FIRST GLOBAL CHALLENGE
DUBAI دبي
2019

TEAM CHINA
TECH FILE

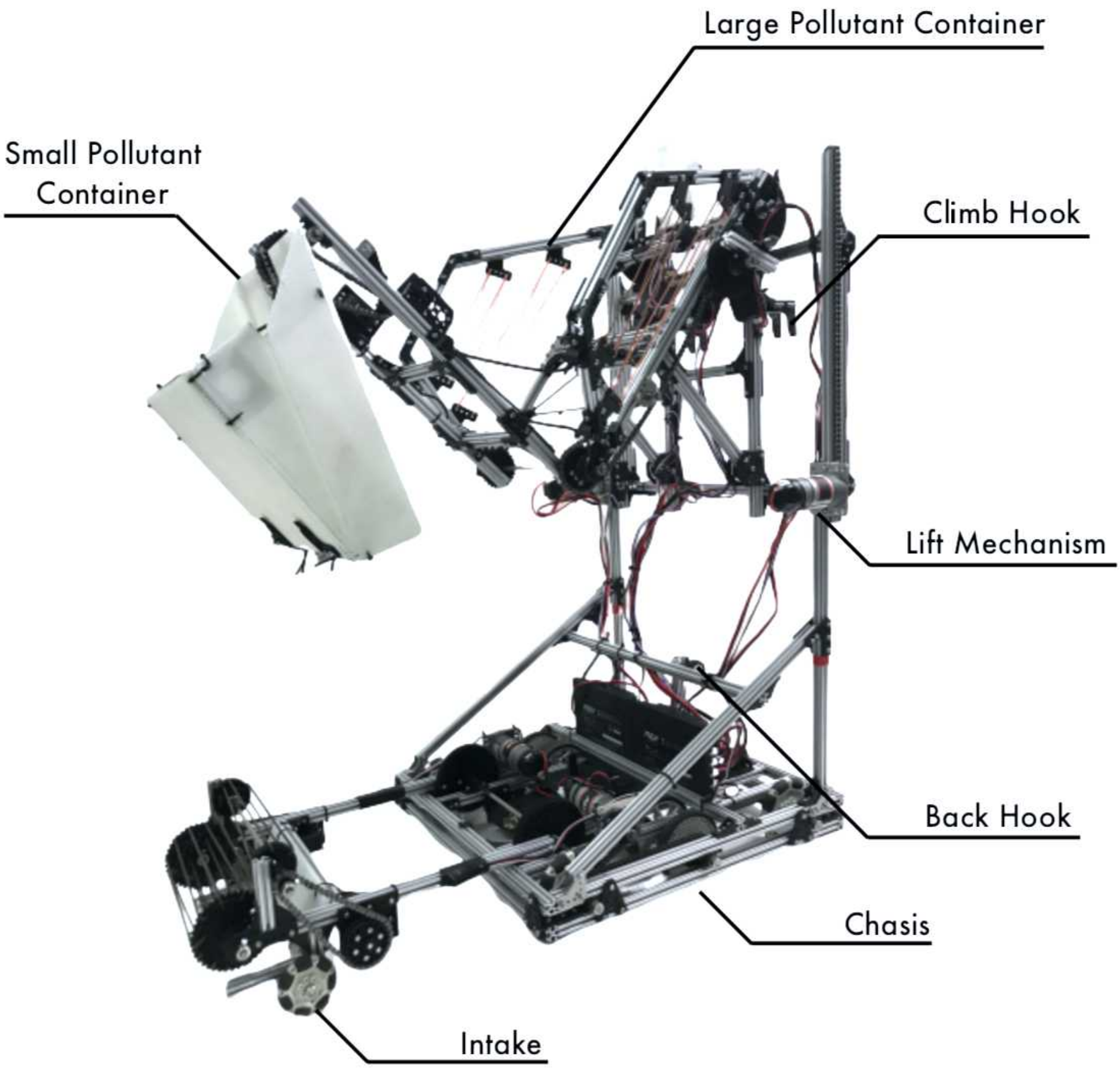
OUR SPONSORS:

MI

IDEADATA

Team China

DESIGN OVERVIEW



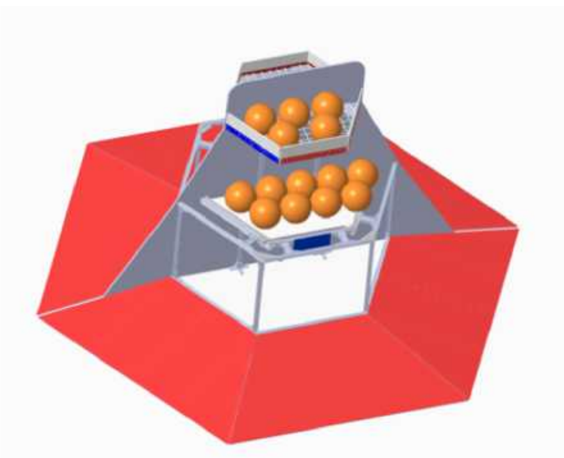
Part I: Comprehension of the Rules and the Game

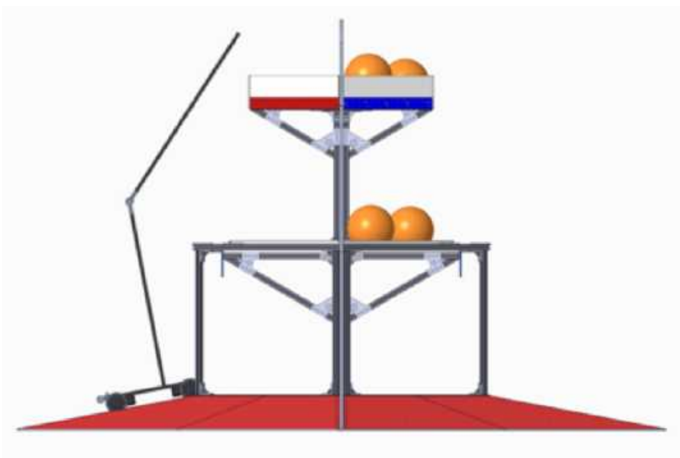
1.1. Game Rules

The objective of Ocean Opportunities is for CLEANUP CREWS to remove both MICRO and MACRO POLLUTANTS from the OCEAN and deliver them to two types of PROCESSORS. Tasks during the MATCH include delivering POLLUTANTS to any of the three levels of the central PROCESSING BARGE and Moving POLLUTANTS to the REDUCTION PROCESSING HUBS. CLEANUP CREWS can earn additional points by DOCKING their COLLECTORS on the PROCESSING BARGE by the end of the MATCH to earn additional points.

1.2. Formulation of Basic Strategies

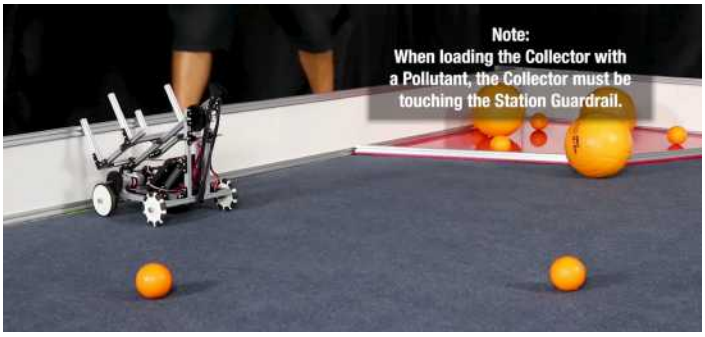
By reading the game rules and watching the rules introduction video, we learned about the general process of the game and the method of scoring. Based on the understanding of the original similar competition (VEX2017, FRC, FTC), we first chose to approach the scoring of game elements using the method of launching projectiles. Our main way of scoring, however, as we further interpret the rules, was not found until we found something interesting:





1. The venue has a total area of 6m*7m=42m^2 (Introduction 2.1.1.Playing Field)
2. There are 30 MICRO POLLUTANTS and 50 MACRO POLLUTANTS (Introduction 2.1.2. Game Pieces)

3. The distribution density of MICRO POLLUTANTS at the site is 0.7142/m^2, while the distribution density of MACRO POLLUTANTS is 1.190/m^2.
4. The HUMAN PLAYER can load POLLUTANTS into any COLLECTORS from their ALLIANCE, provided that (1) the COLLECTORS is in contact with the CLEANUP CREW STATION GUARDRAIL on their ALLIANCE side of the PLAYING FIELD and (2) that the COLLECTORS is fully outside of The REDUCTION PROCESSING HUB at the time that the POLLUTANTS are loaded (see E05).
5.The maximum number of MACRO POLLUTANTS can be sat on the RECYCLE level (middle level) of the PROCESSING BARGE is 5 to 6.



After a deep understanding of these rules, we found that if we can not only handle the MICRO POLLUTANTS with a high score, but also efficiently process the more abundant MACRO POLLUTANTS, we would thus gain better competitiveness.

At first, we thought that sending MACRO POLLUTANTS to the second layer and sending MICRO POLLUTANTS to the third layer at the same time is a very difficult process. However, after trying to model and some calculations on PTC Creo, we found that a system with one elevator combined with two arms is just enough to reach the third layer. After that, we experimented using extrusions and hinges, making a simple connection, which proved that this configuration to be feasible.

Therefore, we redefined the work flow and the strategy of scoring in September. We put forward the following requirements for the robot according to the process and strategy devised:

1. Before the start of the gameplay, our robot should be able to meet the length, width and height requirements. Should have the ability to expand itself after match begins.
2.The robot should have the ability to not only transport the MICRO POLLUTANTS, but also displace the MACRO POLLUTANTS to designated regions.

3.HUMAN PLAYER needs to place MACRO POLLUTANTS in REDUCTION in the robot without touching the robot.

4. The robot should have the ability to place MACRO POLLUTANTS on the second layer of PROCESSING BARGE and the MICRO POLLUTANTS on the third layer of PROCESSING BARGE.

5. The robot should be able to climb.

Task	Value
MICRO or MACRO POLLUTANT in the REDUCTION PROCESSING HUBS	1 point
MICRO or MACRO POLLUTANT on the RECOVERY level (lowest level) of the PROCESSING BARGE	2 points
MICRO or MACRO POLLUTANT on the RECYCLE level (middle level) of the PROCESSING BARGE	3 points
MICRO or MACRO POLLUTANT on the REUSE level (highest level) of the PROCESSING BARGE	6 points
PARTIAL DOCKING of COLLECTOR (ROBOT)	5 points
FULL DOCKING of COLLECTOR (ROBOT)	10 points
ELEVATED DOCKING of COLLECTOR (ROBOT)	20 points
Coopertition Bonus during Ranking MATCHES	1 ranking point
Coopertition Bonus during Playoff and Final MATCHES	75 points

At the same time, in order to further improve the team score, we believe that if the teammates can accomplish the following actions, scoring efficiency would be greatly improved:

1. Ability to move as many MACRO POLLUTANTS as possible into REDUCTION
2. Posses the ability to process MICRO POLLUTANTS in the other side of the FIELD.
3. Ability to climb.

It can be seen that our overall optimization goal is to greatly improve the placement efficiency of MACRO POLLUTANTS, and to achieve higher scores without reducing the efficiency of scoring with MICRO POLLUTANTS.

Before building the robot to implement the function, we also found some limitations and problems that awaits to be solved:

1. Strength problem. Under the condition of constant chassis speed, more MACRO POLLUTANTS need to be transported in one time. After measurement, we found that the mass of MACRO POLLUTANTS is very large comparatively, and this raised the question of how we design structural parts with the required strength to ship or place MACRO POLLUTANTS.
2. Process problems. How can we efficiently process MACRO POLLUTANTS with the same structure while efficiently processing MICRO POLLUTANTS?
3. Manipulation problem. How to improve the handling precision in the process of moving POLLUTANTS and placing POLLUTANTS? How to reduce the burden of Drivers?
4. Efficiency issues.
5. Number of parts, length and strength limitations.

In the following introduction, you will learn how we solve these major problems step by step, and the process of finding and solving some minor problems.

Part II: Structural Design

2.1. Structure Briefing and Work flow

Brief description of the structure:

1.Chasis and Widgets

2.Elevator

3.Arm-level one (For storing and loading Large particles)

4.Arm-levels two and three (For extending to the top of the PROCESSING BARGE)

5.Intake and storage mechanism

Work flow:

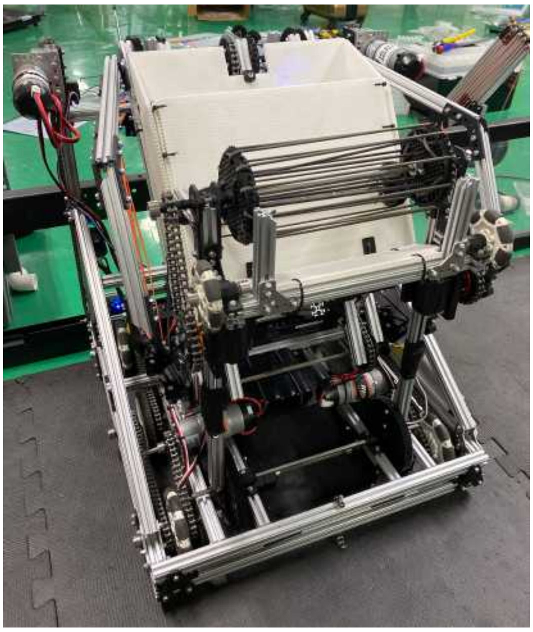
Before start of match:

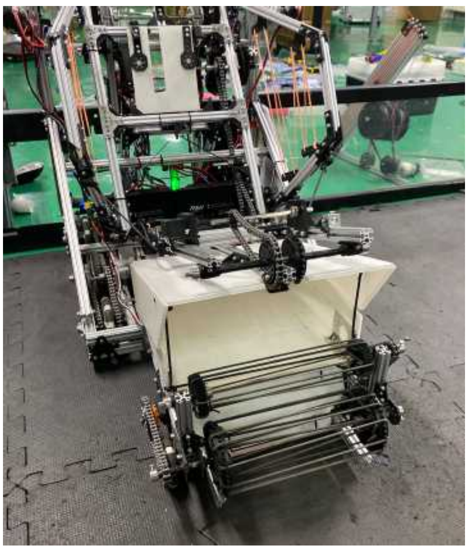
1. Observe pollutant distribution.

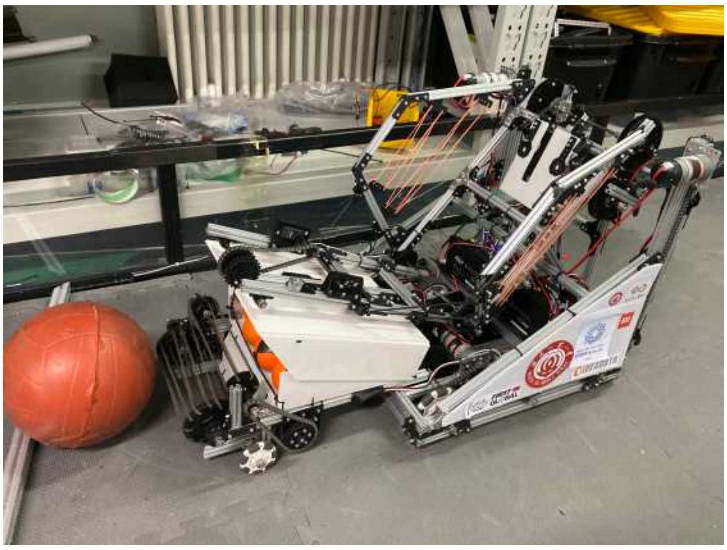
2. Devise a line of MICRO POLLUTANTS to collect from start.

During match:

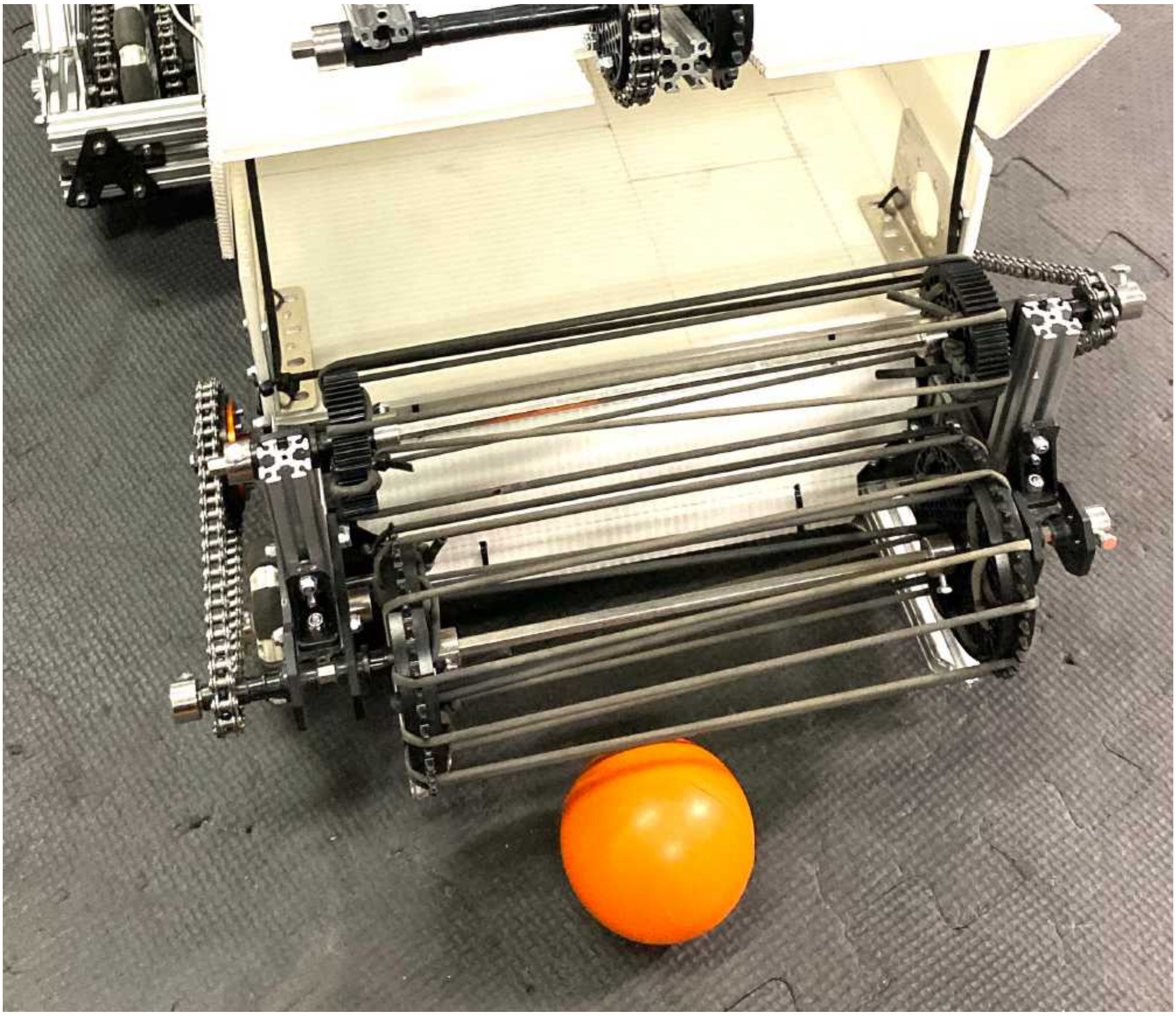
For all Matches, If see any MACRO POLLUTANTS near the REDUCTION PROCESSING HUB, reverse front intake wheel -> push them into the REDUCTION PROCESSING HUB.





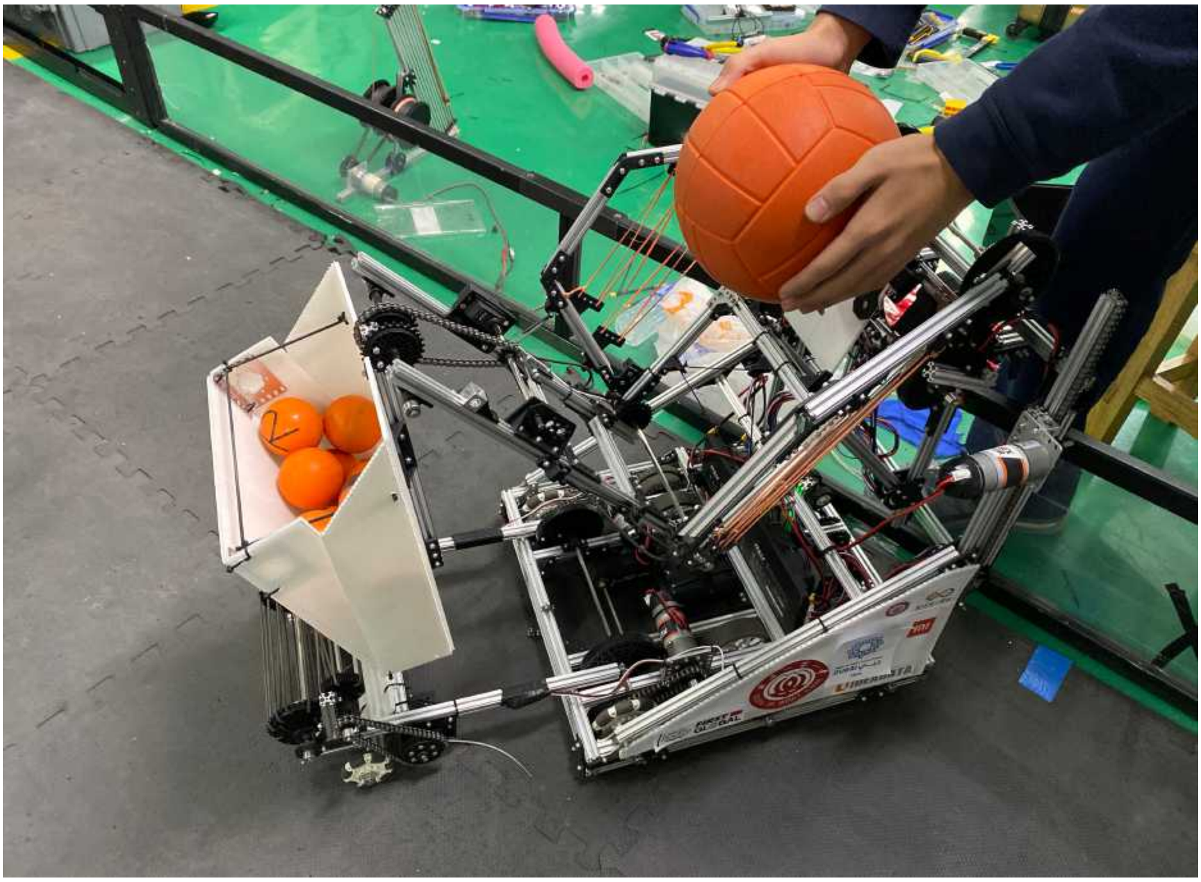


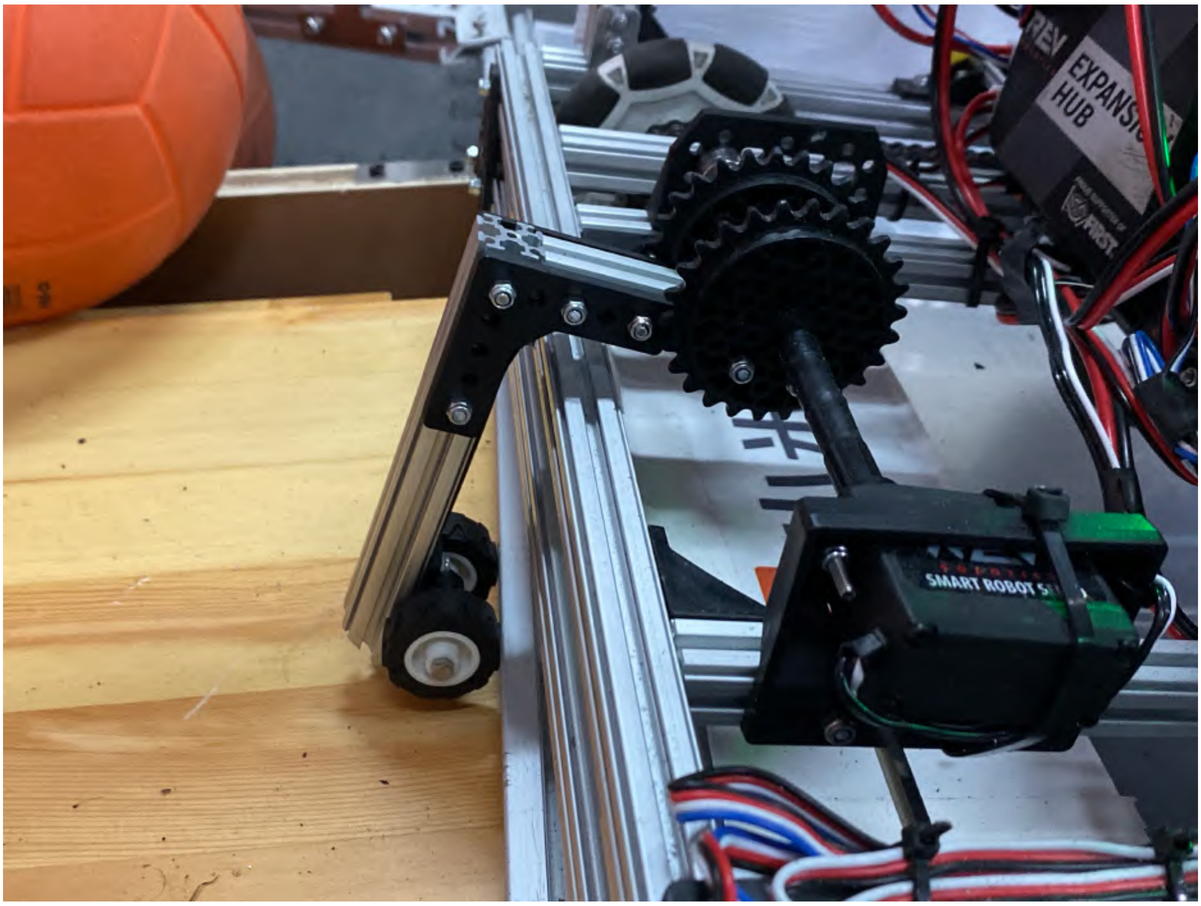
4. Lower level 2 arm to horizontal level-> Inward spin the front intake servo to collect MICRO POLLUTANTS until a maximum of 13.5±1.5 POLLUTANTS, depending on the configuration of the particles, is collected -> spin the level 2 arm to vertical to store the particles.



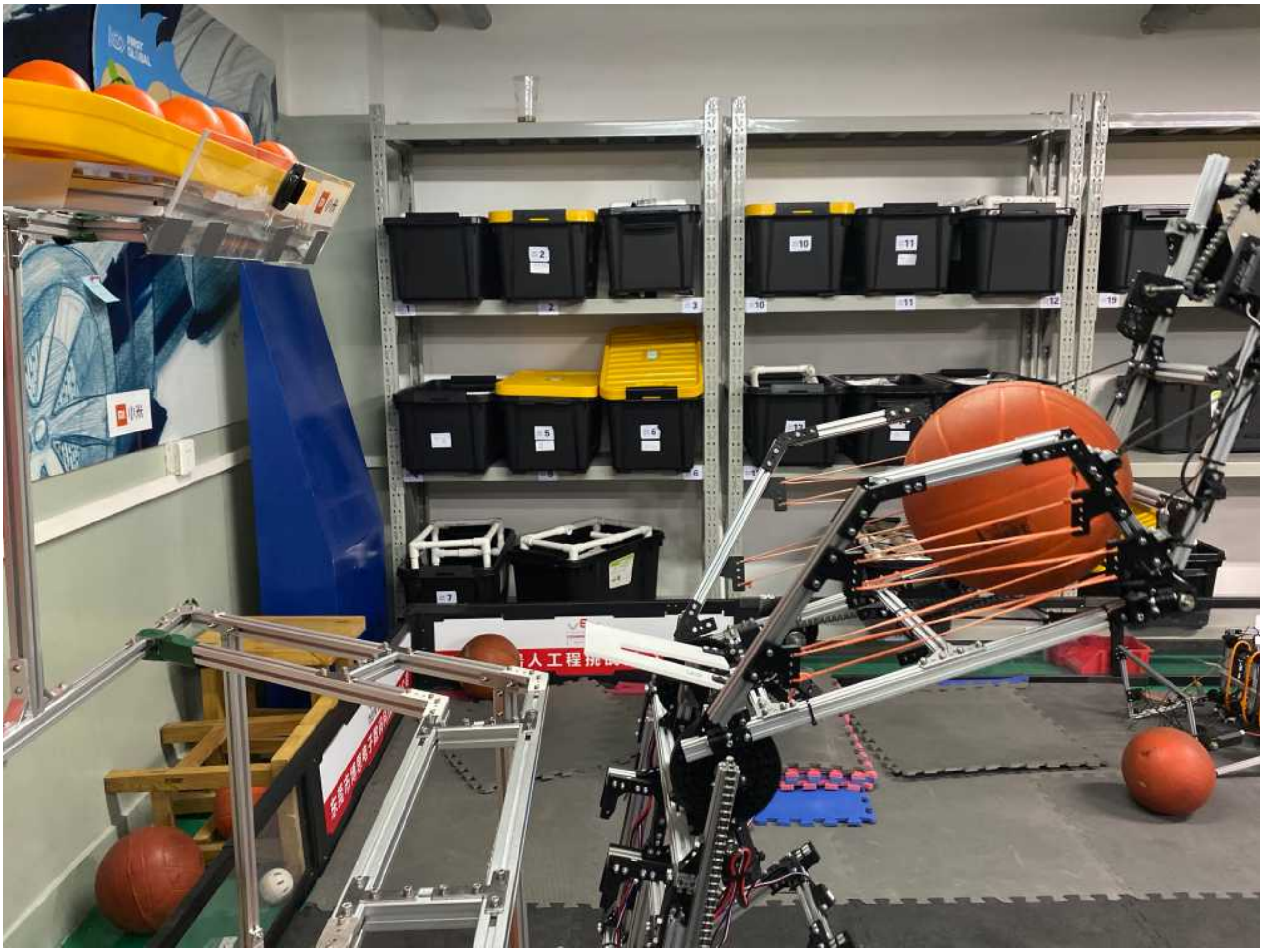
5. Rotate level 1 and level 2 arm -> rotate container to deliver the MICRO POLLUTANTS into the third level of the PROCESSING BARGE.

6. Collect MICRO POLLUTANTS until no MICRO POLLUTANTS are left in our ALLIANCE's side of the FIELD.



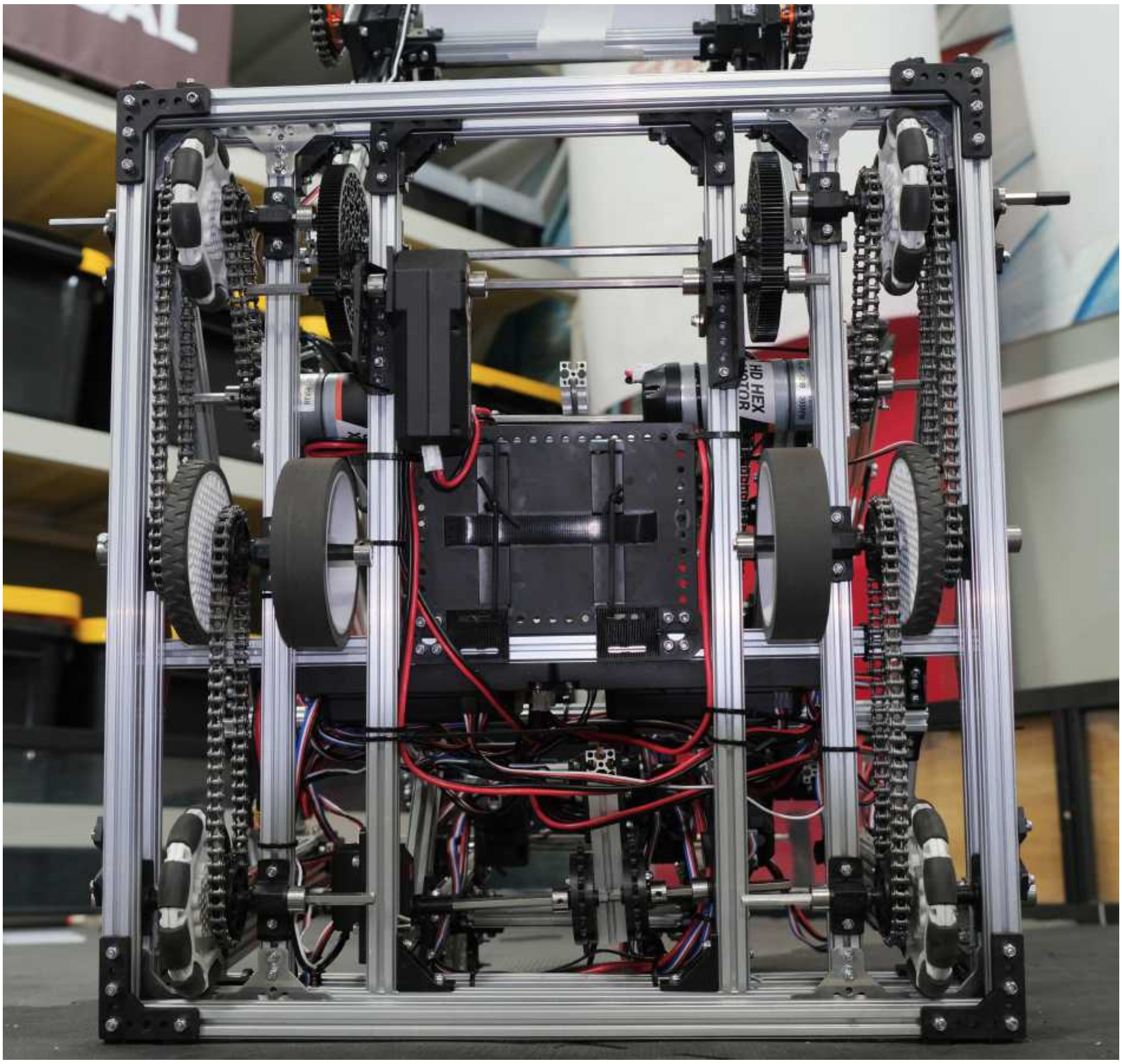


7. Rotate the level 2 arm to free the space between the level 2 arm and the level 1 arm, and manually LOAD MACRO POLLUTANTS into the ROBOT.
8. Rotate level 1 and level 2 arm -> rotate container to deliver the MICRO POLLUTANTS and MACRO POLLUTANTS into, respectively, the third level and the second level of the PROCESSING BARGE.



9. Lower elevator to CLIMB directly onto the PROCESSING BARGE, End MATCH.

2.2. Chassis and Accessories



For chassis design, our main needs are:

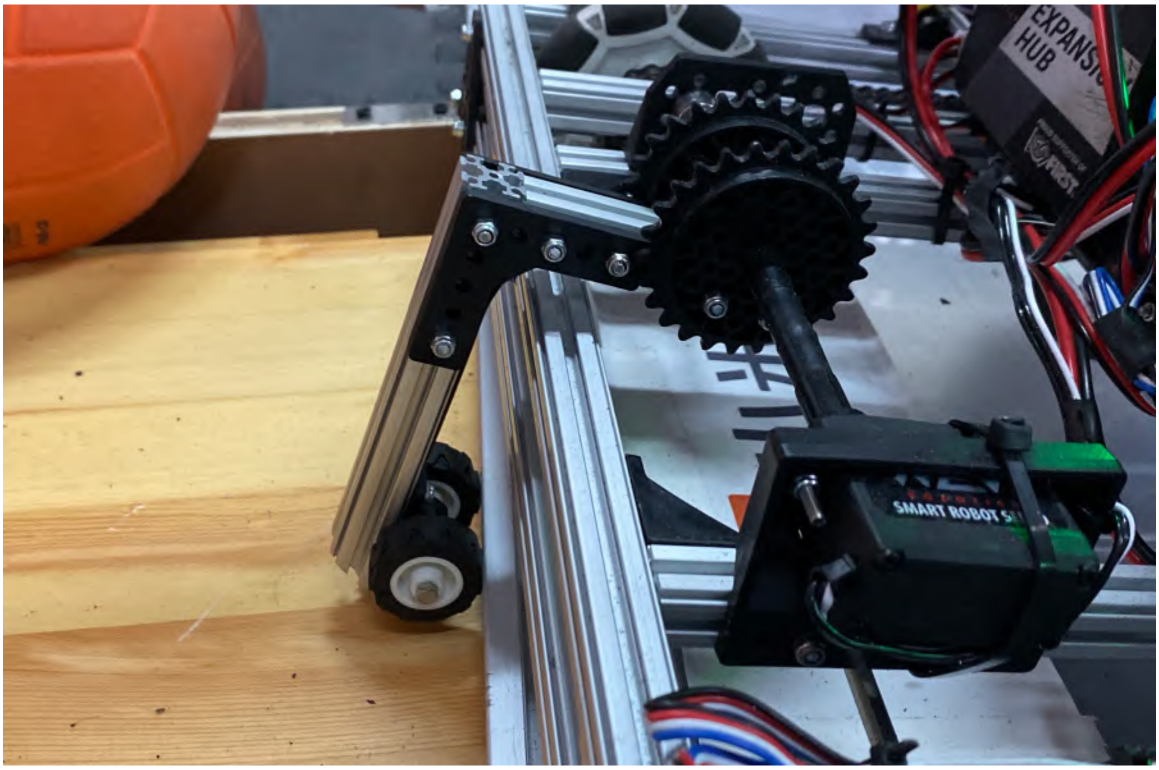
1. Reliability: We need a sturdy chassis that allows us to handle demanding movements, such as the placement of MACRO POLLUTANTS. At the same time we need to be able to hold the POLLUTANTS on the slope. This requires chassis to have a certain minimum amount of friction.
2. Moderate speed: If the speed is too fast, it may lose POLLUTANTS during the movement; if the speed is too slow, it will not be able to move MACRO POLLUTANTS efficiently and transport and place POLLUTANTS back and forth.

3. Safety: Chassis can prevent the robot from being immobilized due to changes in the position of the elements in the field (for example, entering the bottom of our vehicle)

In the chassis design, we chose two 20:1 motor drives, three pairs of load wheels (front and rear two pairs of omnidirectional wheels, two pairs of friction wheels in the middle), sprocket drive, and 1:1 drive sprocket. The arrangement—also known as the West Coast drive—is widely used in various competitions (FTC, FRC).
Compared to chassis with only two pairs of omnidirectional wheels or three pairs of roller wheels with only one pair of friction wheels in the middle, this chassis is on the slope. The performance is more stable because of the two pairs of friction wheels in between.
This is our first design:

Compared to the omnidirectional movement of the omnidirectional wheel into a quadrilateral or triangular chaise, although our chassis design abandons the ability of omnidirectional movement, but at speed, stability and walking The performance of the line is even better.

In the design of the chassis attachment, we installed an anchor-like structure on the back side of the chassis to fix the robot on the inclined surface.



In order not to allow the MICRO POLLUTANTS to enter the robot body, we installed a structure similar to skirts seen on tanks with four facets to reduce the lowest point of chassis, which blocks MICRO POLLUTANTS. In the middle of chassis, we added structures to fix the battery box, EXPANSION HUB and CONTROLLER HUB. At the same time, these two extrusions can also be used for chassis.

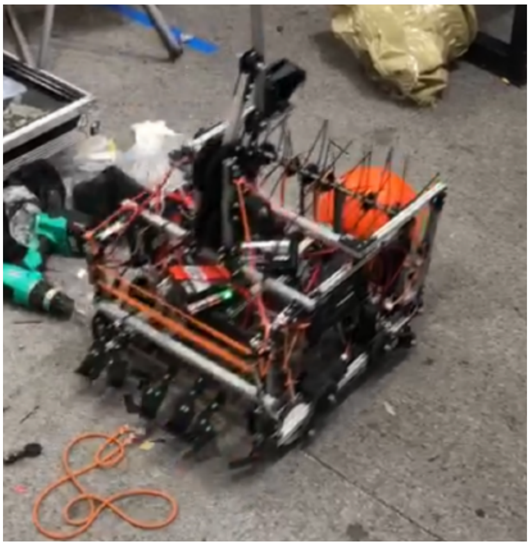
Secondary reinforcement

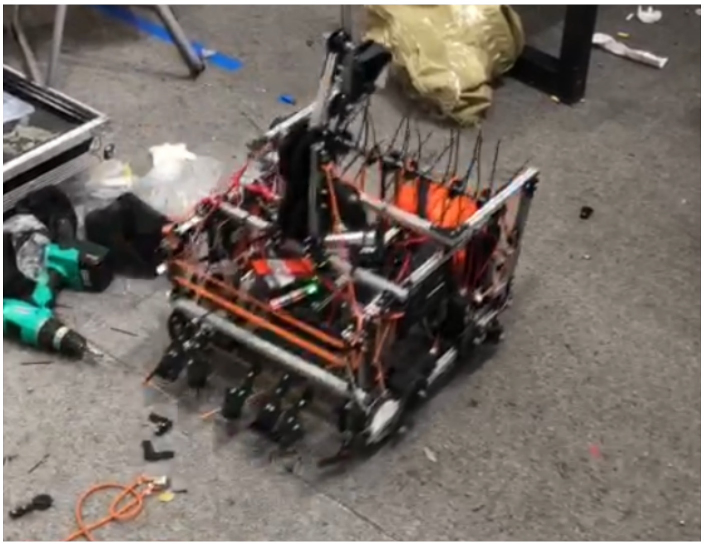
At the same time as the construction of chassis, we are also constructing other structural parts. We have preset the structural components for installing the climb and the elevation elevator and the intake mechanism, which can enhance the stability of the two mechanisms.

In the process of building chassis, we also encountered some minor problems and used some clever ways to solve:

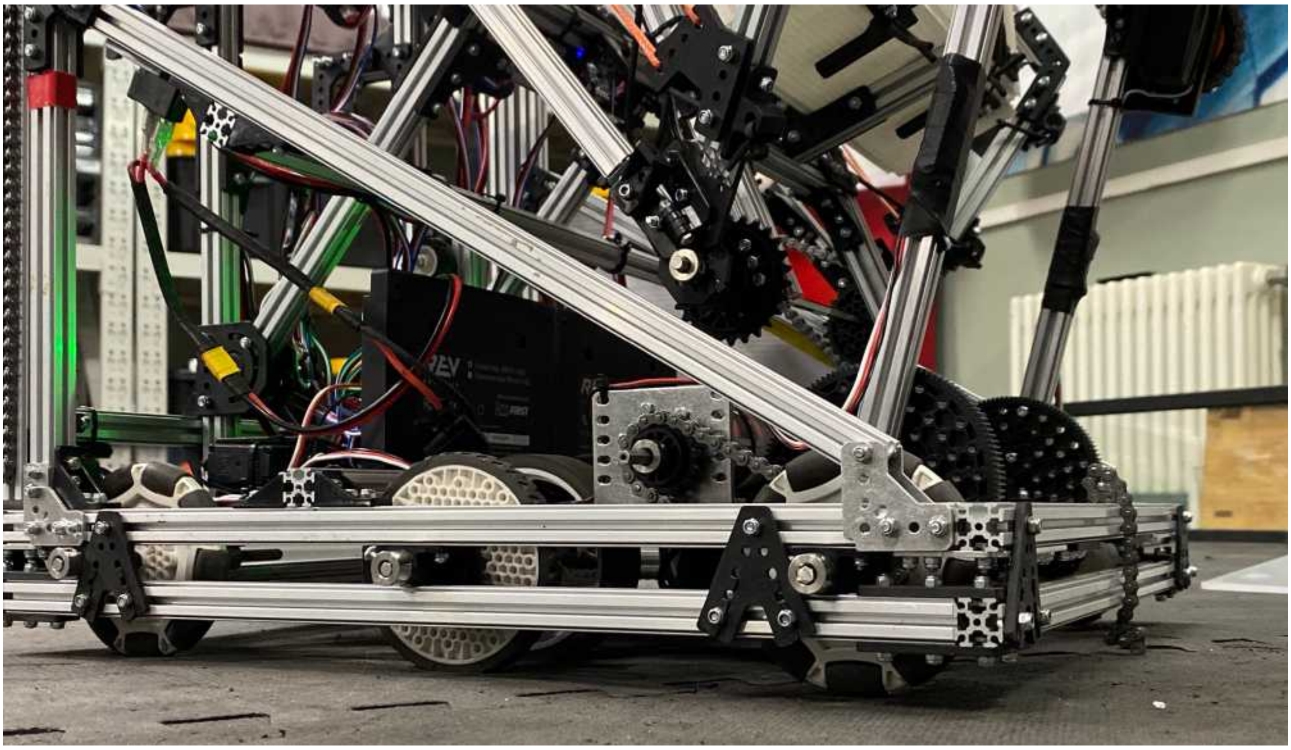
1. The large friction wheel will produce an actual size of 0.8-1.5mm thicker than the drawing size during the drafting process, which will make the chassis uneven. To solve this problem, we use the power tool and sandpaper to polish the large friction wheel.
2. The large friction wheel will have the hexagonal shaft out of the center. The metal flange can be used to fix the relative position of the shaft and the wheel.

3. If the front and rear wheels do not reach the front and rear beams during the uphill movement of the robot, chassis will drag the bottom when going uphill to adjust the height of the MICRO POLLUTANTS mechanism.

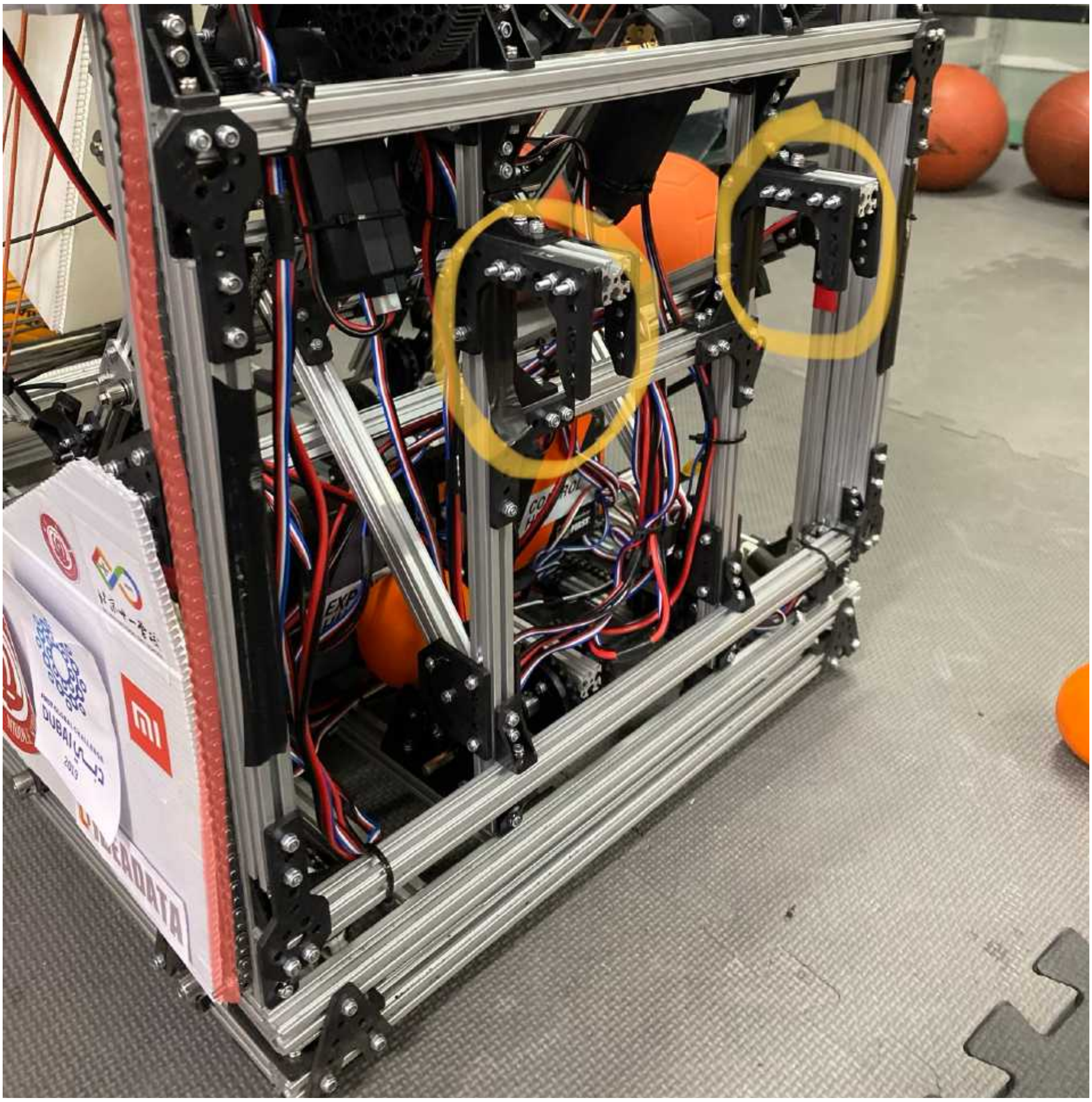




4. Chassis asymmetry will look not very nice, you can use the **vernier caliper t**o position the motor for the wheel.



2.3. Elevator for Climbing and Lifting



For the design of this structure, our main needs are:

1. Reliable. The elevator is the connecting part of chassis with all other functional structures and supports the weight of the entire superstructure.

2. Sufficient speed. Elevator lifting not only determines the length of time we use to achieve a pollutant, but also affects the time required for climbing.

3. Sufficient stroke. We need the elevator stroke to climb and let our robots leave the ground.

4. Upper and lower limits.

5. Supports a climb hook

In the design of the final elevator, we use a sprocket chain to achieve a gear-like transmission to lift the elevator, and use two 20:1 motors to drive, and the smallest sprocket is selected. The power can have enough speed. We use a magnetic sensor as the upper limit of the elevator, and the micro switch as the lower limit of the elevator.

Here are the problems we encountered:

1. Motor installation direction. If the motor is installed on the left and right sides of the vehicle, the motor power cable would be relatively safe, but the internal space would be wasted.

2. The motor is fixed. The motor frame is not stiff enough to fix the motor, and the motor will loose its rigidness during its movement.

3. Incoordination in-between gears. Sometimes the teeth of the sprocket can't mesh with the chain, which causes the height of the two sides to rise differently. The incoordination in-between gears is a problem that we have been solving all the time. The reason for this is that the chain is loose and the motor frame is loose. At first we two shaft clamps are used to fix the position of the sprocket, so the position of the sprocket will also cause the teeth and chain of the sprocket to not engage.

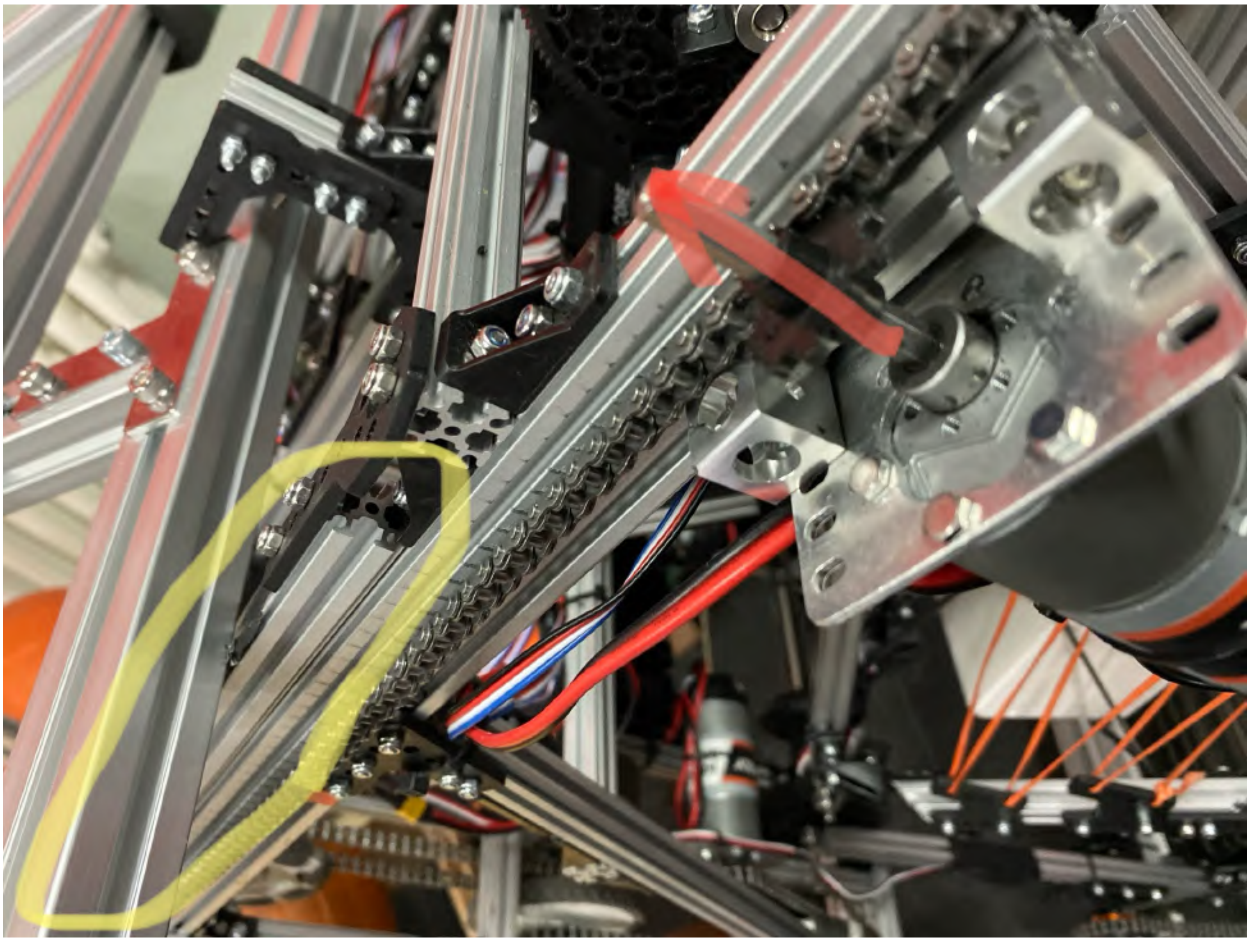
4. Limit. The height of a single micro switch is not enough to hit the bottom end of the elevator, so it cannot function as a limit. The upper limitation is a magnetic sensor, and the lower militating is a touching sensor.

5. The protruding motor shaft will hinder the beam’s descend during the climb of the robot

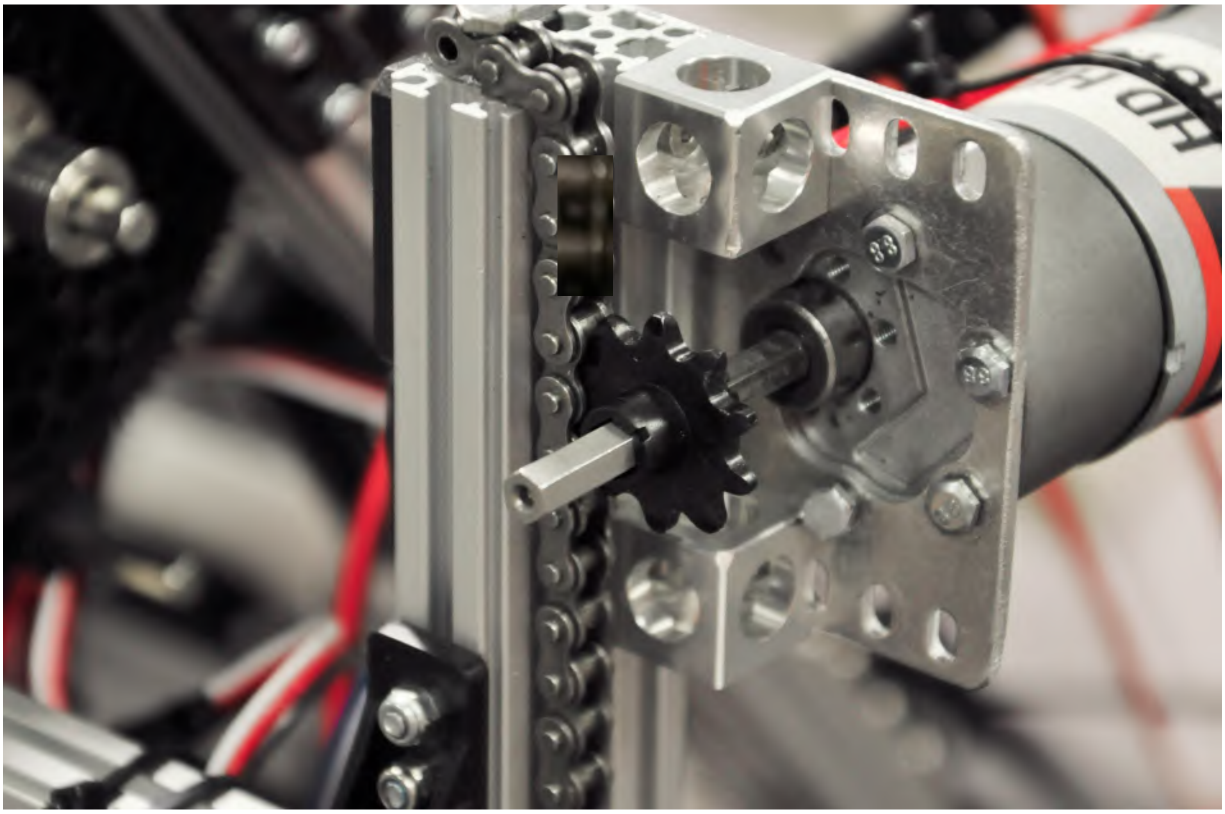
Here are our solutions to these problems:

1. We finally chose to install the motor to the rear side of the robot. Although the motor line is in danger of being scraped away under extreme conditions, it saves most of the space.

2. We installed a right-angle motor frame with a single-piece motor frame for further fixing to make the structure more stable. In addition, we also used a metal block as part of the fixed-plane motor frame, the entire structure for rotation, and thus the resistance is stronger.



3. We removed the shaft clamp and let the sprocket-chain system adjust the horizontal position of the bite so that the sprocket will move to the corresponding position even if the chain is not in the middle.



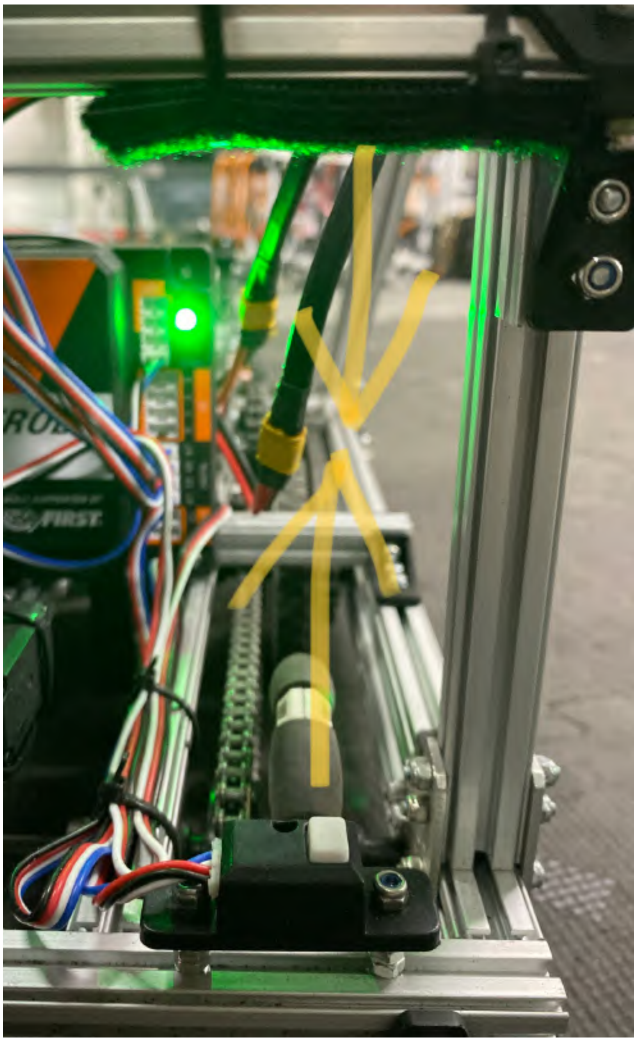
4. Because of the short stroke of the touch sensor, we used the corrugated board + screw to slightly increase the reach of the touch sensor, and also let it to the bottom of the elevator.

5. We have not sawed off the protruding motor shaft, but the extra layer of the beam is used to make the elevator thicker than the length of the motor shaft, so that it will not be hooked. In addition, an extra benefit is due to the decrease of the tension, so that the motor can stand a weaker force.

Of course there are some details to deal with:

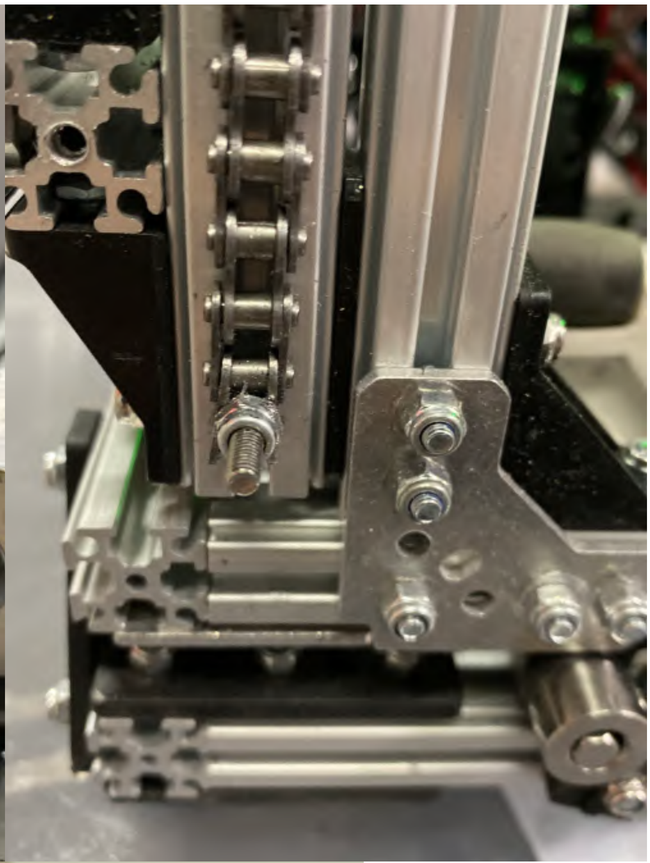
1. When installing the elevator, we need 1*2 corner to fix. When installing, pay attention to the screw installation sequence: first install two holes on one side.

2. After fixing the motor frame and tightening the screws of the fixed chain, due to the loose chain, the elevator will still have the problem of not coordinating when it is ascending. In order to make the sprocket and the chain mesh tighter, we directly fix the sprocket position. The two axle clips are removed, so that the sprocket will fit the chain as the elevator rises.



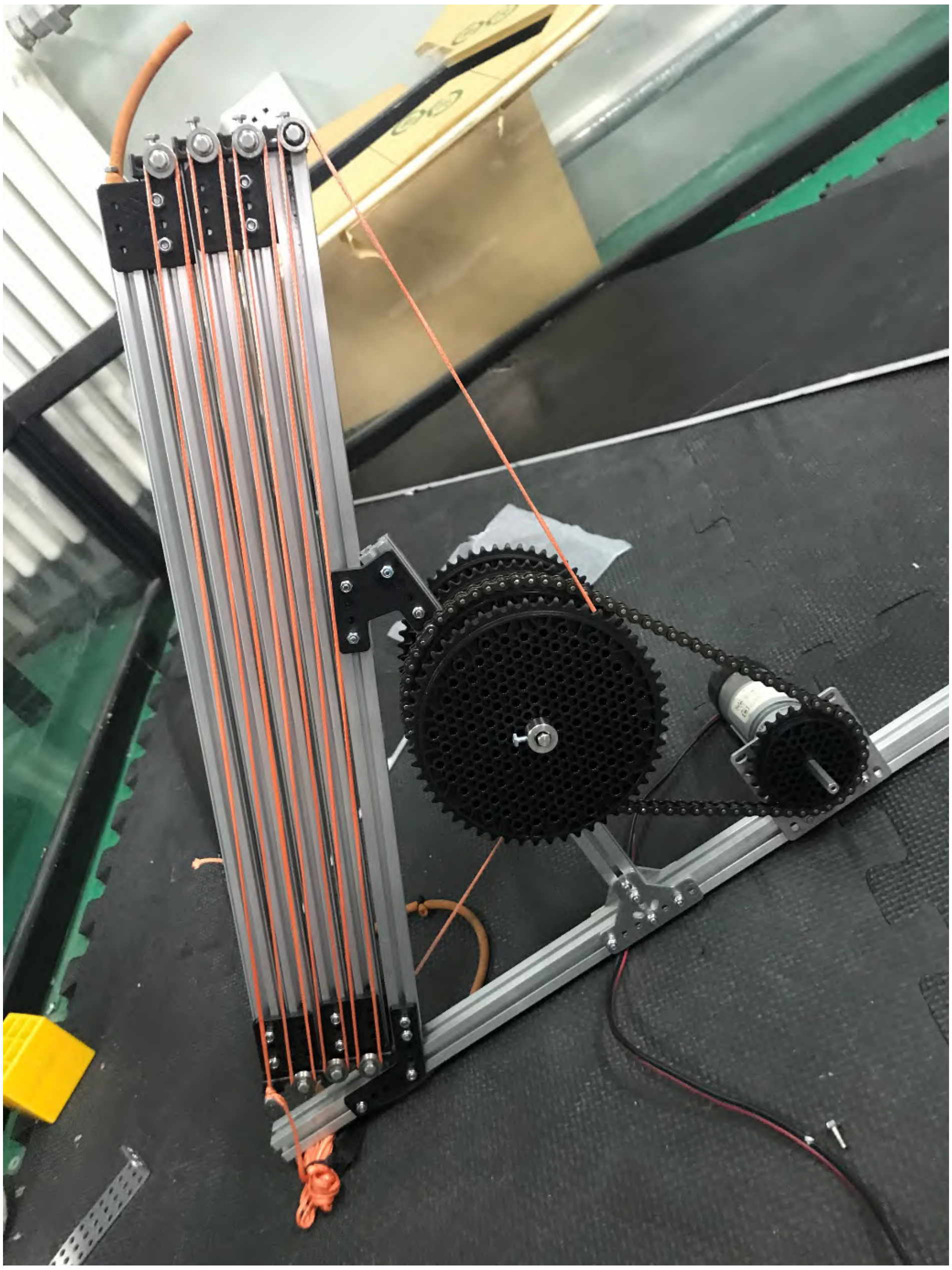
3. We fixed one end of the chain to the top of the profile so that it only needs to move the position (comparatively) to the inferior lower end when servicing (tightening the chain).

4. In the final version of the elevator motor power setting, we have increased from 0.5 to 0.7. This number is not defined by us, but is the result of continuous trial and debugging. If the power is too large, the sprocket chain There may be a phenomenon of tooth skipping; if the power is too low, the speed of lifting will become slower and not enough for climbing.

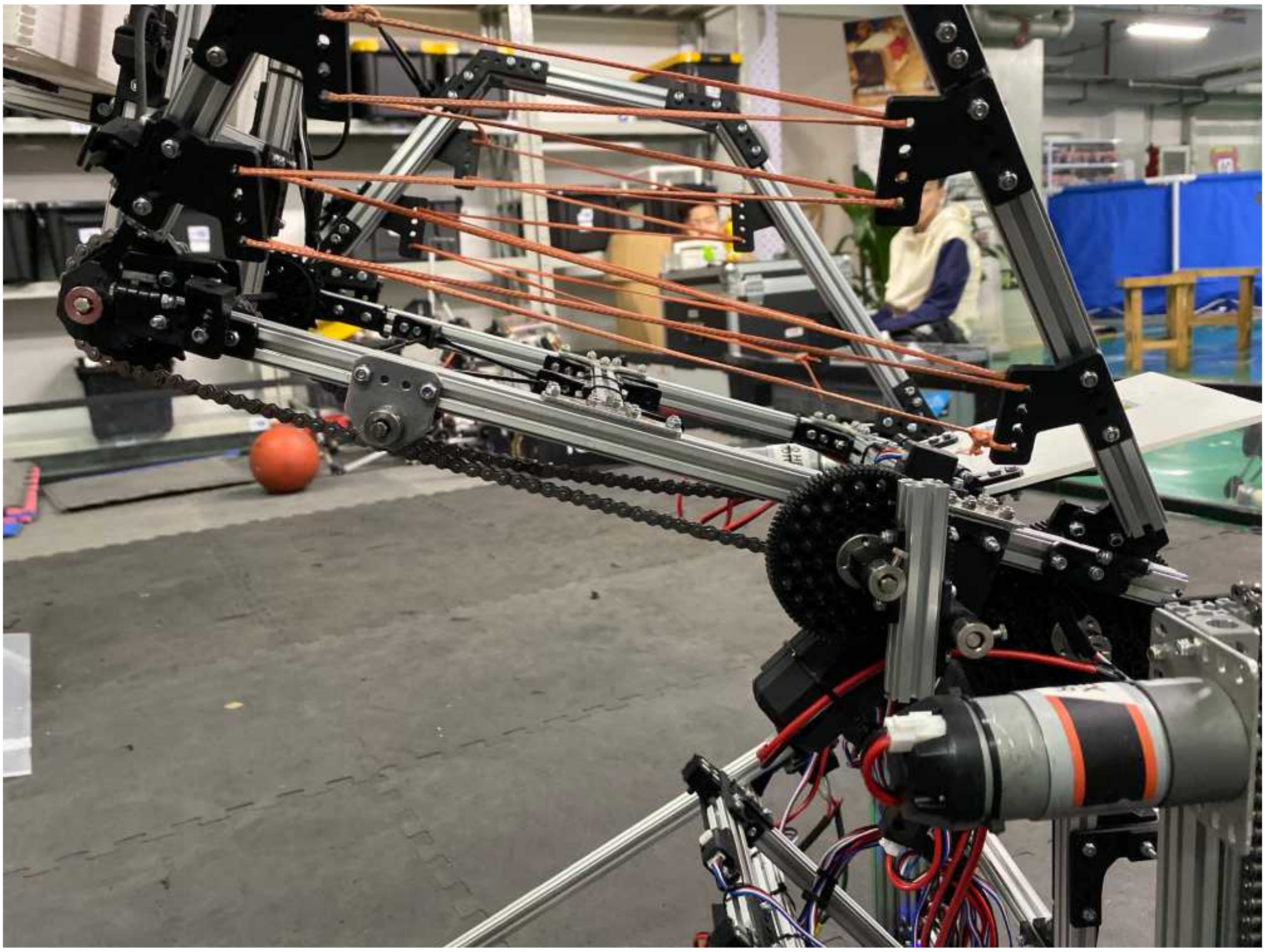


Climbing Hook

It can be seen that in the process of building the elevator, we encountered a lot of problems about balancing strength and speed. The emergence of these problems is inevitable. This set of institutions has its unique advantages and disadvantages compared to other developed strategies. i.e. the conventional Rev-exemplified elevator, which is placed at a certain angle of inclination, the four-stage elevator can quickly ascend and descend and reach the scoring position, but the difficulty is to synchronize the elevators on both sides under stress.



2.4. First Stage Arm



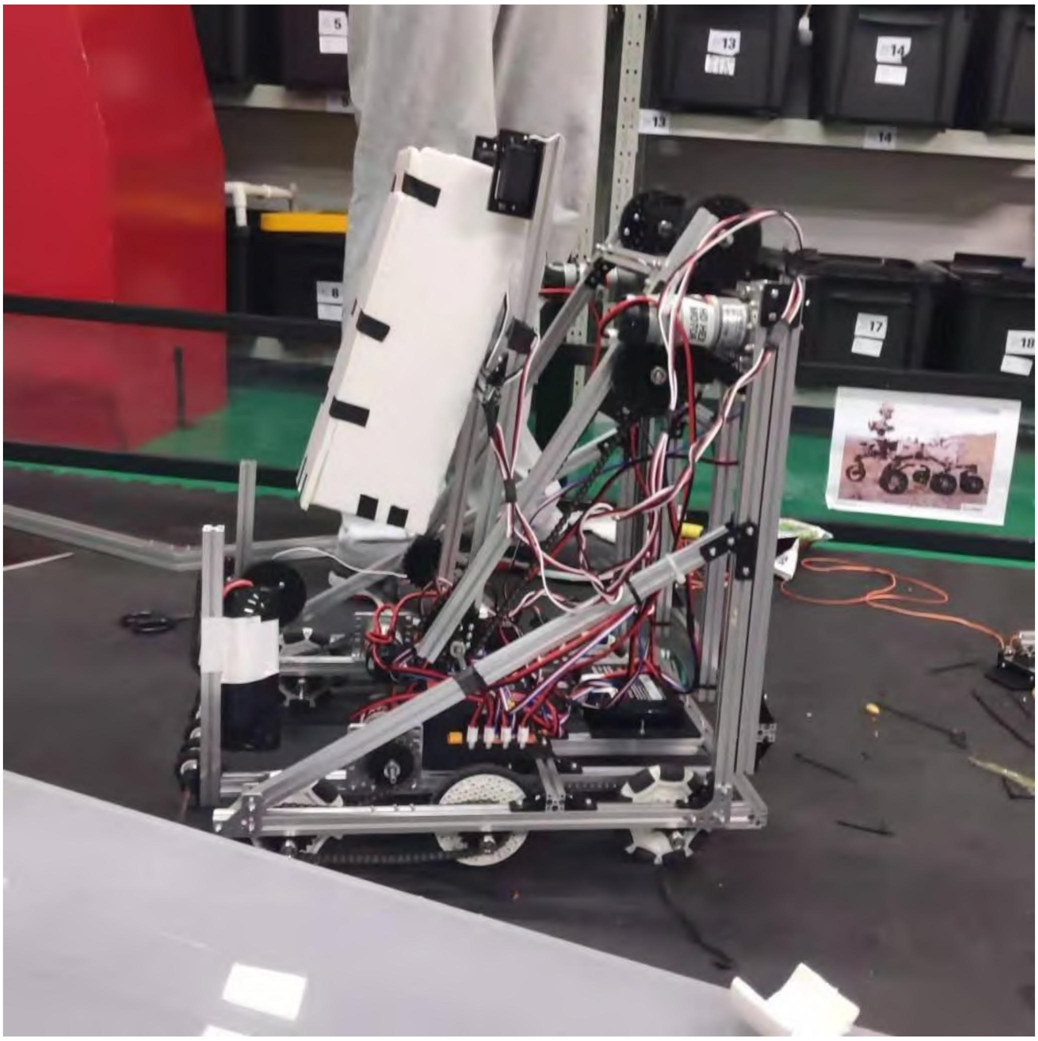
For the first stage turning arm design, our main needs are:

1. Reliable. We need a stable platform that carries the operation of the superstructure. The unstable first-stage arm will cause the entire superstructure to be unstable.
2. The speed must be suitable. Because the total number of operations generally does not exceed three, the pursuit of speed is not as good as increasing the strength (stability), and can increase the weight that can be carried to obtain a higher single delivery score.
3. Safety. The mechanical arm has reasonable limits to prevent it from damaging the robot, affecting the cable, etc. At the same time, it is also necessary to consider the direction of all cables of the superstructure.
4. A box that can put a lot of MACRO POLLUTANTS.

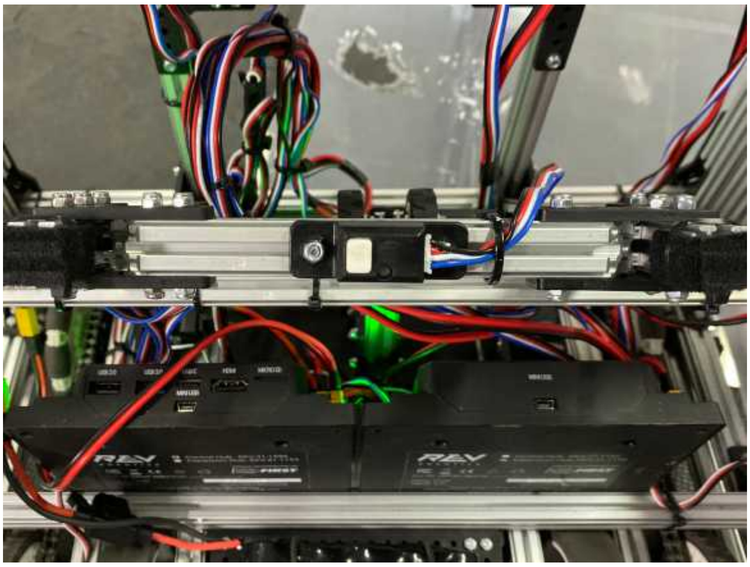
In the design of the robot arm, we chose two hex motors for synchronous drive, gear transmission, and the maximum one-level gear ratio you can get out of the entire kit. This solves the problem that the first-stage rotating arm is not powerful enough to lift multiple MACRO POLLUTANTS. There is no torque problem in the motor configuration and gear ratio, and the performance has a more stable characteristic than the multi-stage deceleration or the smaller deceleration.

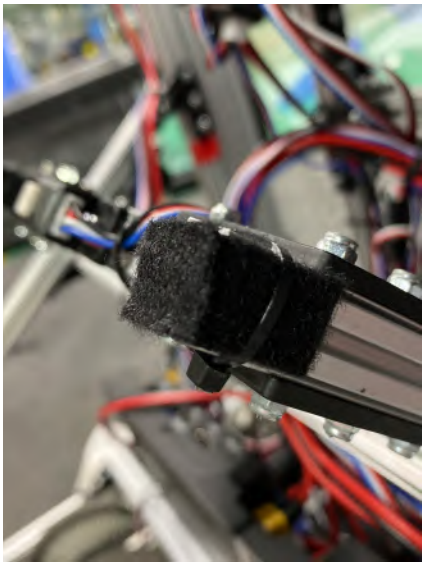
We tried to use the provided PID algorithm to provide correction to the robot arm during the design process. However, since the robot arm involves the rotation of multiple joints, the parameters should be different when the moment of inertia is different, and simple rule of thumbs would not work as efficiently as they usually do. So we went to the open-looped manual control scheme except the necessary limits.

Before the final version, we also tried other gear ratios. Compared with the final version, although there are some advantages in speed, it is far from stable. Although it can transport four in one shipment, it is often in the process of rotation. There will be a phenomenon of tooth skipping.



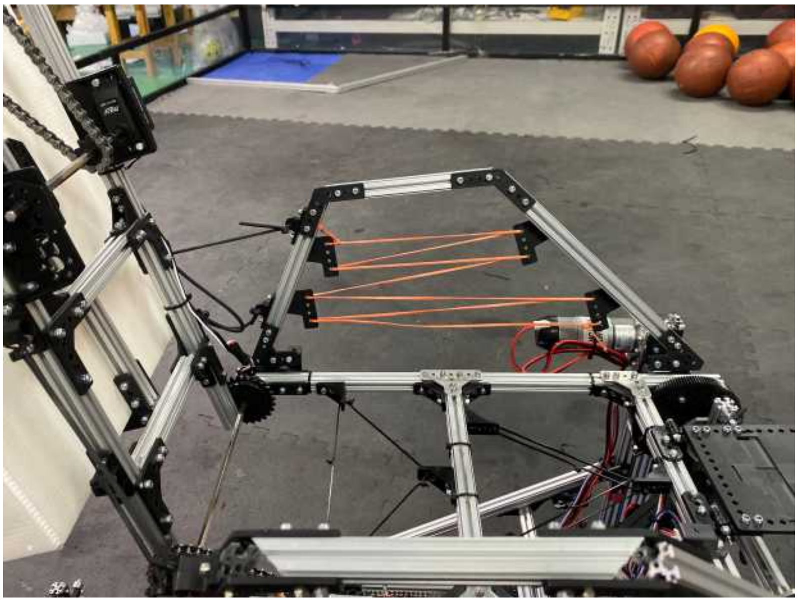
In the limitation, we used a micro switch and the following structure as the lower limit of the rotating arm.

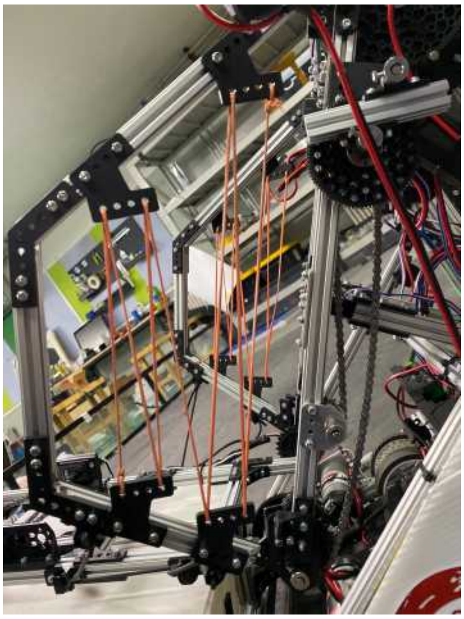




Container design:

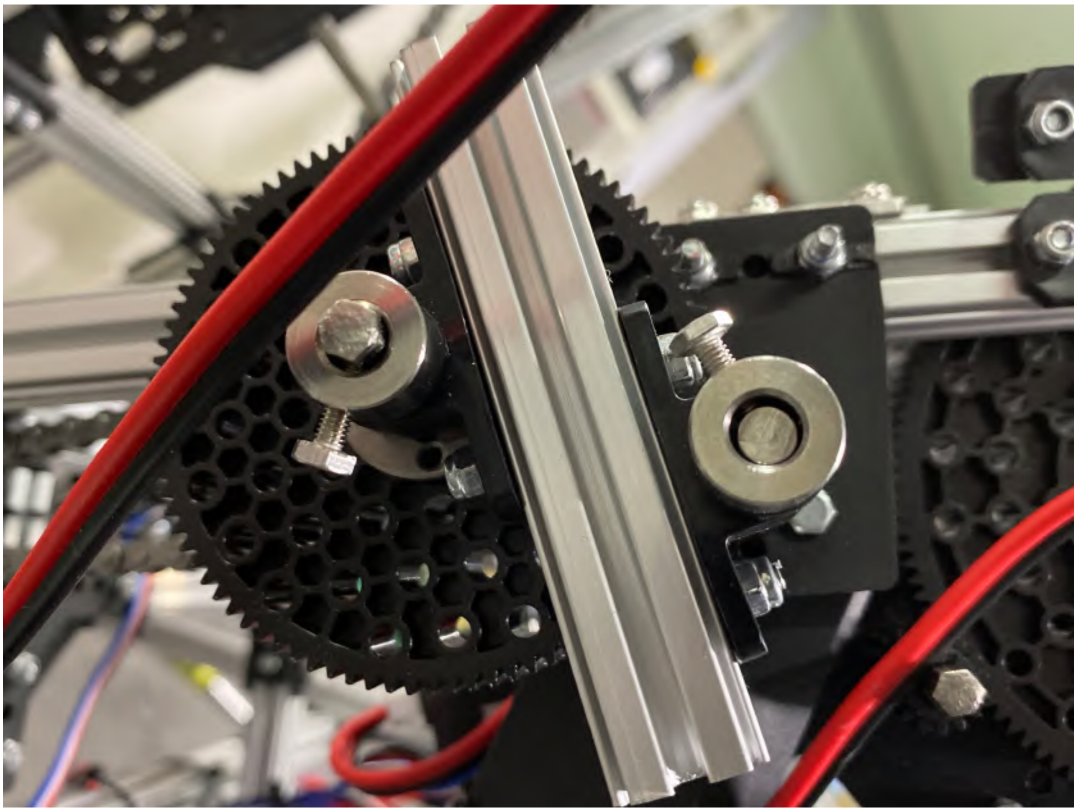
1. Can guarantee that the size requirement is not exceeded
2. Can put a lot of MACRO POLLUTANTS





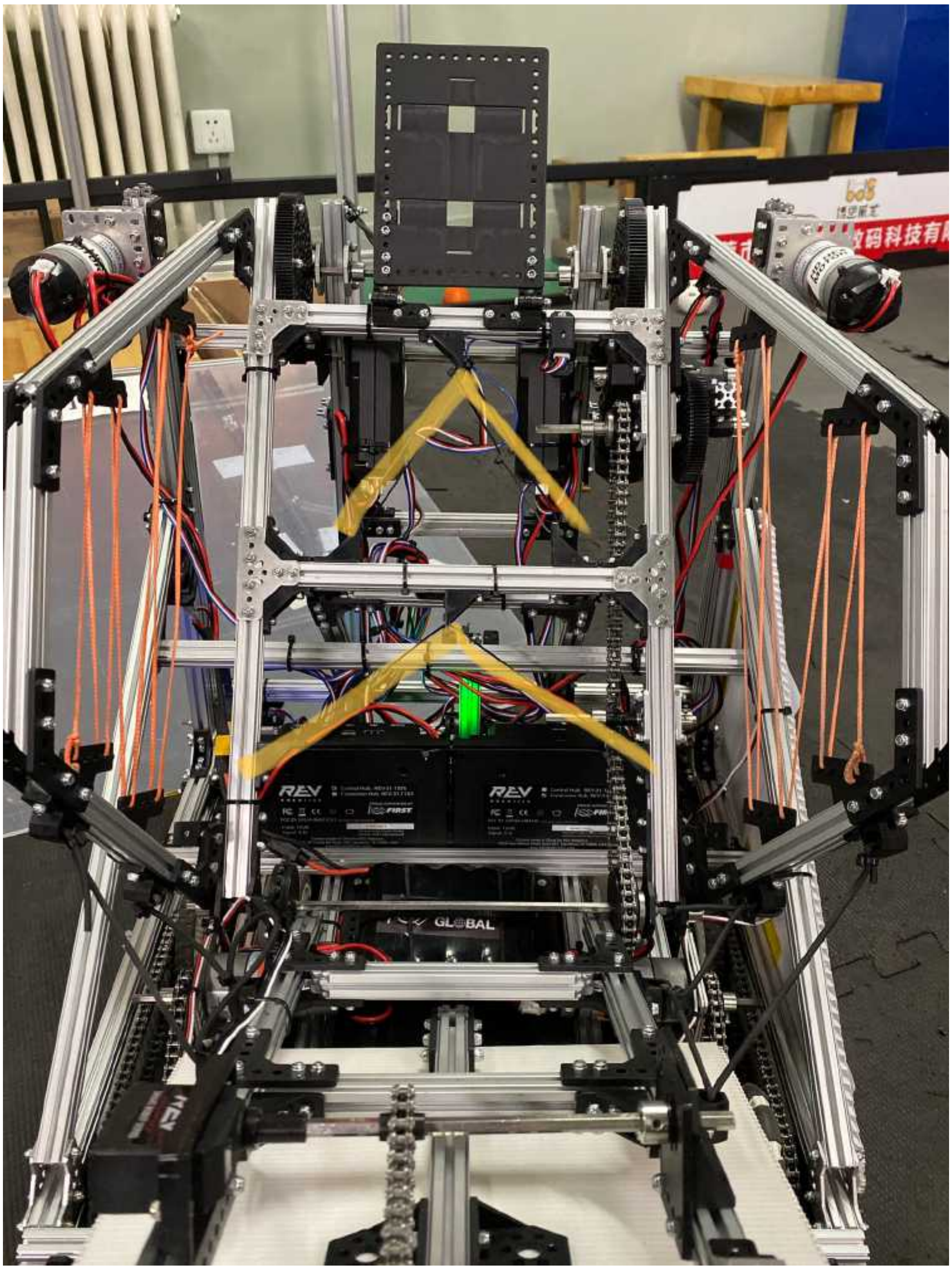
However, we encountered **a series of problems in the installation of this structural member:**

1. Loss of gears. The gears do not mesh, and there are phenomena such as skipping teeth or even broken teeth. After knowing how many times to practice (do not know how many gears are broken), we finally came up with reality and Effective solution.



By tightening this distance, and after tested for several many times, we solved the problem that the two gears are not tightly meshed.

2. When placing MACRO POLLUTANTS, MACRO POLLUTANTS may be stuck in the groove formed by the profile. The following mechanism can partially solve this problem.



2.5. Second and Third Stage Turning Arms

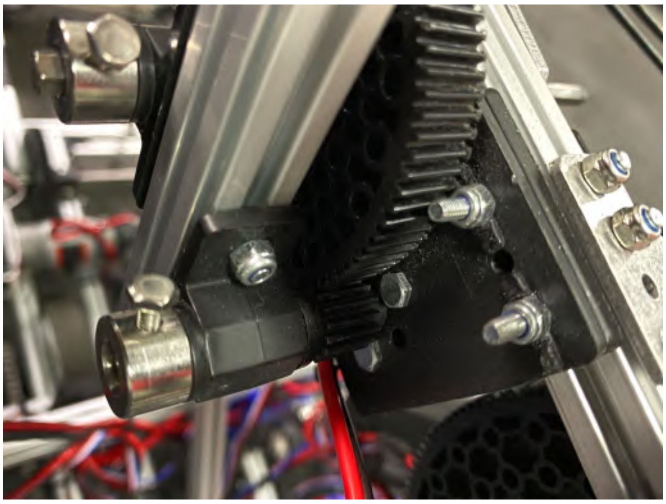
For the second-stage turning arm, our main needs are:

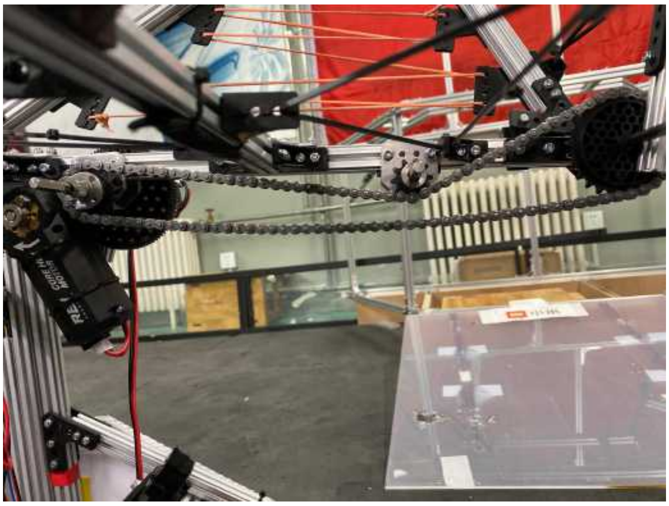
1. Can be synchronized with the first-stage arm (even without PID)
2. Sturdy but not achieved by adding a lot of extrusions. If the kinetic energy is unchanged and the moment of inertia is reduced, the angular velocity will increase by a factor of two, so that the robot will have the risk of overturning while carrying MACRO POLLUTANTS.
3. There are effective limits that can protect the structure.

For the third-stage turning arm, our main needs are:

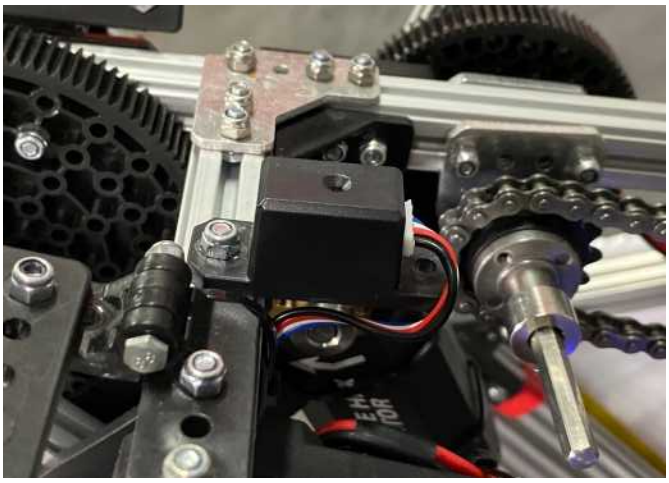
1. Light weight
2. The rotation angle to be relatively accurate.
3. Provide enough force to place a large number of MICRO POLLUTANTS (9-16)

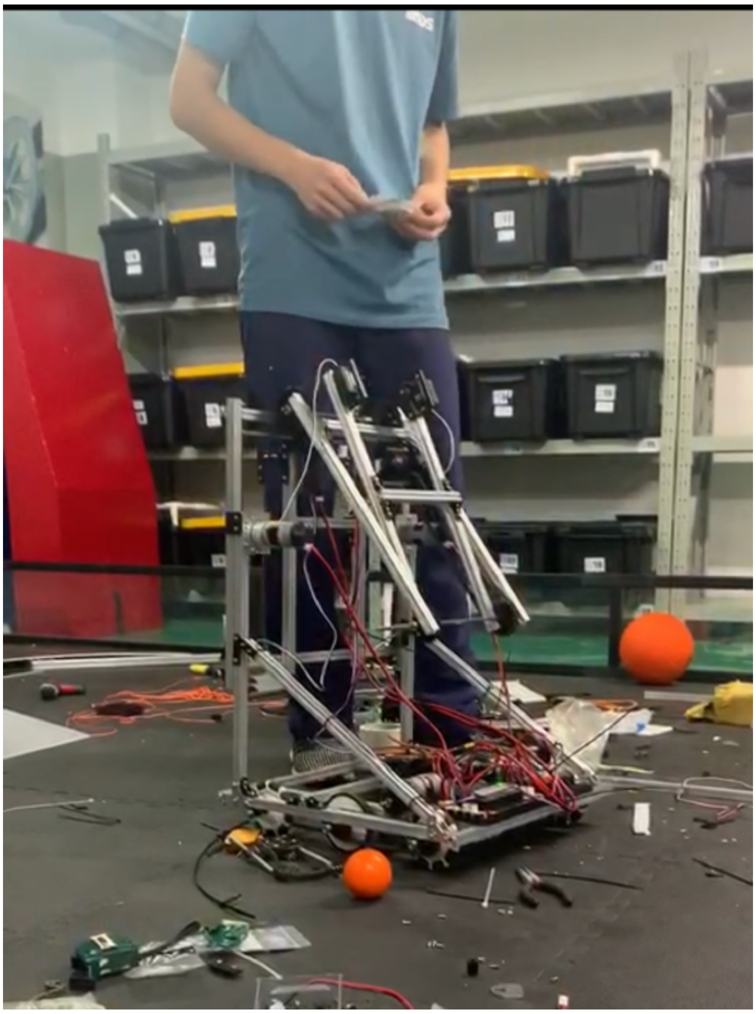
On the second stage of the rotating arm, we still use two complete beams to increase the height that can be lifted. In terms of power, we installed a hex shaft motor and a gear ratio slightly smaller than the first stage arm to synchronize the two's speed. In the repeated practice of driver 2, it was found that the speed of the two stages matches very well. We fixed the motor on the first stage arm and used the sprockets to provide power. In terms of limits, we use a magnetic sensors as the solution. At first we installed the touch sensor on the level one and did not consider the MACRO POLLUTANTS might also trigger the sensor. Finally, we installed a magnet on the second-stage arm and installed a sensor on the first-stage arm to limit it. For the stability of the system and also for the chain to get around the extrusions on its way, we installed a sprocket on the first-stage turning arm to solve this problem.

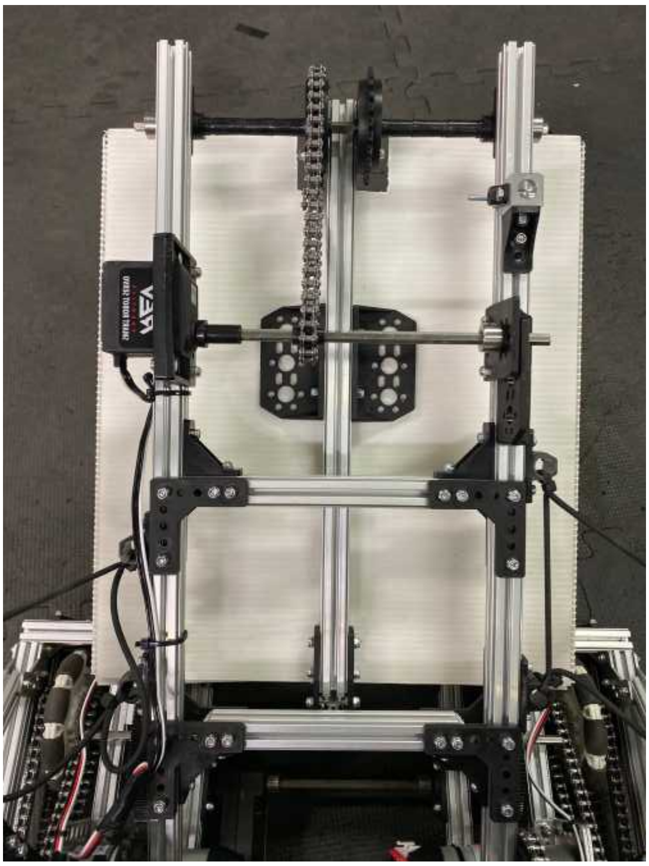




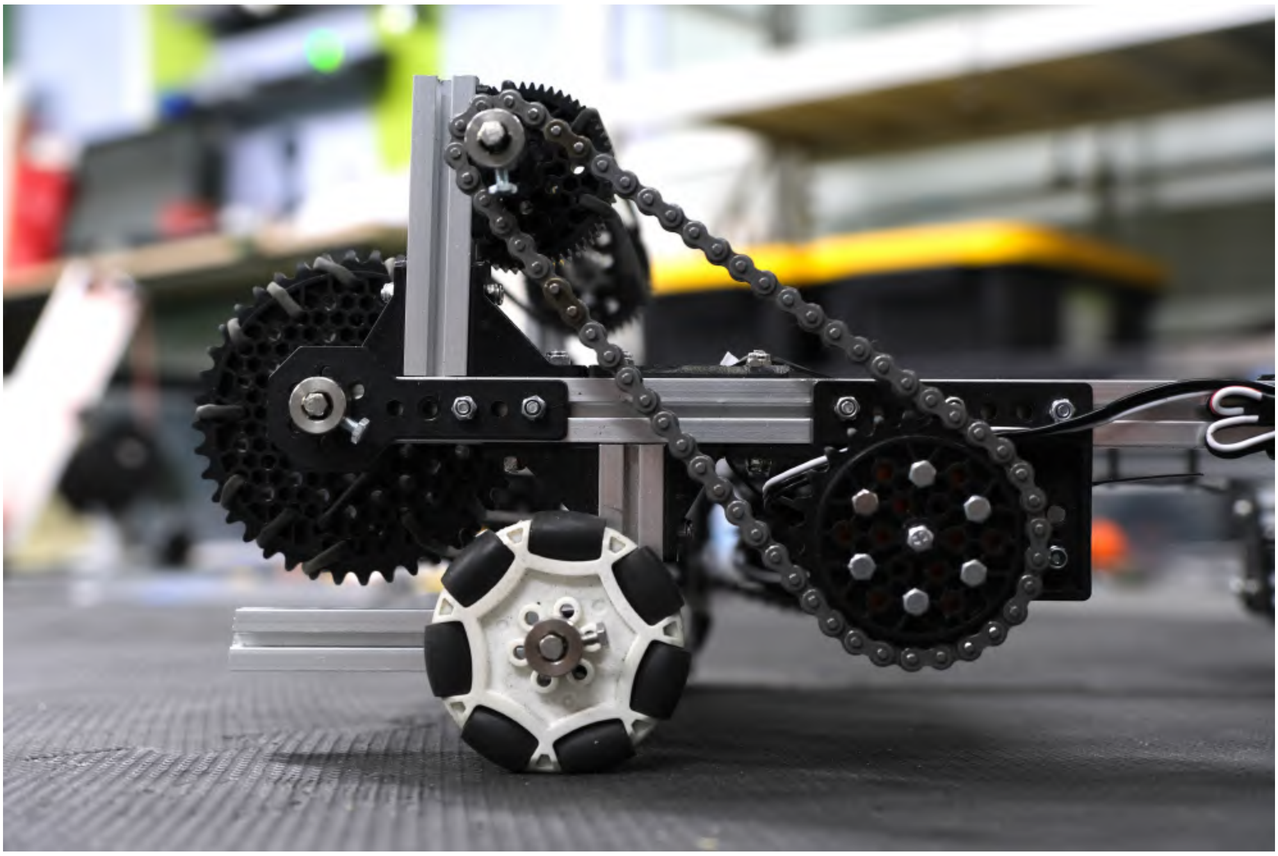
On the third-stage turning arm, we used a steering gear drive and used a first-stage reduction ratio to provide more force to place a larger number of MICRO POLLUTANTS. In order to fix the position of the rotating arm, we padded the shaft of the entire rotating arm with a washer. The reason for choosing the steering gear in this place is that the steering gear is light in weight, small in size, and the angle is accurate enough.

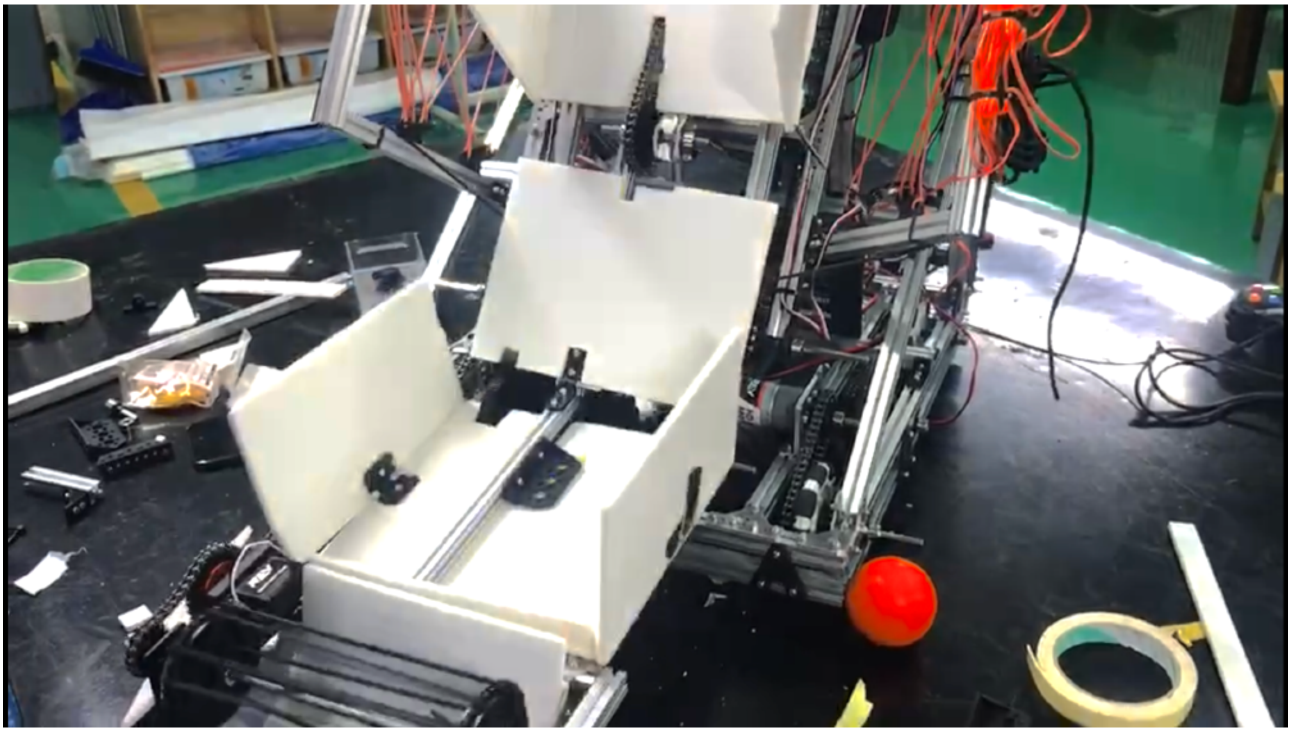


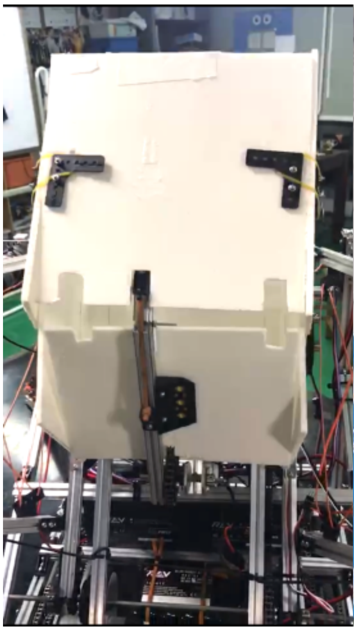




2.6. Intake and Storage Mechanism





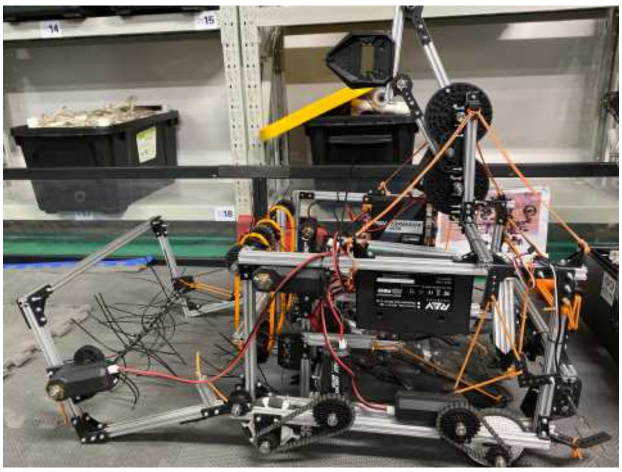


At first, the final version of the intake mechanism did not exist at all. We did not have a clear design for the Intake of MICRO POLLUTANTS at first.

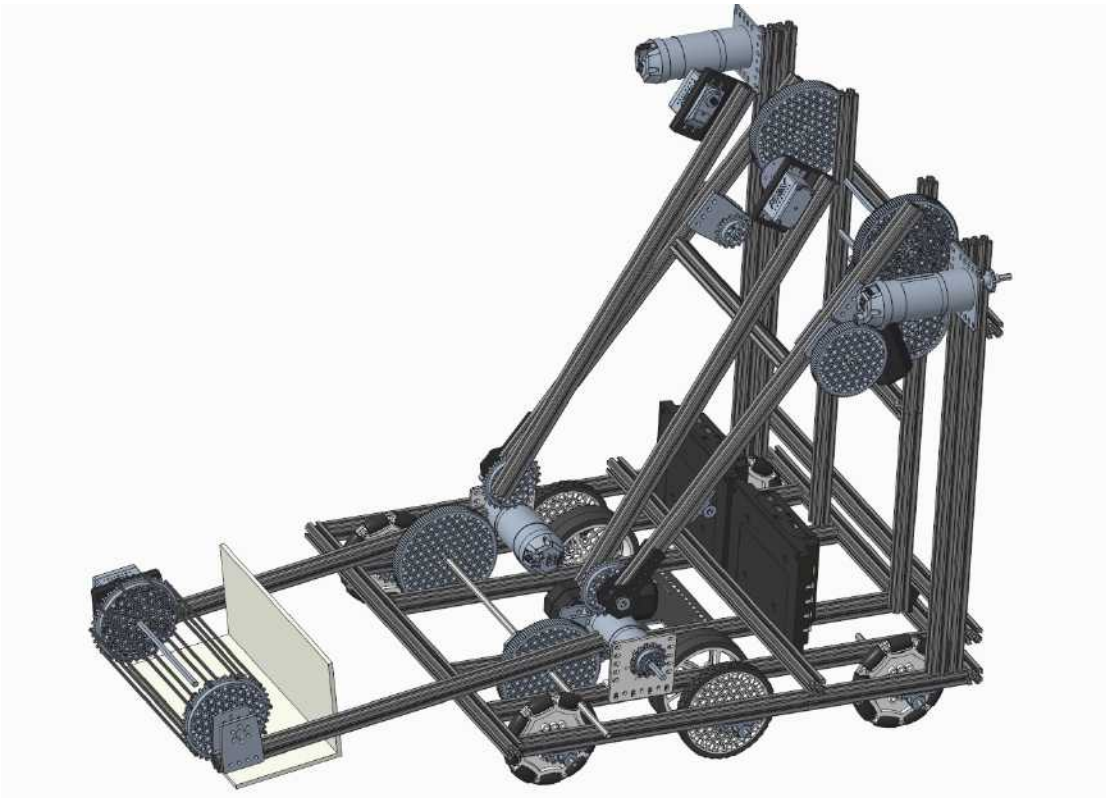
For intaking pollutants and storage mechanisms, our requirements are:

1. The whole pollutant intake mechanism can intake and store the pollutant, and can move the pollutant to a higher altitude. The container of the storage pollutant needs to be placed on the third-stage arm.
2. Ability to intake the pollutant efficiently, not spending too much time on a pollutant.
3. Ability to accommodate the presence of non-singular pollutants. i.e. 4 in a row.

At the beginning we referred to the intake mechanism of the FGC China team in 2017. This mechanism can transport the MICRO POLLUTANTS from the ground to some height. Based on the existing third-stage mechanism, the frame of the MICRO POLLUTANTS can be done very deep, but To effectively use the entire area, the MICRO POLLUTANTS needs to be lifted to a relatively large height, and this mechanism intake mechanism should have a large height.

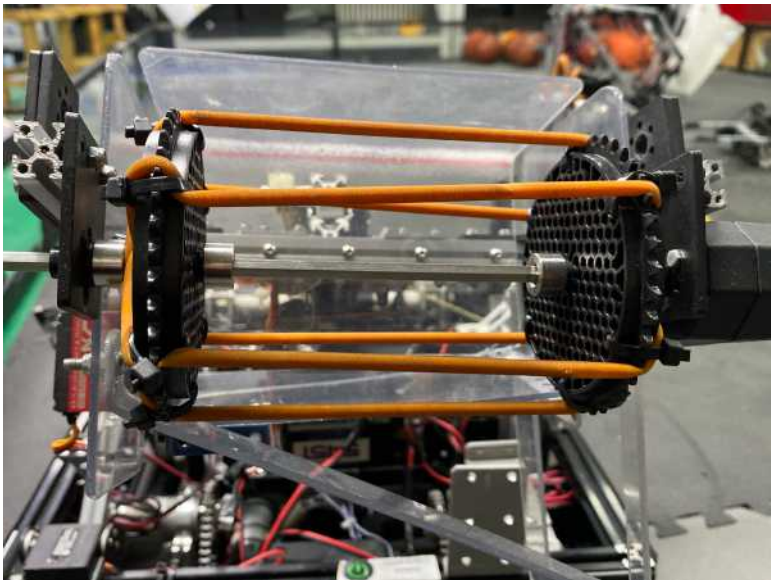



Later, we decided to use a two staged intake to acquire the pollutant and store the pollutant. The two staged in this context means that there is a first-stage mechanical arm that can be rotated. The robot arm has an intake pollutant and a temporary container (for example, 3-5 can be stored), and then passes. Rotate the robot arm to pour the pollutant from the temporary container into the container of the third-stage rotating arm, and then perform the action of reversing the pollutant. Although this mechanism is theoretically feasible, it still has a big problem—the frame that is finally fixed on the third-stage arm will be a two-sided open frame. One side is used to place the MICRO POLLUTANTS on the third floor, and the other side is used to pour the pollutant in the intake mechanism into the frame. This will greatly increase the risk of losing the pollutant in the middle of the game and it is also difficult to store the pollutant in the box, which would be inefficient and not feasible.



After the above attempts, we have came up with some further requirements for the intake pollutant and storage mechanism:

1. The entire frame needs to be fixed on the third-stage steering gear arm. It must be open on one side during the whole movement and can make the movement of the pollutant one-way.



2. The intake mechanism can lift the pollutant a part of the distance and allow the pollutant to enter the third-order steering arm frame. (Picture from FTC #16093)
3. The folding of the intake pollutant mechanism is realized by the rotating arm, and the gear ratio of the arm needs to be large.

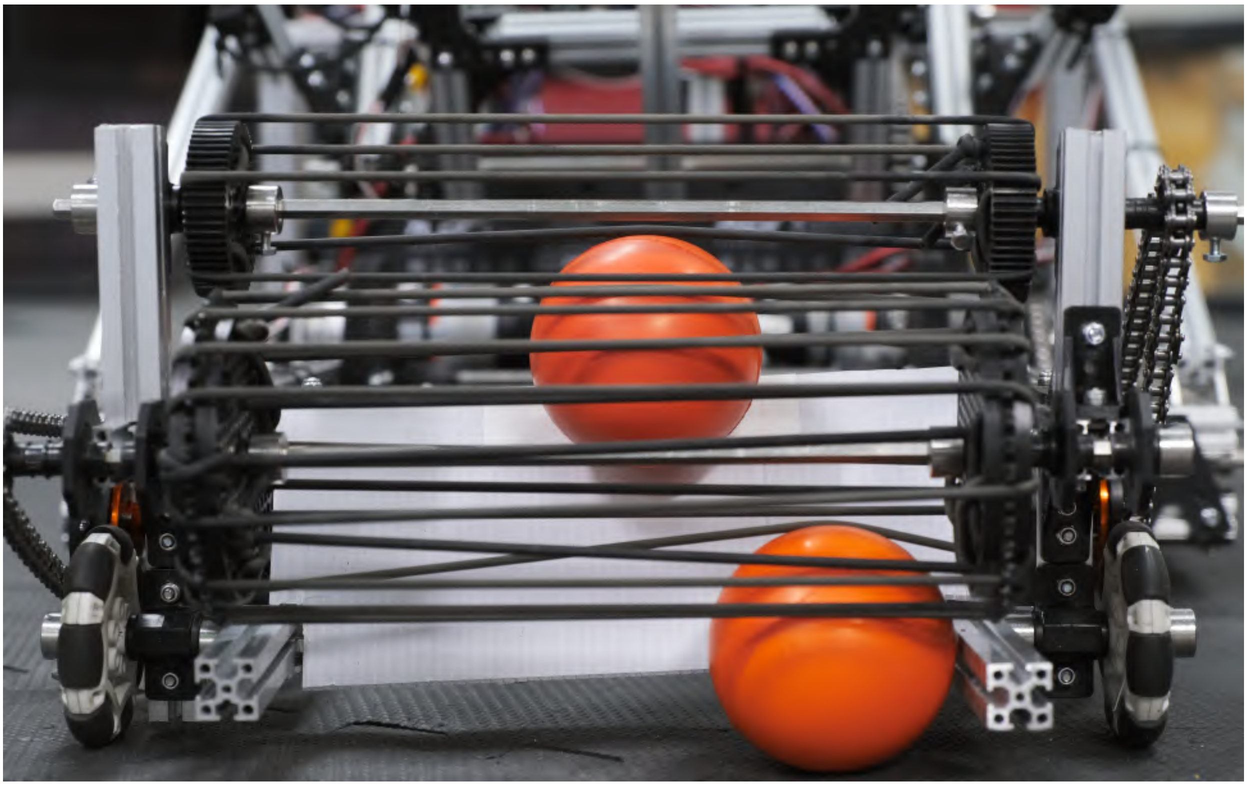
It can be seen that the frame is very important for the whole set of intake mechanism.

In the final version of the design, we let some of the frame rigidly fixed on the third-stage arm, and the other part of the frame is connected with rubber bands, which has the function of shrinking, thus reducing the size.

The intaking pollutant function is mainly driven by the gear ratio and the gear ratio of the deceleration. The deceleration is to deal with the sudden situation. If the gear ratio provides less force, the intake of multiple MICRO POLLUTANTS will stop the servo. On the sprocket Tied the rubber band to use the friction to pull the pollutant into the box. Then squeeze the corrugated board to move the pollutant up to the box.

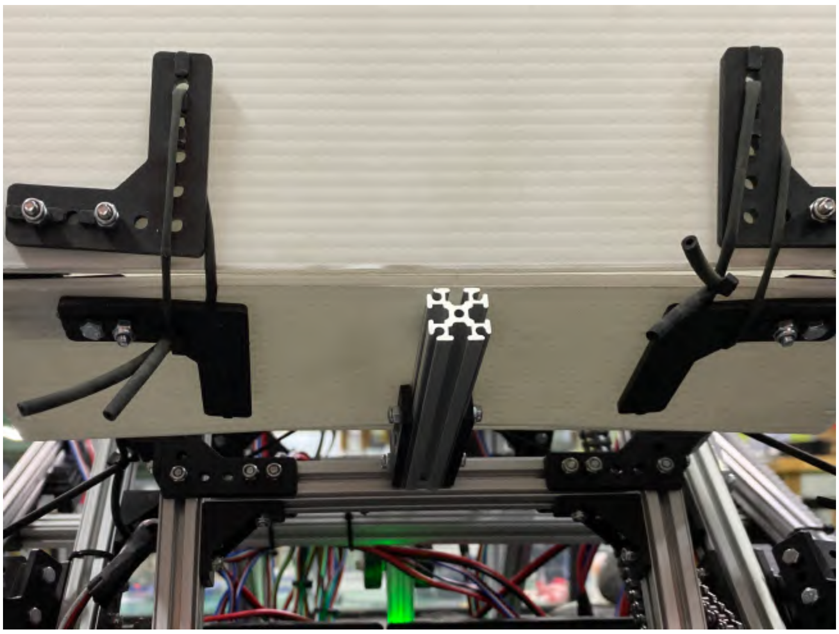
In order to make our movements smoother and more reasonable, we added two small wheels at the bottom to ensure that the intake mechanism can move left and right, and reduce the resistance to the ground when placing the POLLUTANTS uphill.

In order to allow the MICRO POLLUTANTS to smoothly enter the frame of the third-stage steering gear arm, we installed an extra servo to ensure that the pollutant can smoothly enter the frame.This set of institutions has also been used in the intake ball design of FTC 2019 #16093.



For the design of the box, we made nearly ten versions of the box with the corrugated board we bought to simulate. **The production of the box involves the following details:**

1. All the fixing and connection of the frame are realized by double-sided installation of the plastic parts, which reduces the pressure of the screw to the frame and also improves the strength of the frame.



2. The size of the box is continuously tested, measured and changed. Due to the volume of the second arm, we need this box to allow a larger error. (That is, no matter what position box is always able to fit intake The mechanical arm allows the pollutant to enter the frame. Also avoid interference with other components during the design process, such as gears.
3. The rubber band at the entrance of the box allows the pollutant to enter the box and also prevents the pollutant from falling out of the box.

4. The sides of the frame close to the arm are fixed by the right angle motor frame to prevent the intake arm from falling too much and causing damage to the frame.
5. In the intake part, in order to further prevent the inhalation of the MICRO POLLUTANTS card into the sprocket, we added two short beams at the bottom.

Part II:Driver Control Programs

3.1.General Summary

Since there is no autonomous period in First Global Challenge, the robot needs a quick response to the operator, move and show its function. The program should also balances the stability of the hardware and flexibility when maintaining the efficiency and operability. Basically, we separated two drivers by different parts on the robot, the first driver is responsible for controlling the chassis, telling where the robot to go. The second one is about the functions, mechanical arm and servos. Our testing prototypes will presented and discussed at first. Special program features and related code in our final version will be explained below. The key mapping demonstration will in the last part of this chapter.

3.2.Program Prototype

We used blocks programming method, which is more suitable for non-professional programmers, every member in the team can participate in preliminary programming design period. It can help us bring together everyone's ideas effectively. At the same time, simple debugging work is also possible. But as the project becomes more complex and the logic increases, module programming is no longer appropriate. We will migrate the project to Java code.

3.3.Final Version

Controller One

Chasis

We ues a improved POV control mode. It provides a easy way to move stright forward or backward. It allows us to move forward and turn at the same time, result in a perfect curve motion. The linear paremeter data is from `leftJoystick_Y_axis_`, the turing parameter is concluded by `leftTrigger` and `rightTrigger` keys. For driving in narrow spaces and precise operations, we introduced SlowMode, driving when pressing button `X` on the controller multiplies the power of the motor by a factor of 0.5.

```
//Drive
double leftPower;
double rightPower;
double drive = - gamepad1.left_stick_y;

//Turn
double turn = 0;
if (gamepad1.left_trigger) turn = -1;
else if (gamepad1.right_trigger) turn = 1;
else if (gamepad1.right_trigger && gamepad1.left_trigger) turn = 0;
else turn = 0;

if (drive != 0){
    leftPower = Range.clip(drive + (turn*2), -1.0, 1.0);
    rightPower = Range.clip(drive - (turn*0.5), -1.0, 1.0);
}
leftPower = Range.clip(drive + turn, -1.0, 1.0);
rightPower = Range.clip(drive - turn, -1.0, 1.0);

//SlowMode
if (gamepad1.x) {
    driveMotorLeft.setPower(0.6 * leftPower);
    driveMotorRight.setPower(0.6 * rightPower);
}
else{
    driveMotorLeft.setPower(leftPower);
    driveMotorRight.setPower(rightPower);
}
```

Intake Motor

In addition to the chassis, the first operator manages the stowage and deployment of the intake mechanisim. Unfold the intake part at the beginning of the game and retrive it in the final lifiting phase by simply pressing `UP` and `DOWN` on the gamepad 1.

Controller Two

Two-Stages Arm

The second operator has a lot of actions that need to be responsible. The two-stage robotic arm is the most important part. Because the great degree of freedom of our robot arm, many joints need to be monitored. We first used fully automated PIDF conrol on these joints, but if a problem occured on the playing fild suring the match, it is hard to recover and contonue scoring. In this case, we end up on a semi-manual control method, retaining the limits to prevent excessive movement. At the same time, leave spaces for manual and precise operation. These functions are controled by two `joystick` on the gamepad 2.

```
//levelOneMotor
double LevelOneMotorInput = - 0.9 * gamepad2.left_stick_y;
double LevelOneMotorPower = LevelOneMotorInput;

if (levelOneLimit.isPressed() && LevelOneMotorInput < 0)
    LevelOneMotorPower = 0;

if (levelOneMotorLeft.getCurrentPosition()>1100 && LevelOneMotorInput> 0)
    LevelOneMotorPower = 0;

else if (LevelOneMotorInput > 0)
    LevelOneMotorPower = LevelOneMotorInput;

levelOneMotorLeft.setPower(LevelOneMotorPower);
levelOneMotorRight.setPower(LevelOneMotorPower);
```

Intake Servos

When extracting small `Pollutants`, the two intake servos rotate in one direction, and the `Polluants` balls can be continuously transported into the container. We also have actions to push large `Pollutants`. In this case, we need to reverse the servo on below, but keep the servo above continue to rotate forward to prevent the small `Pollutants` from falling out of the container.

```
if (gamepad2.left_trigger){
    intakeServo.setPosition(1);
    intakeServoH.setPosition(1);
}
else if (gamepad2.right_trigger) {
    intakeServo.setPosition(0);
    intakeServoH.setPosition(1);
}
else{
    intakeServo.setPosition(0.5);
    intakeServoH.setPosition(0.5);
}
```

Lift Motors

Pressing `UP` and `DOWN` keys on the gamepad 2 to opreate the lift motors. These motors control the height of the entire superstructure. They need to operate when placing `Pollutants` at the top layer of the `Processing Hub` and in the last few seconds of the game. The current key mapping is intuitive and easy to maneuver.

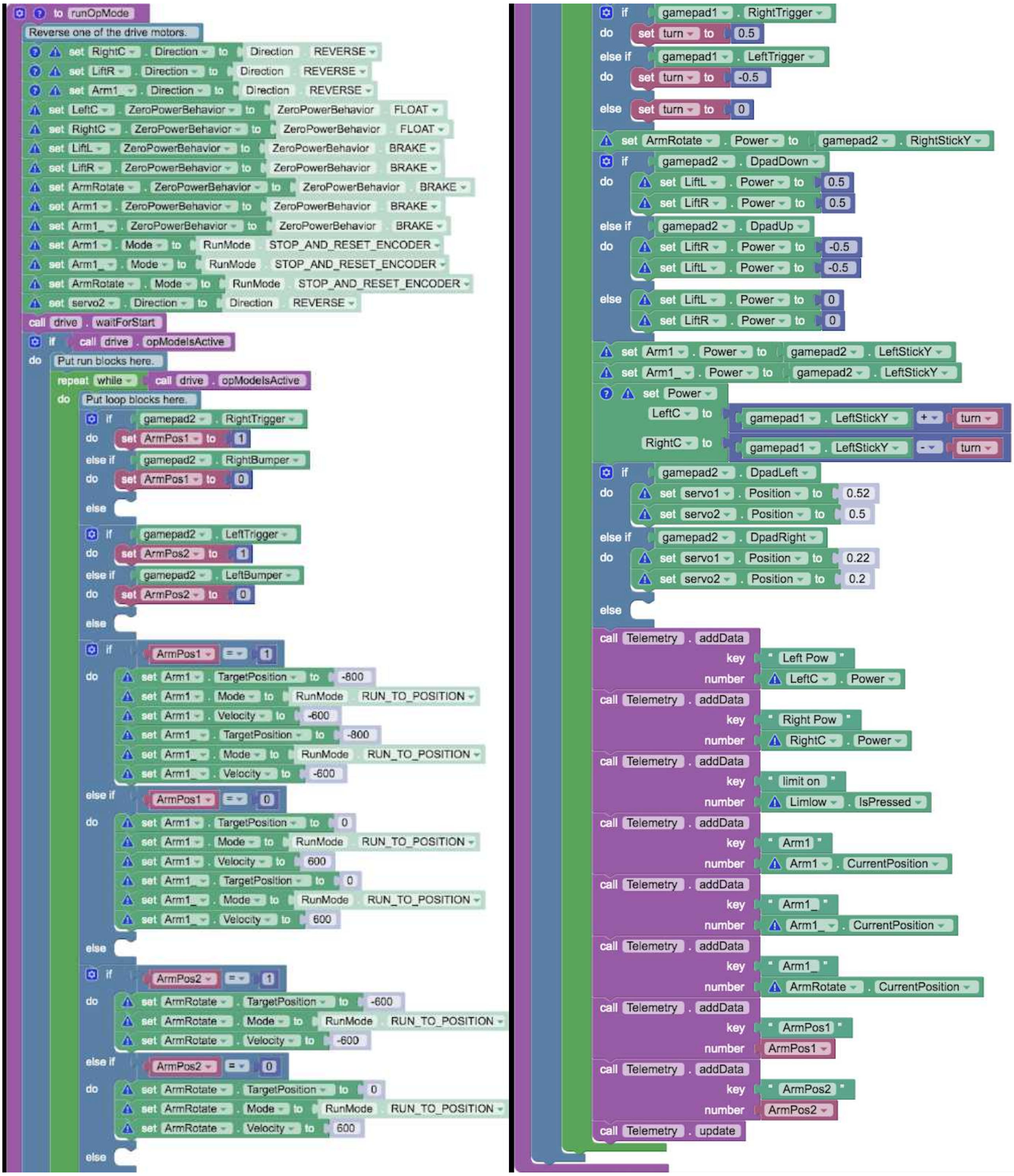
Container Servo

This servo sets the position of three positions while ensuring that the angle of the container does not allow small `Pollutants` to fall out. The human controller could switch between these three postitions with `X` `A` and `Y` keys.

Data Update and Display

```
telemetry.addLine("===================");
telemetry.addData("Status", "Run Time: " + runtime.toString());
telemetry.addLine("===================");
telemetry.addData("Chasis", "left (%.2f), right (%.2f)", leftPower, rightPower);
telemetry.addLine("===================");
telemetry.addData("1stLevelLeft", levelOneMotorLeft.getCurrentPosition());
telemetry.addData("1stLevelRight", levelOneMotorRight.getCurrentPosition());
telemetry.addData("2ndLevel", levelTwoMotor.getCurrentPosition());
telemetry.addData("intakeMotor", intakeMotor.getCurrentPosition());
telemetry.addLine("===================");
telemetry.addData("liftLimitLow", liftLimit.isPressed());
telemetry.addData("liftLimitHigh", liftLimit2.isPressed());
telemetry.addData("levelOneLimit", levelOneLimit.isPressed());
telemetry.addLine("===================");
telemetry.update();
```

Returning and updating datas of the robot is a manageable technique to detect abnormal conditions on the playing field. We show the running time, the power status of each motor, the sensor limit status and other data.


to runOpMode
Reverse one of the drive motors.
set RightC . Direction to Direction REVERSE
set LiftR . Direction to Direction REVERSE
set Arm1_ . Direction to Direction REVERSE
set LeftC . ZeroPowerBehavior to ZeroPowerBehavior FLOAT
set RightC . ZeroPowerBehavior to ZeroPowerBehavior FLOAT
set LiftL . ZeroPowerBehavior to ZeroPowerBehavior BRAKE
set LiftR . ZeroPowerBehavior to ZeroPowerBehavior BRAKE
set ArmRotate . ZeroPowerBehavior to ZeroPowerBehavior BRAKE
set Arm1 . ZeroPowerBehavior to ZeroPowerBehavior BRAKE
set Arm1_ . ZeroPowerBehavior to ZeroPowerBehavior BRAKE
set Arm1 . Mode to RunMode STOP_AND_RESET_ENCODER
set Arm1_ . Mode to RunMode STOP_AND_RESET_ENCODER
set ArmRotate . Mode to RunMode STOP_AND_RESET_ENCODER
set servo2 . Direction to Direction REVERSE
call drive . waitForStart
if call drive . opModeIsActive
do Put run blocks here.
repeat while call drive . opModeIsActive
do Put loop blocks here.
if gamepad2 . RightTrigger
do set ArmPos1 to 1
else if gamepad2 . RightBumper
do set ArmPos1 to 0
else
if gamepad2 . LeftTrigger
do set ArmPos2 to 1
else if gamepad2 . LeftBumper
do set ArmPos2 to 0
else
if ArmPos1 = 1
do set Arm1 . TargetPosition to -800
set Arm1 . Mode to RunMode RUN_TO_POSITION
set Arm1 . Velocity to -600
set Arm1_ . TargetPosition to -800
set Arm1_ . Mode to RunMode RUN_TO_POSITION
set Arm1_ . Velocity to -600
else if ArmPos1 = 0
do set Arm1 . TargetPosition to 0
set Arm1 . Mode to RunMode RUN_TO_POSITION
set Arm1 . Velocity to 600
set Arm1_ . TargetPosition to 0
set Arm1_ . Mode to RunMode RUN_TO_POSITION
set Arm1_ . Velocity to 600
else
if ArmPos2 = 1
do set ArmRotate . TargetPosition to -600
set ArmRotate . Mode to RunMode RUN_TO_POSITION
set ArmRotate . Velocity to -600
else if ArmPos2 = 0
do set ArmRotate . TargetPosition to 0
set ArmRotate . Mode to RunMode RUN_TO_POSITION
set ArmRotate . Velocity to 600
else
if gamepad1 . RightTrigger
do set turn to 0.5
else if gamepad1 . LeftTrigger
do set turn to -0.5
else set turn to 0
set ArmRotate . Power to gamepad2 . RightStickY
if gamepad2 . DpadDown
do set LiftL . Power to 0.5
set LiftR . Power to 0.5
else if gamepad2 . DpadUp
do set LiftR . Power to -0.5
set LiftL . Power to -0.5
else set LiftL . Power to 0
set LiftR . Power to 0
set Arm1 . Power to gamepad2 . LeftStickY
set Arm1_ . Power to gamepad2 . LeftStickY
set Power
LeftC to gamepad1 . LeftStickY + turn
RightC to gamepad1 . LeftStickY - turn
if gamepad2 . DpadLeft
do set servo1 . Position to 0.52
set servo2 . Position to 0.5
else if gamepad2 . DpadRight
do set servo1 . Position to 0.22
set servo2 . Position to 0.2
else
call Telemetry . addData
key " Left Pow "
number LeftC . Power
call Telemetry . addData
key " Right Pow "
number RightC . Power
call Telemetry . addData
key " limit on "
number Limlow . IsPressed
call Telemetry . addData
key " Arm1 "
number Arm1 . CurrentPosition
call Telemetry . addData
key " Arm1_ "
number Arm1_ . CurrentPosition
call Telemetry . addData
key " Arm1_ "
number ArmRotate . CurrentPosition
call Telemetry . addData
key " ArmPos1 "
number ArmPos1
call Telemetry . addData
key " ArmPos2 "
number ArmPos2
call Telemetry . update