Hydralisk

Robot book

2018

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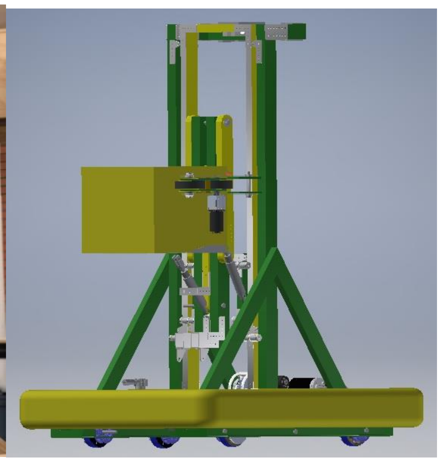
1. Introduction

The main objective of this book is to present a highly detailed look at how our 2018 robot works and some of its building process. We will be presenting a mechanical description of the robot, in which we will go through our design process and the technical specifications of each systems. Then we will proceed to make an analysis of our control system and how our code operates.

1.1 The Robot

Under Control's 2018 robot is called Hydralisk, it is 54in tall, 28in wide, 33in long and weighs 115 lbs. The robot was 100% designed on **CAD**, with only few physical changes. Here we can see the complete 3D project for the robot and the complete robot side by side.



1.2 Strategy

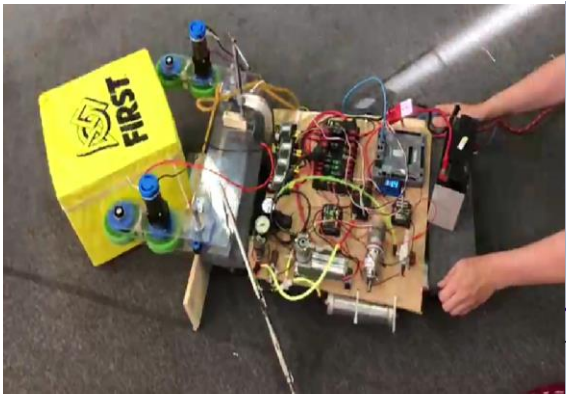
To develop a strategy for FIRST POWER UP we first created a list with the **priority tasks** that the robot needed to perform in order to be competitive:

I. Have a good and reliable drivetrain;
II. Acquire/expel **Cubes** reliably;
III. Score **Cubes** on the **Switch**;
IV. Score **Cubes** on the **Exchange**;
V. Score **Cubes** on the **Scale**;
VI. Climb.

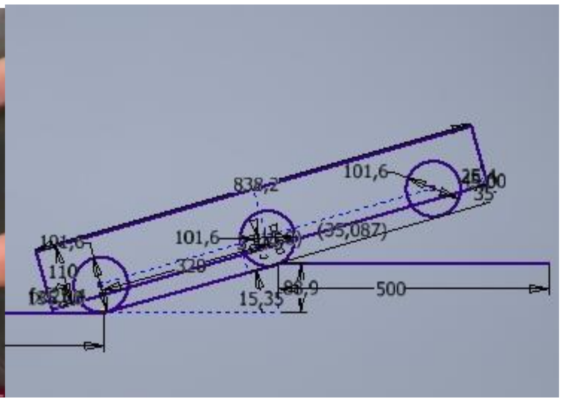
During a match, our **focus** is to control the switch and the scale. Since we get points during the time we control the scale/switch, once you control them you can start doing the exchange, our objective is to score up to **2 cubes during Auto** depending on where we score, increasing our control over the scale and the switch early on.

1.3 Initial Design

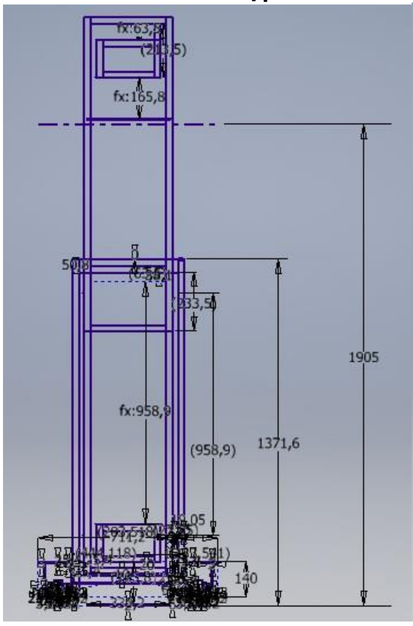
During the early stages of the design, after having defined our priority list, we used **prototypes** and **2D sketches** to test concepts and define parameters for the final robot. Here we can see some of those aids used during the build season:



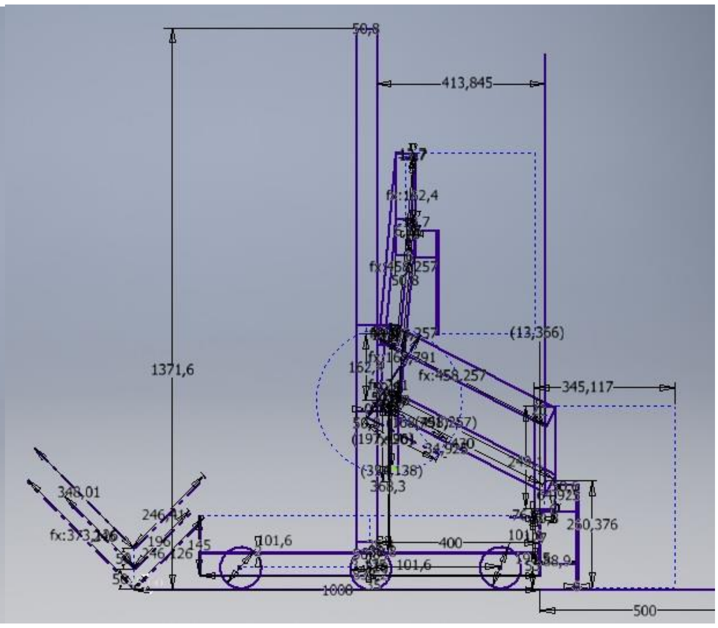
Robot Prototype



Chassis and Platform Contact Sketch



Elevator Frontal Sketch



Chassis and Platform Contact Sketch

2. Mechanical

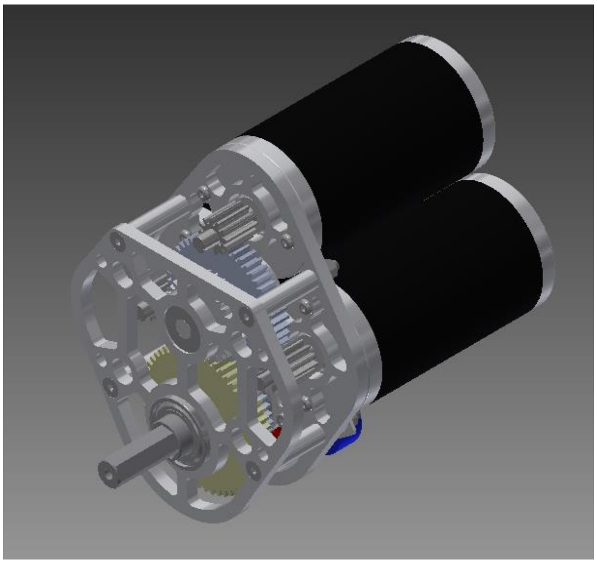
To build and design Hydralisk it was divided into 4 subsystems, which were later integrated into the final robot:

- Drivetrain
- Intake
- 4-Bar
- Elevator

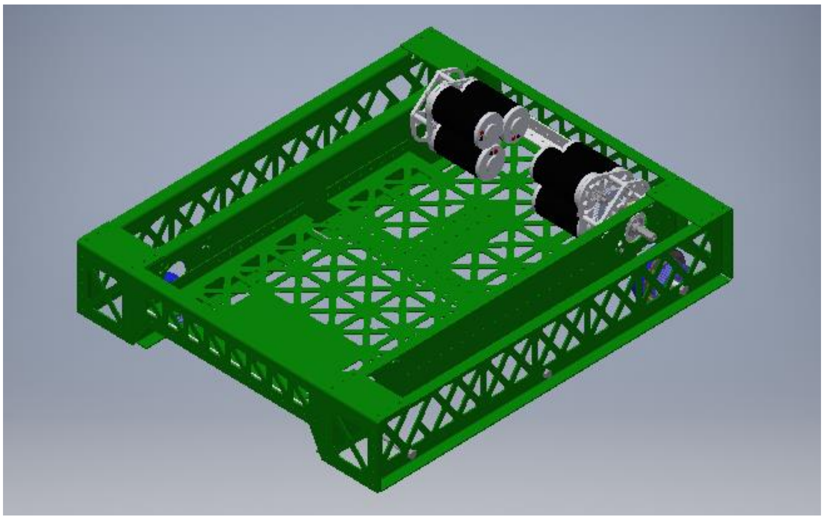
2.1 Drivetrain

Hydralisk's drivetrain consists of **6 plastic wheels** with **blue nitrile** rubber tread for increased traction and tread longevity. The wheels are arranged in two rows of 3 wheels on the sides and with a ⅛" **drop on the center wheels**, decreasing the distance between wheels on turns and increasing maneuverability. The wheels are powered by **6 CIM motors** on custom **2-speed gearboxes**, allowing for a cheap, flexible and powerful solution. The back wheels are powered through gears, the middle and front wheels through timing belts, increasing the reliability and efficiency of the system. This system allows us to achieve a top speed of **20.5ft/s** on high gear and **7.5ft/s** on low gear.

We realized that a too short robot with a **chassis** close to the ground could get stuck on the Scale's sides platforms. In order to avoid that, we sketched and built a prototype drivetrain to test a concept of a robot with a taller chassis (sketch above). The idea was to maintain the 4" wheels and change the chassis height.



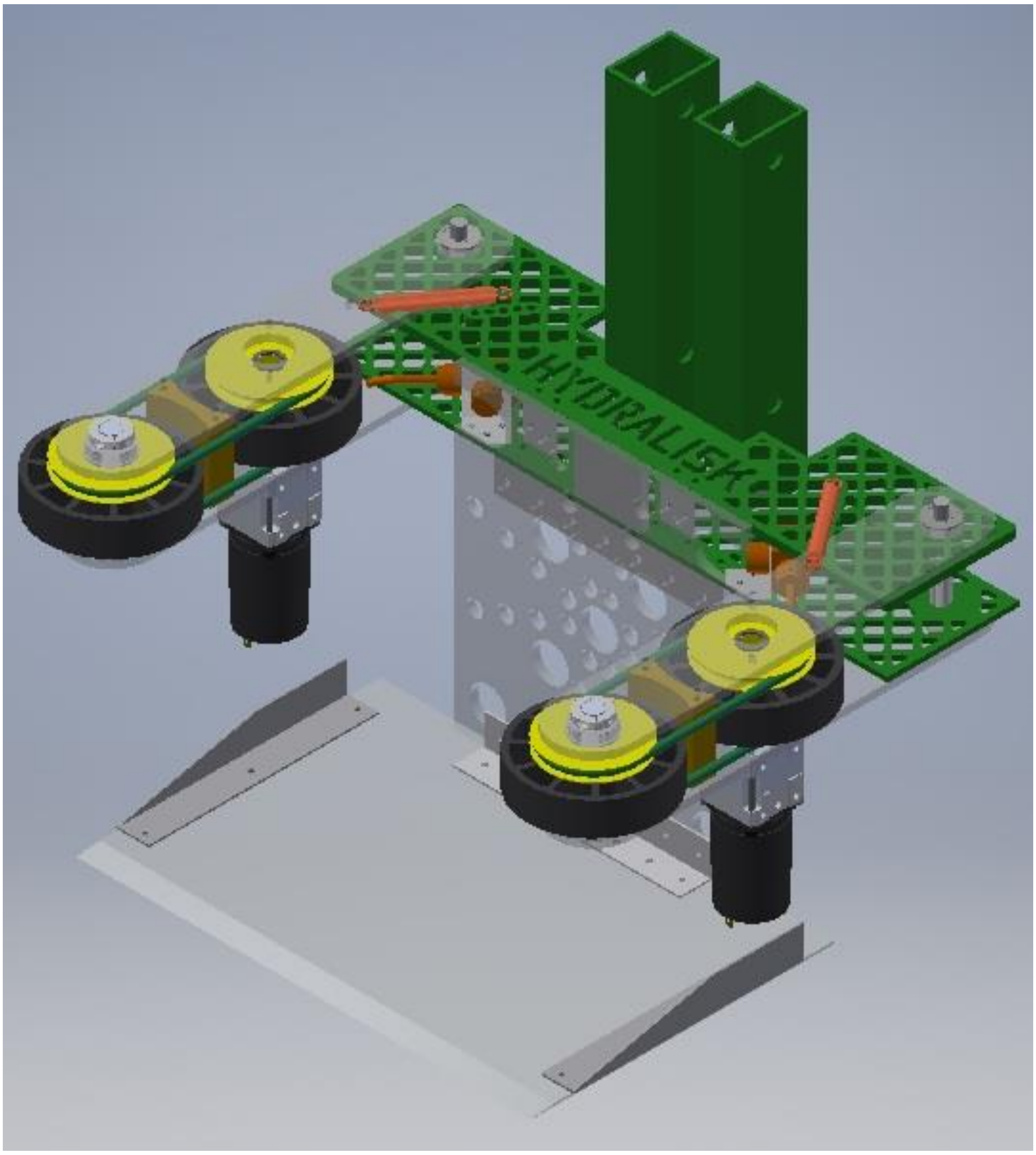
Drivetrain Gearbox



Drivetrain Assembly

2.2 Intake

Hydralisk's intake is powered by 2 **775 pro`s** with planetary reduction and four **4" compliant wheels**, to have a better grip on the cube, the arms are spring-powered so they aren't limited to one position and can adapt to the cube's shape. We used a polycarbonate sheet on the lower part of the intake so we could have a better control of the cube during quick turns.

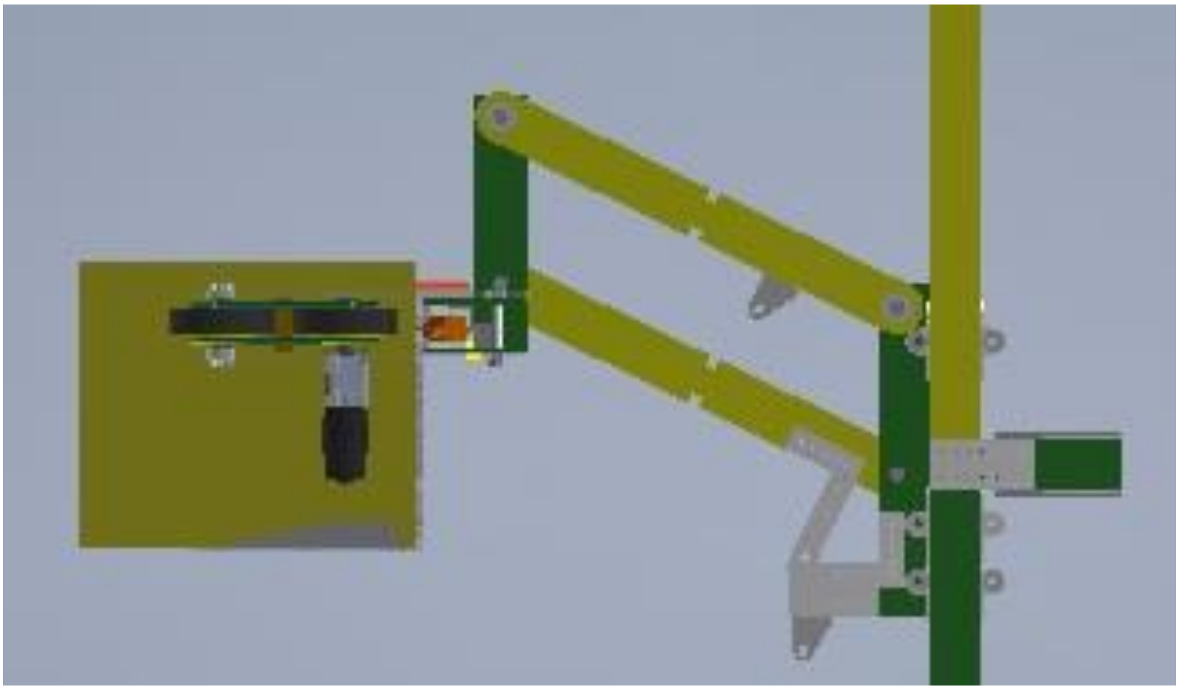


Intake Assembly

2.3 4-Bar

The 4-Bar is the mechanism that moves the intake and is fixed to our elevator. It is powered by **two pistons**, and uses two rubber bands to facilitate the upwards movement. The 4-Bar has four main functions:

- integrate the elevator with the intake;
- increase the height to score Power Cubes in the scale;
- keep the intake in the Start Configuration;
- score in the switch without moving the elevator.

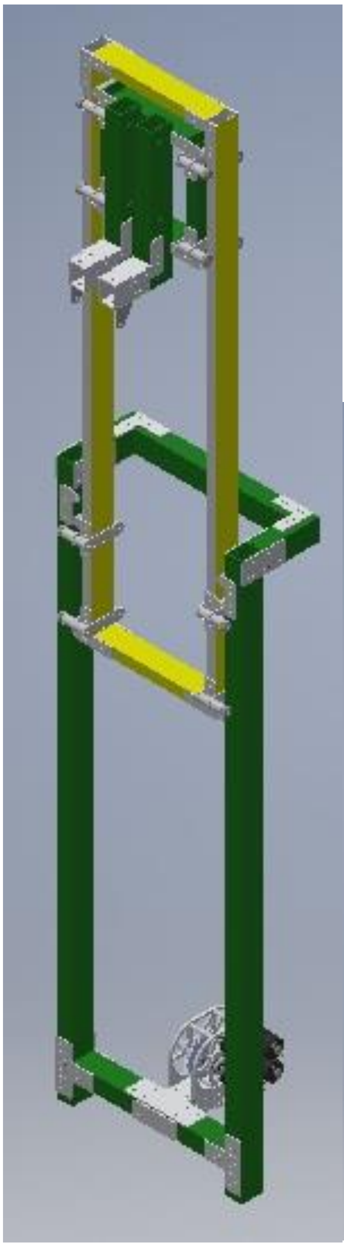


4 Bar Assembly

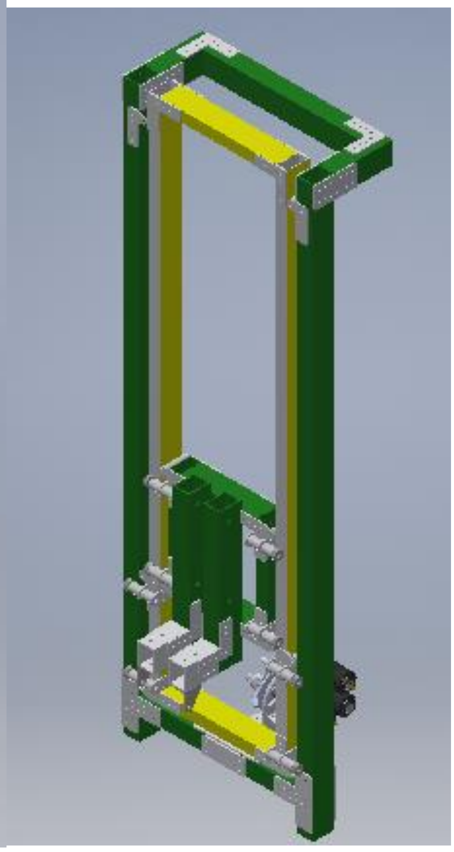
2.4 Elevator

Our elevator has three stages and is powered by a custom gearbox of **2 775-pro's** close to the floor. The third stage carries the 4-bar and the intake. The elevator in its open state can score the Power Cube in a **height of 90".**

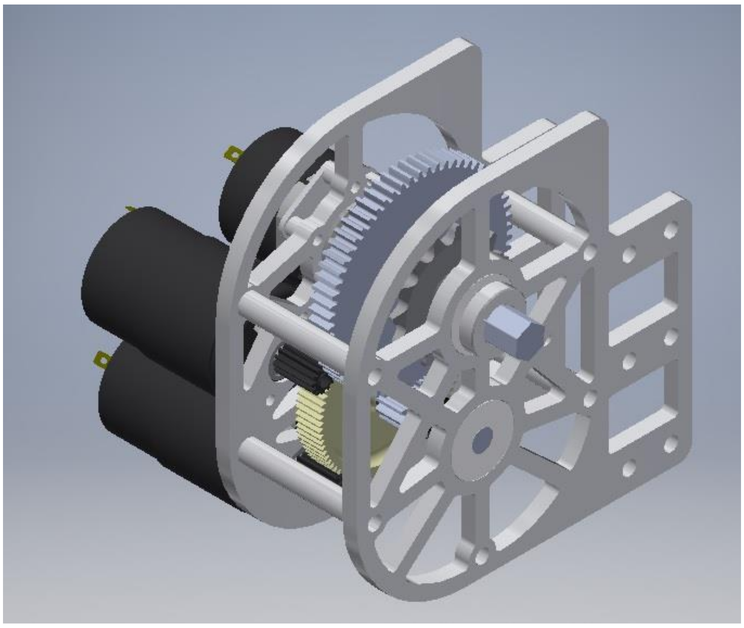
We developed a custom gearbox with slots for 4 775-pro motors. The purpose of it is the ability to choose the right reduction for the elevator, in our case, it is 33:1. We kept in mind the importance of a well-structured gearbox to avoid vibration, so we designed it to be completed supported by the elevator aluminum profile.



Elevator Assembly Open



Elevator Assembly Closed



Elevator Gearbox

3. Control System

In this section we will make a detailed analysis about control system and all derivations of it, such as robot sensors, subsystem control and the autonomous modes.

3.1 Subsystem Control

In this chapter we will explain how each subsystem is **controlled**, and how they were programmed to **aid the drive** during the tele-operated period.

3.1.1 Drivetrain

The **Drivetrain control** consists of a 6-wheel **modified arcade drive** controlled by an Xbox joystick during the tele-operated period.

To move it precisely around the field during autonomous, we use two **Grayhill 63R encoders** to measure the distance traveled by the wheels and a **MXP NavX** to measure the absolute heading of the robot.

- **Cheesy Drive**
  - open-loop control algorithm;
  - allows the drivers to develop turns of constant radius during teleop, making the robot easier to drive in higher speeds;
  - embedded rate limiter;
  - steeper learning curve when compared to the classic tank drive.

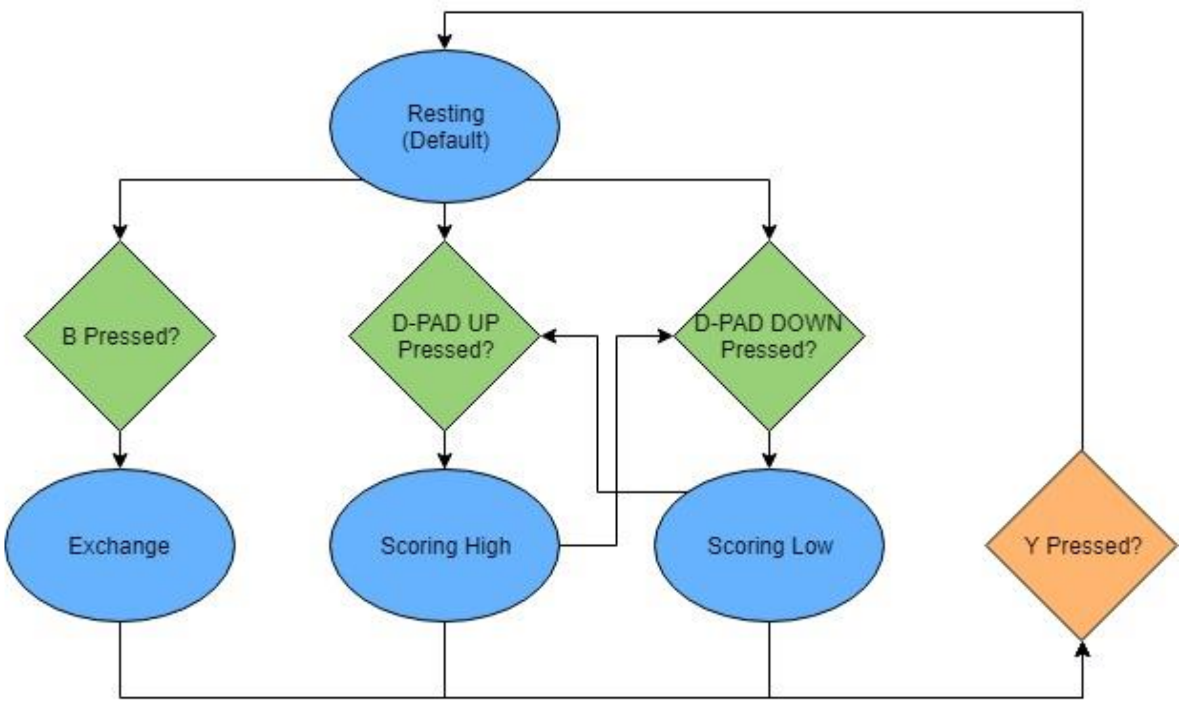
- **Gear Shifting**

To increase Hydralisk's speed and torque on the field it uses custom made **two-speed** gearboxes, designed and created by team members. To shift between high and low gears the driver uses a **trigger** on the joystick. The driver also has a visual feedback, through **LEDs** on the robot, to check in what gear it currently is.

3.1.2 Elevator

- PID Control
  - Smooth up and down motions, to safely operate the elevator with maximum speed without breaking it;
  - Stable at the setpoint;
  - 0,9s to maximum height

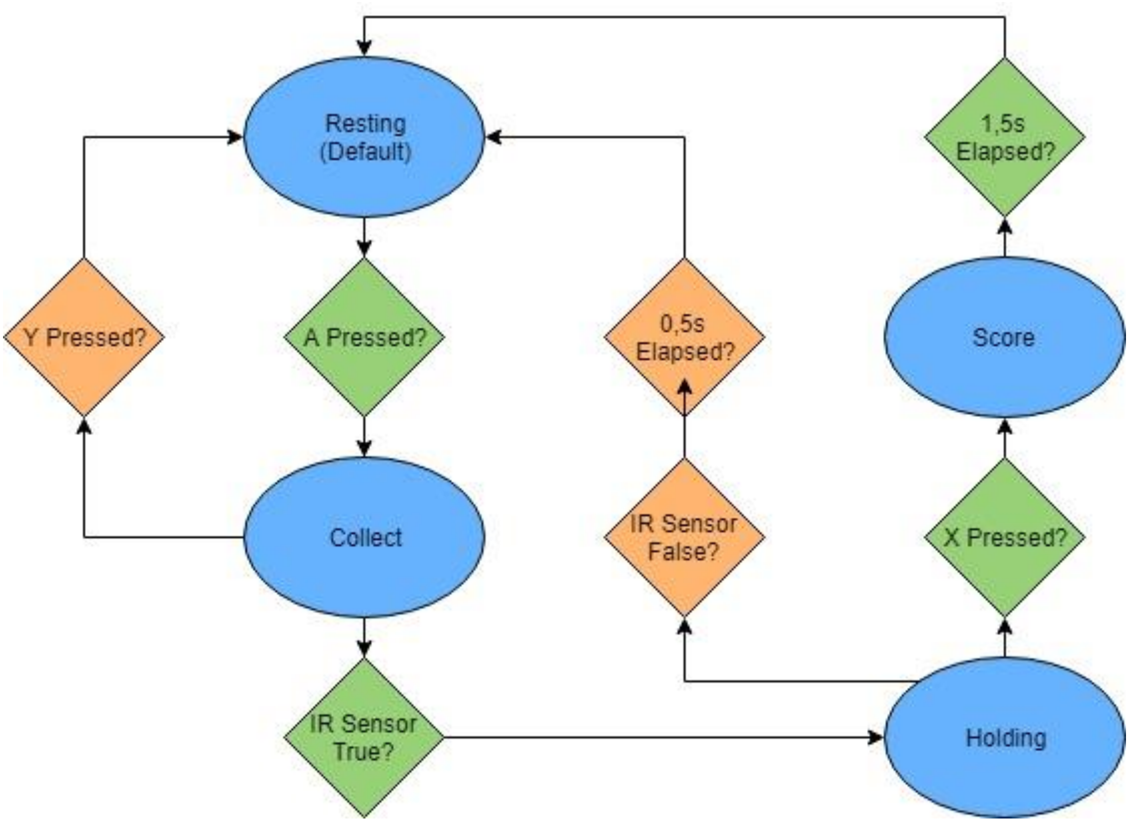
- Elevator control flowchart:



3.1.3 Intake

- **IR Sensors**
    - **2 redundant IR sensors, to assure no false positives;**
    - **LED's on the robot that it has acquired a cube**

- **Intake control flowchart:**



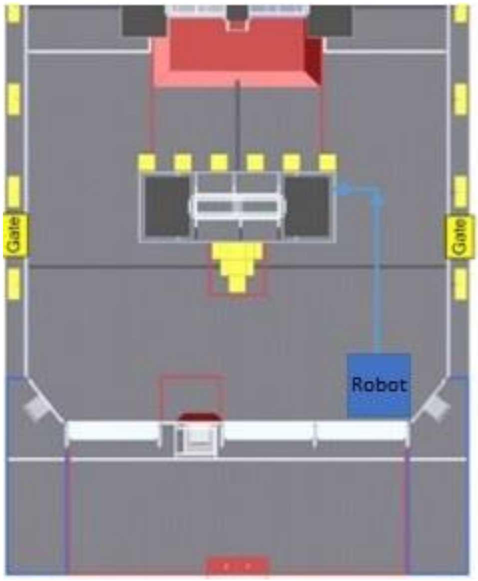
3.2 Autonomous Mode

3.2.1 Autonomous Selection

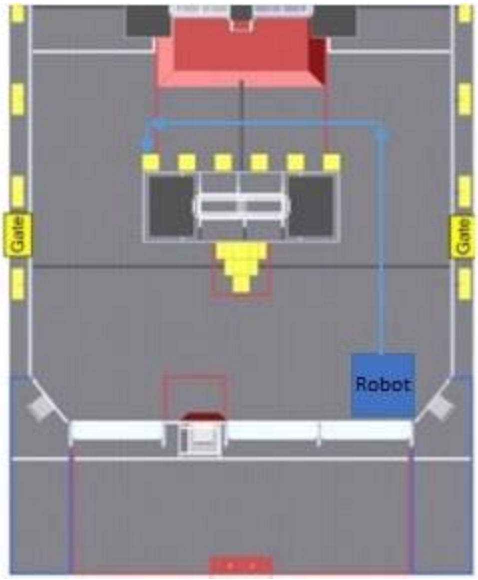
For increased versatility we have built multiple autonomous routines to allow different strategies with our alliance partners. The routine is defined these 4 variables:

- Driver priority (scale or switch);
- Robot starting position (left or right);
- Time to wait (50ms – 10000ms);
- Randomized game data.

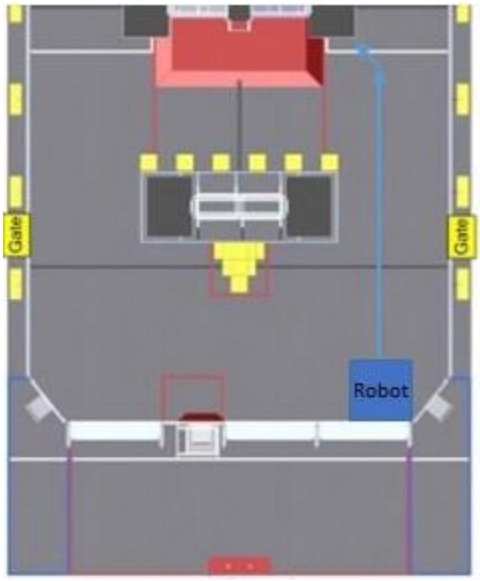
The following routes can be taken during auto, with each routine having a mirrored version for when the robot is positioned on the left side of the field.



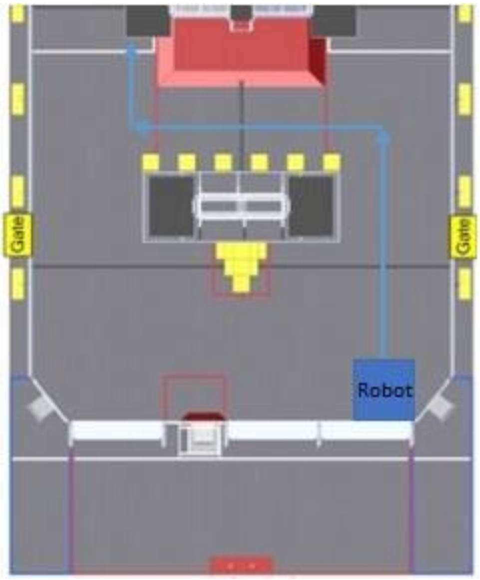
Nearest Switch Autonomous



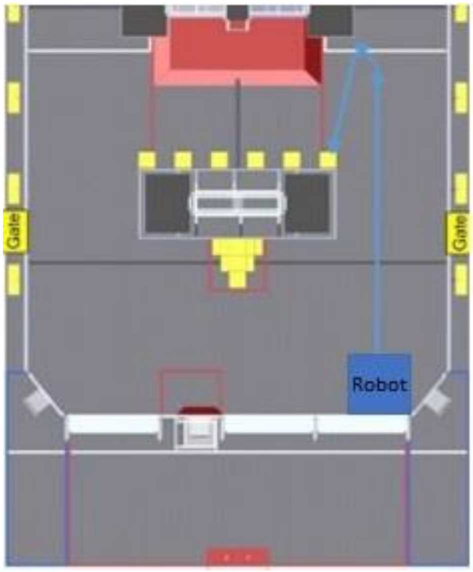
Further Switch Autonomous



Nearest Scale Autonomous



Further Scale Autonomous

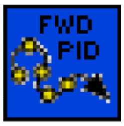


2 Cube Autonomous

3.2.2 Autonomous Control

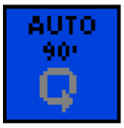
To have autonomous routines that could be easily changed or created during competition we have developed 2 custom functions. These functions are easy to use, but have a very robust implementation relying on several algorithms to make sure that the robot is going to work.

- **Forward movement**



  - PID control with encoders to ensure correct distance has been traveled;
  - PID control with gyroscope to make sure the robot is driving straight;
  - Only input is distance to travel.

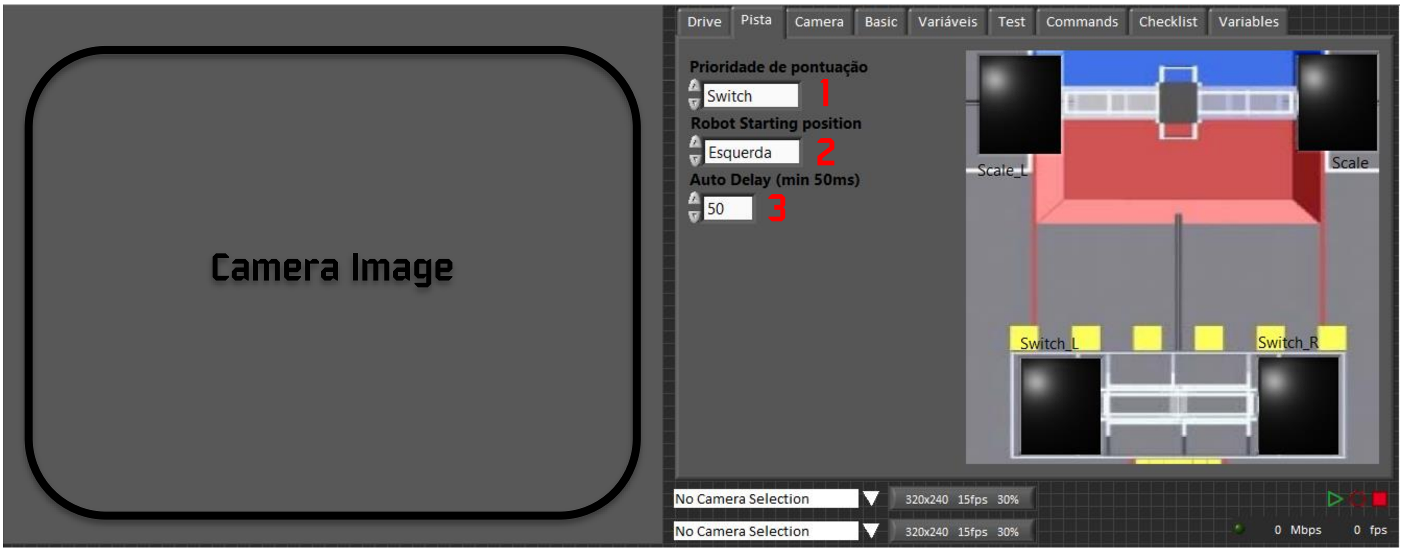
- **Turn on point**



  - PID control using Gyroscope to make precise turns
  - Timeout function in case the PID takes too long to act.

3.3 Dashboard

To send drivers and programmers useful information, we modified the default LabVIEW dashboard to meet our needs:



1. Priority selector
2. Starting position seletctor
3. Delay selector

Fun Fact

Our 2018 robot was named Hydralisk after the troop unit on the game Starcraft. like Starcraft's Hydralisk it shoots air and ground with great striking power, Under Control's Hydralisk gathers cubes and place them on low and high goals to score.