# ROBO SAPIENS

#19117 RO_016

# 2020



SAPIENS

# Team Overview

This is the 6th FTC season our team is participating in. Our team consists of core members and extended members.
**CORE MEMBERS**: Gabi, Miruna, Maria, Andrei, Mihnea, Ioana, Isa, Mihai, Alex, Lara, Victor
**EXTENDED MEMBERS**: Laura, Sia, Mara, Bianca, Betty, Thea, Irina, Iris, Rares
**MENTOR**: Petronia Dumitrescu

# The Agile Method

Agile is centered around the idea of iterative development, where requirements and solutions evolve through collaboration between self-organizing cross-functional teams. Through Agile, we have a greater aptitude to respond to change and manage our time, as well as much more effective communication skills.
We operate according to the Scrum methodology. This relies on breaking work into goals that can be completed within time-boxed iterations, called sprints, which in our case last 2 weeks. During the sprint we have held the following meetings:

- **Sprint Planning**: a meeting in which we lay out our goals and specific tasks for the sprint
- **Daily Standups (Fig 1.1)**: 2 weekly gatherings, usually around 10 minutes, in which we discuss the progress made so far, as well as add or remove tasks according to our needs
- **Sprint Review**: a short summary of the goals achieved in a sprint, held before the Retrospective
- **Sprint Retrospective**: a meeting, lasting around 1-2 hours, in which the team reflects on the sprint and finds solutions to overcome the problems encountered during it

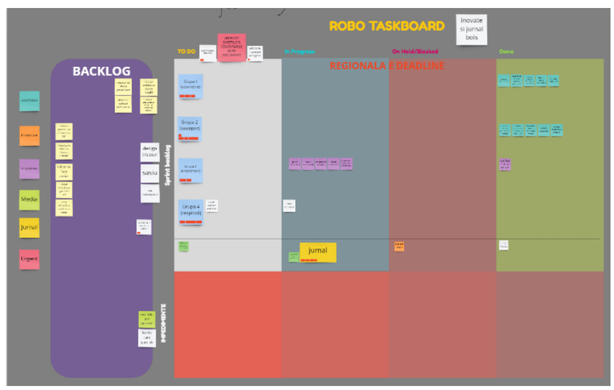

*Fig. 1.1*

To keep track of it we use *Miro*, an online platform which allows us to keep everything organized. We split the board into four sections so that we would know the status of the task. (to do, in progress, on hold or done)

# Team Management

Our team consists of over 20 members, each with expertise in various domains. For the last two years, we have exchanged the department system, as it is not suitable for our workflow, for a system in which people receive tasks based on their skill set.
Since our team is so extensive, it is oftentimes complicated to keep everyone engaged. To combat this, while also sticking to the Agile structure and avoiding a bureaucracy-type hierarchy, we kept last year's management structure, a small group of people who were the most involved called the conclave. This group is responsible for laying out each sprint's goals (see Agile Method), assigning tasks, keeping track o
progress, and establishing rules. Thus, this group has an additional administrative role, apart from working on the robot, and is completely autonomous. The other team members are the supplementary workforce.

# Skillset Overview

## Building and CAD

The building and CAD departments are responsible for building and designing the robot according to the game rules and annual theme. This year, we decided to have a 3D project of the mechanisms we want to use before building them, which meant that the building and CAD teams had to work together. For this to happen, we had brainstorming meetings for each mechanism where we discussed the concept, its advantages, and disadvantages. In order to make sure the members from these two departments communicate efficiently, we created a Communication Protocol, which consists of

- A Product Owner (PO), a person who will come up with a description of the product, and an Executor (E) who will design it.
- The PO and E will debate the idea and analyze the needs and options, and state the purpose of the product. They will also draw a general sketch and will debate the technical details based on those two aspects.
- The sketch must contain accurate dimensions, clear shapes, well-defined positions and will be uploaded on our team's Google Drive.
- The E will do a round-up of the product and the PO will verify it. Afterward, the E will design the product.
- In case of a complex project, the E will announce on the group chat the milestones of the project, and the PO will verify the product. The PO will announce the finalized product. Members with either skill set must understand the basics of each mechanism and its concept.

Moreover, the CAD team needs to know how to work with appropriate design platforms such as Fusion and CraftWare, and fully grasp how the 3D-printer functions. Having "building skills" means that you know the purpose of each part, how to use tools correctly, and have great motricity.

## Programming

The programming team is tasked with writing the appropriate code for the subsystems, as well as devising Autonomous and Tele-Op strategies. Engaging in these activities means being familiar with the FTC applications and basic programming concepts. Knowing how to use Android Studio to write code in the Java programming language, and having a clear understanding of how each mechanism works and its purpose is key for writing the optimal code.

# Final Robot

## I. Final Game Strategy

1. **Autonomous Period**
   During this period of the game, our main goal is to place the pre-loaded freight on the correct level of the shipping hub and park completely in the warehouse. This way we can earn a decent amount of points during this game period.
2. **Driver-Controlled Period**
   We decided that the most efficient way to earn points is by collecting freight and placing it on the highest level of the shipping hub.
3. **End-Game**
   Our main goal is spinning the carousel since it would earn us a significant amount of points. We would also focus on parking the robot in the warehouse at the end of the match. Additionally, we would attempt collecting the team shipping element and placing it on the shipping hub.

## II. Robot Overview

Before deciding what systems to build on the final robot, we held several meetings where we discussed each idea, its benefits and drawbacks.
The mechanisms we designed, in the end, are the *Chassis -chapter*, the *Odometry System -chapter*, the *Carousel System -chapter*, and the *Intake-Outtake System -chapter*. You can find out more about our thought and design process in the following chapters.

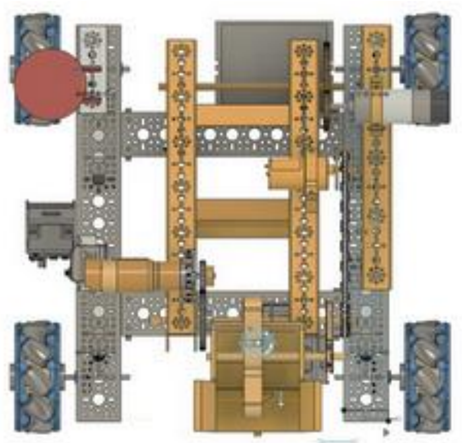

*Fig. 3.1*

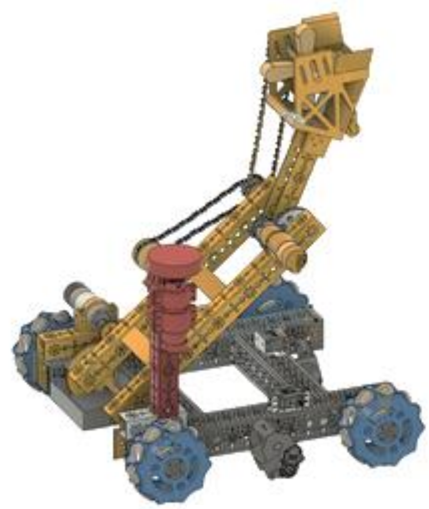

*Fig. 3.2*

## III. Movement on the Field

### a) *The chassis*

### 1. Hardware & CAD

**Hardware:**
The chassis (which includes the drivetrain) is the load-bearing framework of any FTC robot. The configuration of the active systems -which will be presented in future chapters-revolve around the chassis structure.
The design of a new chassis was our top priority for this season.
A few shortcomings present in earlier chassis models were:

- The positioning of the motors and center odometry wheel made us change the positioning of certain systems, such as ramps (fig 4.1). The diameter of the odometry wheels was too large, therefore the mechanisms that were placed near the center of the robot needed to be raised or put at a very big angle.
- The accessibility of the chassis parts was poor. We were not able to access the main parts, such as the wheels and bearings that supported the wheel shafts, transmission, and lateral odometry wheel through a minimally invasive operation

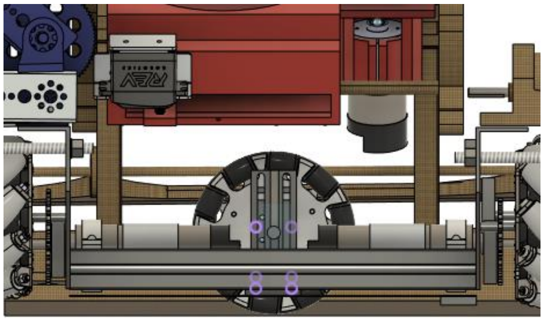

*Fig. 4.1*

## Framework:

When deciding the basic structure of the chassis, we chose to make a configuration that allows us to place the motors inside the framework. Therefore, we opted to use 50 mm U channels to fit the motors.

*Fig. 4.1*

## Motion:

The mecanum wheels were fixed to 8mm shafts, supported by 2 bearings (fig 4.4). In order to make the wheels more compact, we used flat-headed M5 Allen screws (fig 4.2).

Because we decided to put the motors perpendicular to the wheels' shafts, we used bevel gears for the transmission (5:7 gear ratio). (see fig 4.5 and the "Spiral bevel gears" paragraph in the CAD section)

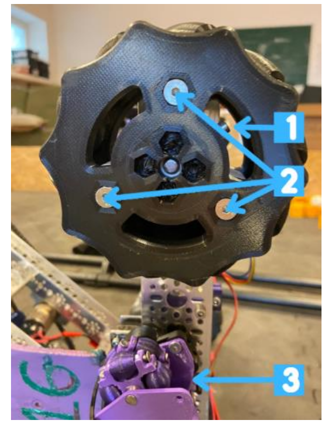


*Fig. 4.2*

*1-set-screw; 2-flatheaded M5 screws; 3-lateral odometry*

## CAD:

Due to multiple reasons such as price and adaptability, we decided to design and 3D-print our own mecanum wheels and spiral bevel gears used to engage them.

- Mecanum wheels (fig 4.6)


*Fig. 4.4*

*1-set-screw; 4-gear transmission*

The wheel's diameter determines the ground clearance of the robot, therefore, designing the wheels allowed us to choose the perfect size (narrow enough so the robot will fit in the size box, and have a large diameter so it will pass over the barriers). The mecanum wheels bring a larger range of motion for the robot than most other wheels.

- Iteration 1: This version of the mecanum wheels was downloaded from a CAD site and modified to our desire. This included a total modification of its holes and the addition of nut slots to make the wheels more compact. In order to fix the wheels to their shaft, we used threaded inserts (fig 4.3) that were bolted to the core of every wheel.
- Iteration 2: The second project was made when we realized the diameter of the wheel wasn't large enough to pass the barrier and so we scaled the object in height and length, omitting width. This was a major flaw as it turned out that the rollers lost the previous 45-degree angle, which meant they wouldn't have worked properly.

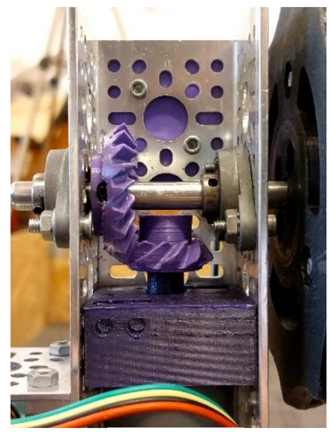

*Fig. 4.5*

*Fig. 4.3*

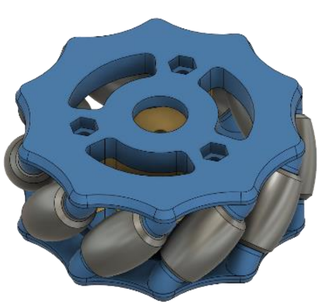

*Fig. 4.6*

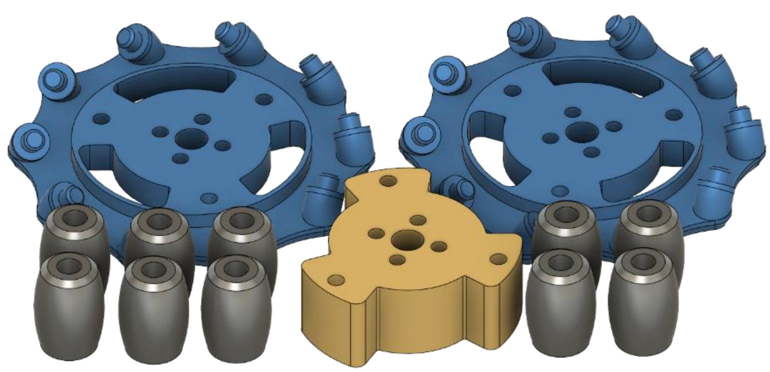

*Fig. 4.7*

*Components: Gray-10xRollers; Yellow-1xWheel core; Blue-2xWalls*

- Spiral bevel Gears

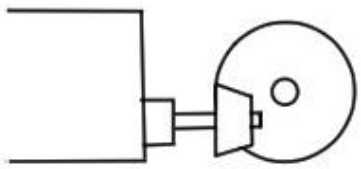

*Fig. 5.1*

Seeing as ordering a set of suitable metal bevel gears would take more time than creating our own through trial and error using plastic filament, we decided to do just that. The spiral bevel gears are far different from the original goBilda parts, the design changes suited our needs and compensated for the lack of resistance, the need for a strong and reliable thread for the set-screw and the offset of the motor shaft from the wheel shaft. (fig 5.1)

  - Iteration 1.0: The first version of this transmission was created after calculating what would be the optimal speed and torque. We used a program called MITcalc which helped us calculate the proportions of the gears based on the dimensions of the motors, the offset and distance between the shafts, and the gear ratio, we added improvements such as a wider extrusion (fig 5.2) for the smaller of the two gears to prevent is from sliding down and for the axle pin to have a better screw angle.
  - Iteration 1.1: This variation consists of a change in filament, from PLA to Nylon, without altering the design. We considered nylon's superior resistance as a serious advantage. Yet after some tests, we decided against using this type of filament because of its brittle nature. The main issue was that the gear would get worn out rapidly, meaning that we had to change them every other match. We also encountered problems with the printing.
  - Iteration 2.0: (fig 5.3): The second and last iteration included stepping away from the original idea of using a grub screw through the plastic wheel. Instead, we thought of using an M6 nut, drilled with a 6mm bit on the inside and threaded on the side, for an M3 set-screw. This was a better idea since the plastic thread is unreliable. It is important to note, however, that the nut was only added to the larger of the 2 gears, as it was the only one struggling to stay fixed. (fig 4.1)

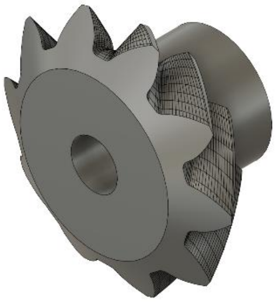

*Fig. 5.2*

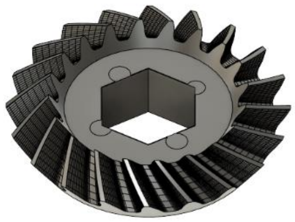

*Fig. 5.3*

### *b) The odometry system*

Even though we did not end up using the odometry system (element 3, fig 4.2), it was fully functional and one of our greatest achievements this season. The reason we decided not to use it was because the programming department this season was in a constant learning process and they did not have enough time to implement the odometry system's code until the regional phase of the competition.

## 1. Hardware & CAD

**Hardware:**

Our main priority this season was to make the odometry system pass over the barriers, without causing any damage to the field or robot and to not lag the robot's movement. Our idea for this system started from the "open odometry" concept from Wizard.exe FTC #9794 (fig 5.4), after which we started working on our own take of this design, suited for our chassis and encoder (fig 6.1 & 6.2). The main differences between the 2 designs are explained in the CAD section below. We used an axle to connect the Omni wheel to the encoder. To make the system move accurately we added tension to its sides by using rubber bands.

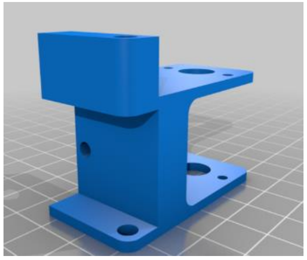

*Fig. 5.4*

**CAD:**
The main issue with the original odometry was that, due to our different model of Rev Through Bore encoder, the design did not fit inside our chassis. Our team quickly started working on another design, which instead of being fixed on the inside of the U-Channel would be mounted on the outside, with the help of an axle attached to the channel. The Omni wheel would also be included in this project and be 3d-printed.

- Iteration 1 (fig 6.1): This version of the odometry turned out really good. It was designed from the ground up using only the custom Omni wheels, the rev encoder, and a goBilda profile as references.
- Iteration 2 (fig 6.2): The last version of the project was created due to the mount being a bit too close to the ground, not allowing the wheels to properly turn, and slightly dragging itself across the playing field. It also included a major cut-down in unnecessary walls.

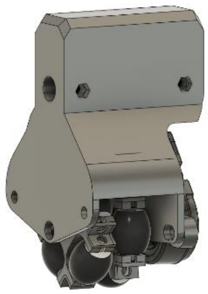

*Fig. 6.2*

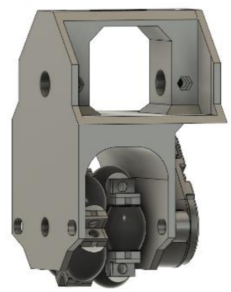

*Fig. 6.1*

### 2. Software

Since the regional competition came too quickly, we did not manage to code the odometry system in time. Instead, we use some sleep methods for creating trajectories. This is the most efficient way we can write a functioning Autonomous mode given our circumstances.
Since we don't need sophisticated trajectories, we only give some turn instructions and power to the motors in order to position the robot as accurately as possible for the tasks at hand.

## IV. Handling the freight

### 1. Concept

The Intake-Outtake system was designed to collect the freight easily, regardless of shape and size. It had to be able to ship the game elements to the shipping hub in a swift motion by securing them in the storage unit using a silicone wheel that would later help drop them on the rack.
Our initial ideas were a lot more complicated until we realized how severely we underestimated the capacity of an arm. We came to the conclusion that as long as the gripping component was suitable for all the shapes and sizes a simple two-part arm would be enough for the base structure.

### 2. Hardware & CAD

**Hardware:**
The system is divided into those parts: **the framework** and **the sweeper.**

**a. The framework (1-6):**
The framework consists of two "U" profiles (5) connected by one shaft that also acts as a pivot point (4). Two other L profiles were added for structural integrity (6). To make the whole system rotate we used a gear transmission with a 3:1 ratio (3).

**b. The sweeper (7-14):**
The sweeper itself is made out of the storage unit and the transmission.
For the sweeper wheel to rotate, we used a Tetrix MAX DC motor (12). The most compact way of incorporating it was by using a 1:1 gear ratio chain-driven transmission (13). In order to have constant tension in the system when the sweeper rotates, we used the pivot of the sweeper (9) to support 2 sprockets coupled with an 8mm hub. One sprocket is driven by the motor and the other one drives the sweeper wheel shaft (14). The hub is not fixed to the pivot shaft, because it is not supposed to engage it.

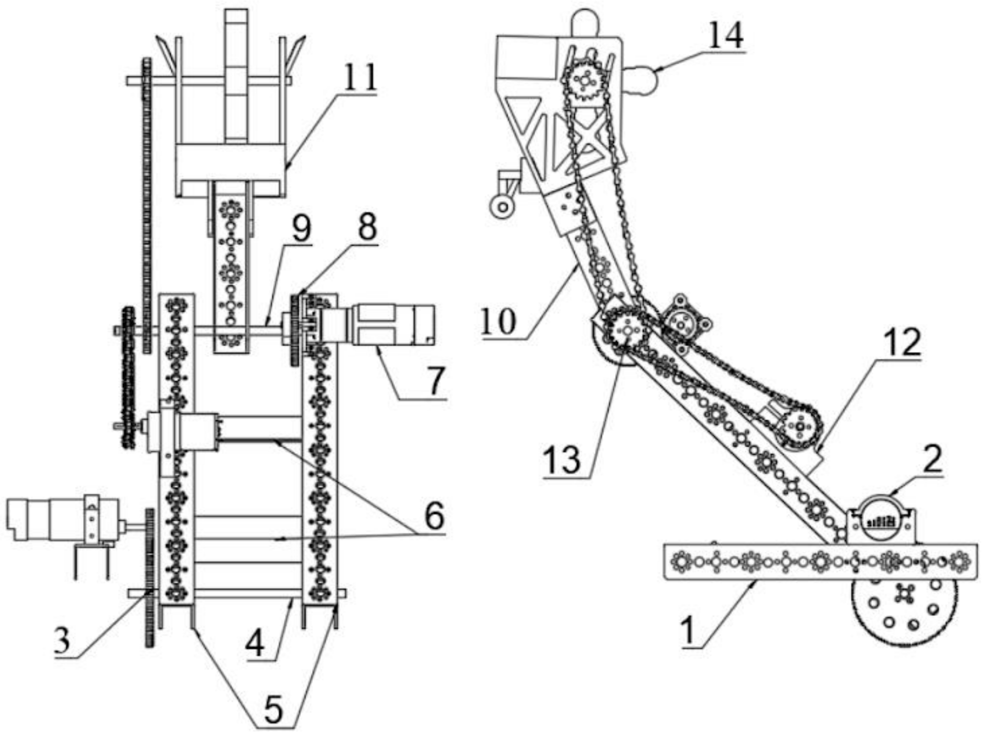


*Fig. 7.1*

*1-Tetrix "U" channel that supports the transmission; 2-NeveRest 60:1 motor; 3- spur gear transmission; 4-base pivot shaft; 5- Tetrix "U" channels; 6- aluminum L profiles for reinforcement; 7-goBilda motor; 8-spur gear transmission; 9-sweeper pivot shaft; 10-Tetrix channel; 11-storage unit; 12-Tetrix motor; 13-chain driven transmission, 1:1 final gear ratio; 14-sweeper wheel*

**CAD:**

The storage unit (fig 7.2 & element 11, fig 7.1) of our sweeper was fully printed from PLA material, due to weight and durability concerns. Rudimentary prototypes of this object from OSB and dibond taught us that we need to treat the aforementioned concerns with care. Our team quickly came up with a great design and sent it to one of our sponsors for printing. It included an adjustable slot-hole for the wheel and its bearings, mounts made in mind with the Tetrix hole design, and a caster wheel so the movement of the robot with the object on the ground would not damage the playing field. There was a single iteration of this design.

*Fig. 7.2*

## 3. Software

The arm's motor's encoder is used for lifting the arm in the position for placing freight on the top level of the shipping hub. The storage unit's motor goes to different positions, with the help of the encoder, corresponding to the level on the shipping hub on which we want to place freight. The sweeper can go both ways, for intake and outtake, and can go slower so as to not launch game elements.

# V. Spinning the carousel

## 1. Concept

To complete this task, we opted for a fixed mechanism due to its simplicity. Seeing as the Intake-Outtake system takes up a lot of space on the chassis, we agreed to make it as compact as possible while still maintaining the features we desired. The only purpose of this system is to deliver the ducks in a swift motion, therefore our aim is to rotate the carousel plate using only a wheel as the initiator.

## 2. Hardware and CAD

The system (fig 8.1) was built using two components: a 25 by 25 mm U channel which we called "the pillar" and a 3D-printed wheel.

- *The pillar* (1) was placed on the front left corner of the chassis to give the wheel (4) better access to the side of the carousel. For it to work accordingly, we placed the wheel at the same height as the carousel. The wheel is actioned by a 5000 series goBilda motor (2), which was fixed on the pillar with a two-piece 3D-printed mount (3) designed specifically for this system.
- *The wheel* itself was a 3D-printed piece from one of the previous robots. We used rubber sealing strips to improve the grip so it could rotate the carousel.

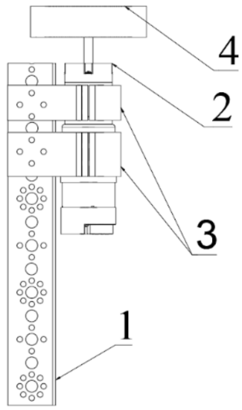


*Fig. 8.1*

*1-Tetrix "U" channel; 2-goBilda motor; 3-3D-printed motor mounts; 4- 3D-printed wheel*

## 3. Software

This subsystem is not too complicated; the motor is set to spin the carousel as fast as possible without throwing the duck off of it.

# VI. Identifying the position of the duck

## 1. Concept

This mechanism is crucial for collecting points during the autonomous phase by identifying the location of game elements on the designated barcode. We didn't need anything more than a camera for this system, so this was a rather easy task.

## 2. Hardware & CAD

**Hardware:**
For the camera we used a Logitech C270.
**Cad:**
Since it would have been easier to 3d print a mount than fix the camera to the chassis (fig 8.2), we decided to do just that and made a 10cm tall mount with angle adjustability of 30°.


*Fig. 8.2*

### 3. Software

For this task we opted for using the high-resolution webcam from last year and settled on implementing an OpenCV class, deciding it would be the most efficient for the task. OpenCV is an image processing library that can detect colors in given areas of the camera feed and it can easily tell us where an object is by searching for its color. That is achieved through thresholding, which means setting a range between two colors and looking for the color of the object in that range. We set two rectangles in which to look for a yellow object (being duck or game element) for two of the barcode squares. The third square isn't visible due to the camera angle, so if the first two squares are empty, we assign the object's location to the third.

# Prototypes

In this section, we will go over the concepts that underpin our final intake mechanism. This is the only system we prototyped this season since we were more focused on the final robot.

## The claw mechanism

### 1. Concept

This mechanism was based on one from the previous season which had the same name. It was a simple 'arm' made out of two parts: the frame and the 'claw'.

### 2. Hardware

- Framework

The framework was made out of a U profile that was actioned by gears and a motor. At the end of the profile, we added a servo that would activate the 'claw'.

- The claw

The 'claw' was last season's wobble goal lifting mechanism. We 3D-printed it to make sure that it had the right proportions. It had two parallel 'arms' gripping the freight from both sides.

**Lessons learned:**

Some of the problems that we faced were that:

- It was inconsistent
- The freight could easily slip
- It was very slow
- It put pressure on the drivers

# Outreach

## 'Spooky-Sapiens'

'Spooky-Sapiens' was an online competition in which multiple teams had to choose a theme and dress up accordingly. Following that, they had until October 30th to post a photo on Instagram with the hashtag #SpookySapiens21 and tag us.

In order to determine the winners, we divided the awards into two categories: *the audience favorite* and *our personal pick*. We made a voting form in which the public could support the competitors by voting for their favorite costumes. The winners would receive customized memes based on the photos they submitted for the challenge. In an attempt to promote the event, we also participated and dressed up as the Scooby-Squad.


*Fig 10.1*

| Expectations | Outcomes |
|---|---|
| • We expected a large number of teams to participate in the contest. | • Because of the small number of people joining our challenge, we dropped the voting form and the prize. |
| • Bonding with other teams through events. | • There was only one team that took part in the competition. |

**Lessons learned**

- Make sure we give enough time for the other teams to complete the challenge.
- Consider how difficult it must have been for the other teams to meet up under the current circumstances.
- We gave little to almost no time for the other teams to organize themselves.

## RoboTalks

During the team's event brainstorming which we had had at the beginning of the season, we decided we wanted to come up with a new event idea that would help us interact better with the FTC community and strengthen our relationship with other teams. Taking into consideration our past experience with events, we wanted to have an interactive event during which the participants could exchange ideas and learn something new. Thus, we thought the most suitable idea was to have a debate event, in collaboration with our high school's debate team. The subject of the debate was whether or not strong AIs should be banned.

| Expectations | Outcomes |
| --- | --- |
| • FTC teams would be interested in joining, therefore we would have a lot of participant teams | • We only had two registered teams |
| • Have good quality content and share the information about the event clearly | • We only had one speaker, instead of two |
| • Have an interactive opening ceremony with speakers about artificial intelligence | • The second speaker canceled last minute |

**Lessons learned**

In case we want to organize the second edition of this event, here are the things we consider worth approach different:

- Change the target audience to anyone who is interested in debating, not only FTC teams
- Before announcing the event, make sure we have settled all aspects related to the schedule and the people attending
- Have a back-up plan in case things don't go as planned

## Gaming Festival

This year, we also conducted an online video game tournament on our private discord server. We wanted a high-quality event where we could get to know people in the FTC field better while also having fun. Unlike prior events, it was open to not only other FTC teams but also their acquaintances. As a result, teams would be able to compete alongside their friends.

| Expectations | Outcomes |
|---|---|
| • A significant number of people joining our competition | • The target number was not reached |
| • Have an opening ceremony in which we would announce the tournament brackets | • There were last-minute changes in some teams |

### Lessons learned

- Double-check that none of the participating teams have canceled and that they will be able to attend.
- Make sure that all organizational aspects are well described before announcing it, including the schedule and registration requirements

## Steam week

We were invited by team Neurobotix to participate in a charity event that aims to educate 5th–8th-grade students about the world of robotics. We wanted to give children the opportunity to discover their passions in the stem field. Therefore, we have held several online courses covering different topics such as marketing, 3-D design, and how to use a markup language for web pages such as HTML.

The minimum participation fee was 20 RON, which was contributed to the St. Dimitri Foundation, a non-profit organization dedicated to improving the lives of children from low-income families.

## xRC Freight Frenzy Tournament

The current scenario is unfavorable for many robotics teams. However, things must continue, and we must all work together to evolve! As a result, this year we decided to take part in an online tournament featuring the xRc SImulator, organized by team TehnoZ in order to prepare our drivers for any obstacles they may encounter during the competition.
Even though we didn't win the tournament, we had a fantastic time with the other teams and are grateful for the opportunity to participate.

## 'Mystery Freaks'

Our team participated in Mystery Freaks, an online treasure hunt organized by Team CSH that brought together several tech domains such as cryptography, OSINT, and steganography. We had an incredible day, putting our minds to work deciphering and looking for clues in a virtual world.

## 'Maniacs switching it up'

We also took part in "Maniacs Switching It Up," an online event in which we had to collaborate with members from other FTC teams in order to create multiple projects based on the category we signed up for. Special thanks to the Gear Maniacs for organizing an incredible competition in which we not only gained valuable experience but also formed special friendships!

## DEMO BrickBots

We were quite eager to put our robot to the test before the regional competition. Our excitement slowly diminished when we faced lots of new technical difficulties. However, we did not back down, and they only served to motivate us to improve our performance. We are very thankful for the opportunity that BrickBots has given us!

# Sponsorships

We tried reaching out to as many possible sponsors as we could, however, despite our best efforts, not all of them answered.
In the end, we only managed to gain two sponsorships: *Absolut Services & More* offered to sponsor our shirts this year, and *Plastic 3D* was kind enough to print the sweeper for our system. Although these sponsorships were small, we're very thankful for each of them!

# Thank you for another amazing FTC season!