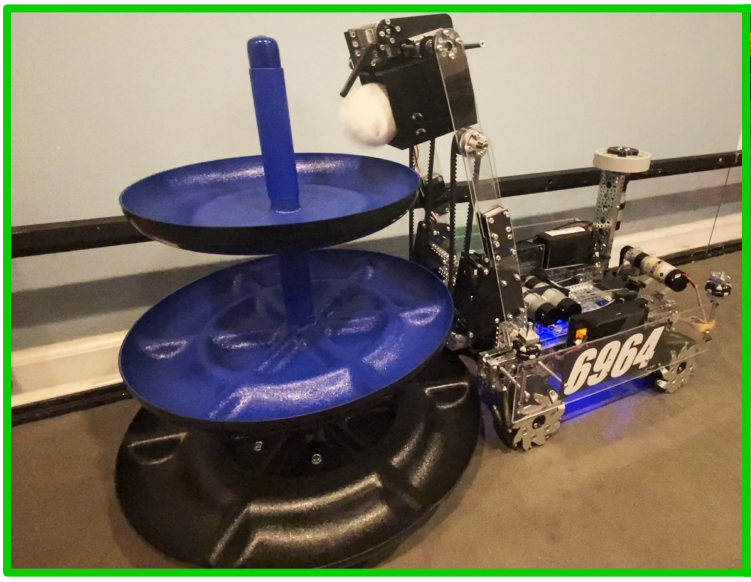
- Aerospace Industry-styled Isogrid strengthening pattern
- The entire bucket pivots and increases the deposit angle due to the displaced center of mass
- Bucket passively pivots back to the intake position when the arm is lowered
- Two servos are used to contain the game elements while transporting to the proper deposit level

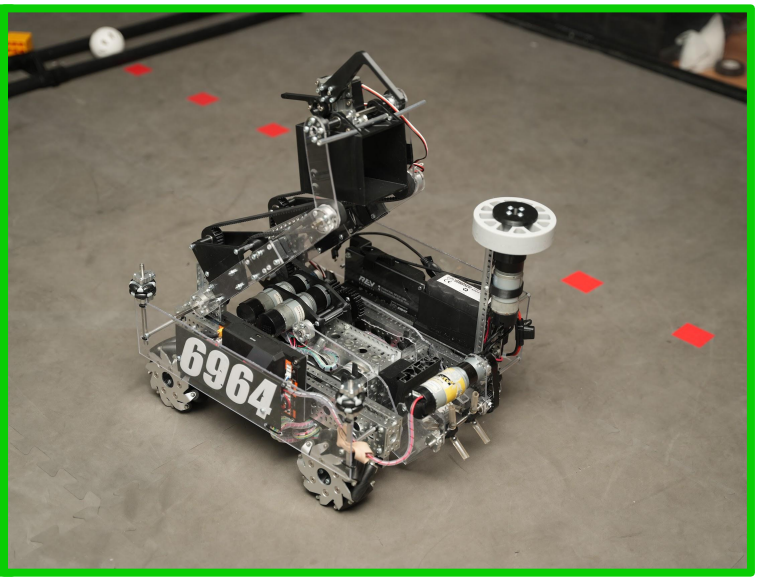
Subassembly Design - V

Carousel Spinner

- Large Flexible wheel allows for more variance in the robot's positioning in both autonomous and end game
- Adjustable speed motor driven system decreases the cycle time necessary for delivering a duck



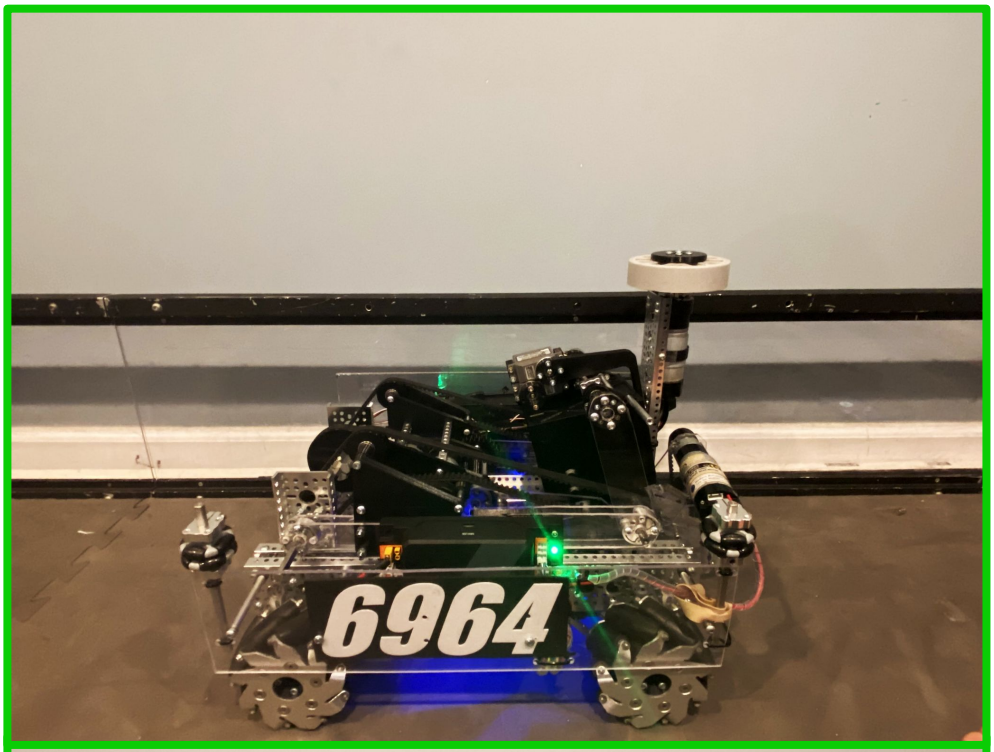




Delivery Sequence

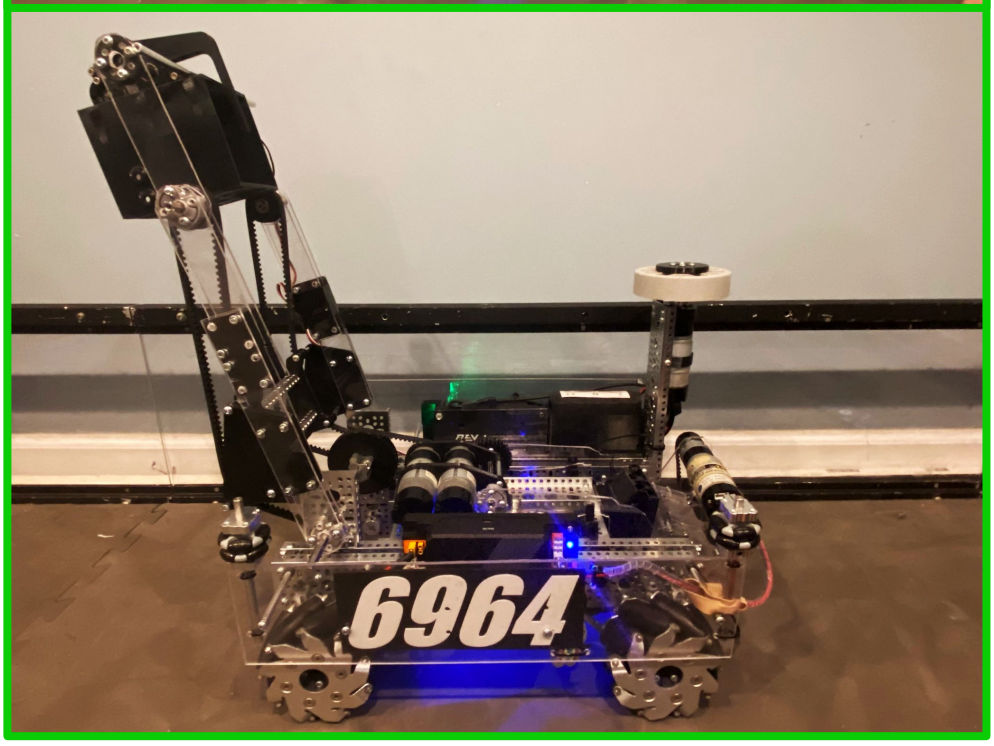
Intake Position

- Freight is easily transferred to the bucket
- The drivetrain rails constrain the delivery bucket to a consistent location every cycle



Delivery Position

- Delivery bucket tilts downwards to overcome the friction force of the freight boxes
- 3 delivery levels for each level of the alliance shipping hub



Automation

Automation has been a crucial part in our robot design strategy. Every major hardware subsystem was designed to be used with automation. Automation reduces driver workload and decreases cycle times, allowing for increased point scoring throughout a match

In the event of a sensor issue, we have redundant controls on the second driver's controller that does not use the automation features. This controller also has the ability to reset encoder values to fix any automation issues in a timely manner.

Intake

- One button controls the intake flip up positions using encoder values and a PID algorithm. This button also confirms that all servos are in the necessary place to eliminate the possibilities of jams. This reduces driver workload.

Delivery Arm

- The driver selects which level to move the delivery arm to, and this level is remembered throughout the match until it is next changed. If the driver is cycling the high level of the shipping hub, the set point only needs to be hit one time during the match. The driver has a single button that raises and lowers the bucket to the desired set point using encoder values and a PID controller.

Deployment Sequence

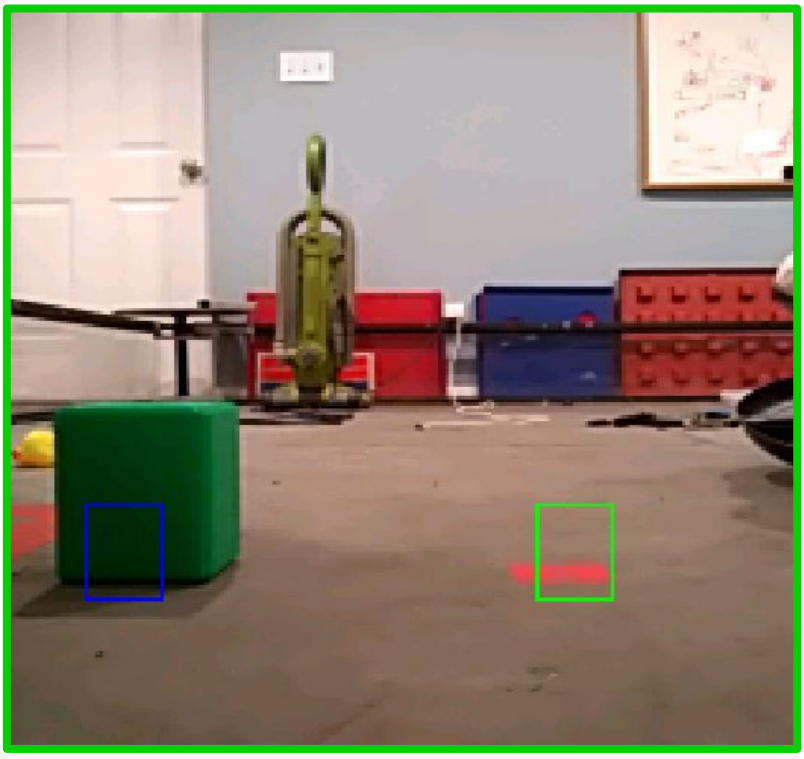
- One button releases all servos necessary to deliver a piece of freight and resets the delivery arm back to the intaking position.

Localization with Motion Profiling

We track the encoder counts on our drive motors to easily track the position of our robot. Using the IMU, we read the heading value and calculate the exact position and direction of our robot. In previous years, we have used external field tracking omni-wheels with encoders, but due to the added terrain, we made the decision to use the encoders on the drivetrain wheels. This was a necessary tradeoff to still meet our other game strategy constraints. To reduce the error caused by wheel slipping, we use a color sensor to detect the white warehouse tape line to re-calibrate the drive position. Using our high positional accuracy, we use a motion profiling library to create complex paths and follow them. This motion profiling library also maintains accurate control of the robot's velocity and acceleration. This enables us to have smooth and precise path following capabilities in autonomous.

Team Element Sampling

We created a custom solution for team element detection after testing other methods. We found that the TensorFlow and Vuforia methods were inconsistent under different lighting conditions. Our solution compares the mean color values in the YCRCB color space inside of predefined squares. This colorspace is heavily resistant to lighting differences. This custom solution allows us to reliably determine the position of the team element in autonomous.



Custom Tuned PID Controller

We implemented a custom PID controller for both our delivery system and our intake transfer system. This allows us to make more precise and more repeatable movements during teleop and autonomous. Our PID controllers allow us to greatly reduce our cycle times by consistently moving our delivery system and our intake transfer system to the correct positions and maintaining their location. The PID controller also removes any inconsistency caused by external factors, such as belt tension or battery voltages.

Modular System / State Machine

Our Modular code system decreases the time needed to make changes to code and allows us to program more efficiently. Each robot hardware component is represented as a module in our software. For example, by representing our drivetrain and intake as separate modules, we can separate their responsibilities in code. This decreases the risk of making unintended changes to other mechanisms. By separating our arm code from our drivetrain code, we know that the drivetrain can not be affected incidentally. We can reuse these modules in Teleop and autonomous, thus reducing duplicate code.

We use a state machine system to make code modifications more efficient. In our state machine, every action is known as a state, and each state contains multiple different actions. Each state transfers to the next, just as a flowchart goes from one action to the next. This creates a chain and allows us to easily change the flow of code execution, as well as making debugging easier.

Outreach

FTC-LIB

Many teams often lack mentors to teach programming. There is a big scarcity on programming resources specifically for FTC. We created a library with a couple of teams to combat this issue, https://ftclib.org/ . It includes everything needed to program in FTC. The library is extremely flexible for both rookie and experienced programmers. We have premade systems for teams to build upon with clear documentation for ease of use. We hope FTCLib can be the FTC equivalent of WPILib from FRC. There have been over 3500 downloads of the library this year.

Mentoring Local Robotics Teams

We are very active with other high school robotics teams in our area. At one of our local high schools, students have been gathering to form a VEX robotics team and compete in their yearly competitions. The team was able to acquire parts, funding, and interested students, but did not have all it needed to get off the ground. They needed mentorship from other students who were interested in similar topics. We showed them some of our hardware tricks and explained how we make engineering decisions. Our programming advice was especially crucial. We helped them get their drivetrain controls working and taught them how to optimize both code and driver controls. It was a perfect learning opportunity for both teams, as we also learned how their design process worked and implemented many of their prototyping strategies.

The other local high school in our area has an FTC team, Team 10771, Le Pamplemousse. Our team met with them and gave them design advice, as well as taught them how we use CAD to efficiently design and test subsystems.

Business Plan

Mission Statement

Our mission is to inspire young people's interest in a science and engineering career by engaging them in exciting mentor-based programs that build science and technology skills, foster teamwork, enhance self-confidence, and teach other life skills like problem solving, creativity, communication and leadership.

Our Services

Igutech Inc. is a volunteer-based organization that offers mentor based programs in the field of science, technology, and engineering. The programs are meant to go beyond the scope of the STEM education offered in public schools and allow children to unleash their creative engineering potential in a challenging yet fun environment.

Igutech Inc. encourages middle and high school students to join teams that participate in national science and engineering challenges and competitions. The goal of these programs is to stimulate the children's curiosity and train them to work creatively and efficiently as a team to solve tough engineering problems as well as develop social awareness for real-life problems in their community. These goals are accomplished by participating in non-profit science & engineering programs like the ones offered by the FIRST organization, based in Manchester, NH. All teams are mentored by volunteer coaches, parents and subject matter experts that teach engineering principles while increasing the participant's self-confidence, deepen their science knowledge and building life skills.

One key aspect of Igutech Inc. is to allow all participants to develop responsibility toward a self-motivated ownership of progress and achievements. Coaches and mentors are always present to provide a safe environment and to offer guidance, however, the children are encouraged to actively participate in all aspects of project management of the programs. This way, all participants can develop leadership, practice their communication and presentation skills, and become proficient self-motivated team leaders toward a successful engineering career.

Igutech Inc. offers in-depth technical programs in the field of robotics. Best-engineering practices, mechanical design skills as well as computer programming are taught in small team settings. To motivate young people to give their best, Igutech teams participate in challenging national science and engineering competitions.

Sponsorship

We are registered as non-profit organization in the State of Pennsylvania with the federal tax-exempt status 501(c)3. All donations are tax-deductible by law.