Team Description Paper 2024

RCJ Soccer League- LightWeight

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WONG KIN SON (mentor)

ESCOLA DOS MORADORES DE MACAU

Abstract

In our project, we have created both a defense machine and an offense machine, each equipped with distinct features. The defense machine is integrated with a camera, whereas the offense machine incorporates a dribbling device. Correspondingly, we have formulated separate defense and offense programs. Over a span of six months, we refined our designs by introducing new elements such as a camera, dribbling device, and kicker. To enhance performance, we crafted a proprietary omni wheel and grayscale board. Moreover, we revamped the entire structure and improved the materials used in the project.

Introduction

WONG PAK HANG	CHEONG IOK CHI	YE CHON KIT	PUN CHON LAM IVAN
Captain	Mechanic	Program	Program
design	camera	Circuit	3D printer
Mechanic	Video	camera	Video

Our team consists of three high school students and one middle school student. The above is our division of labor. We have participated in two RoboCup Junior Soccer Lightweight Tournaments in China in two years and won the championship.

Overall Process

Drawing ⟶ CNC cutting or 3D printing ⟶ Programming ⟶ repeat

Contents

Hardware

1.Before and now

This is a comparison between our previous year's robot and this year's robot. We have added a lot of new equipment and optimized the program.

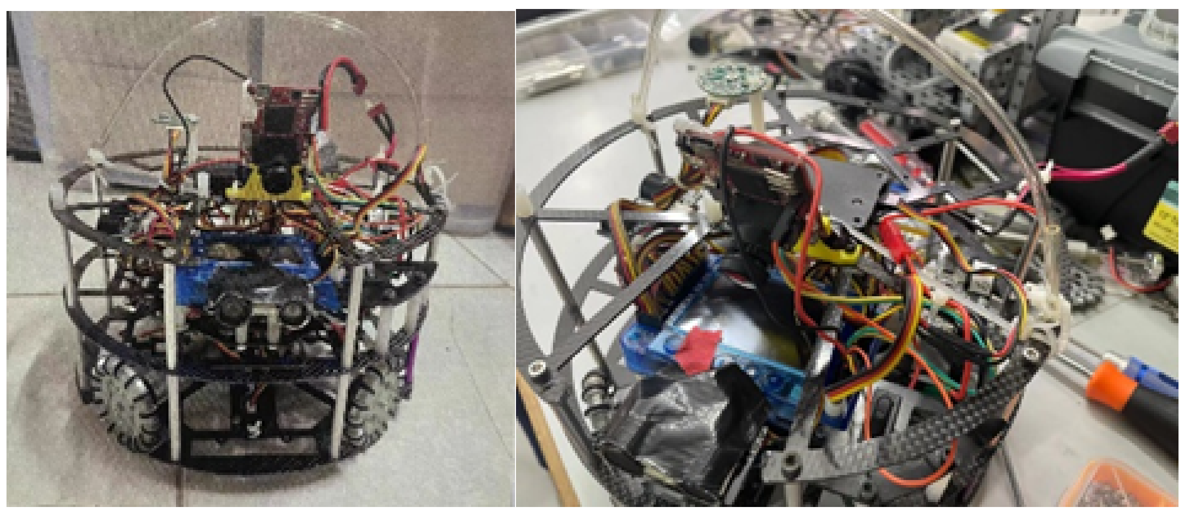

Fig.1 2023 Robots

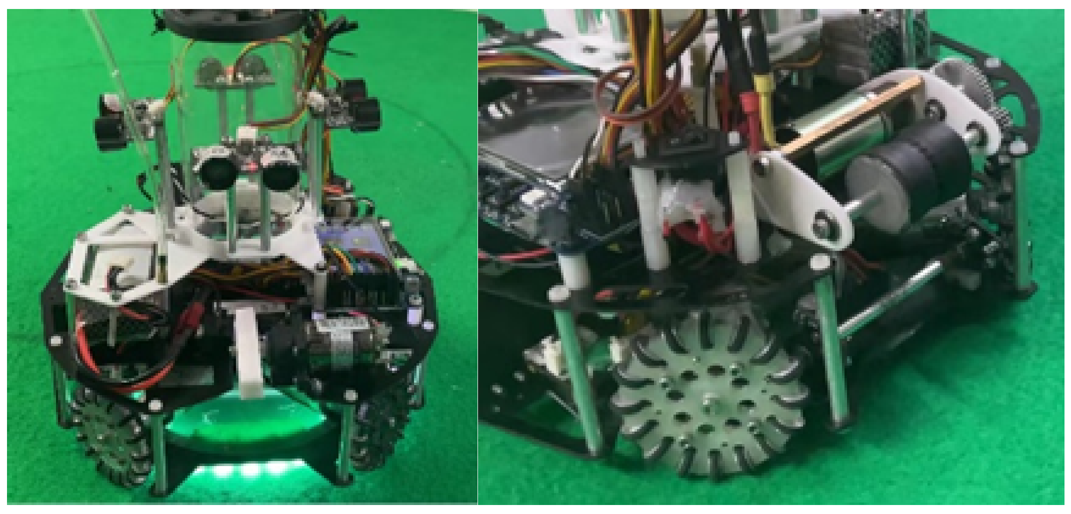

Fig.2 2024 Robots

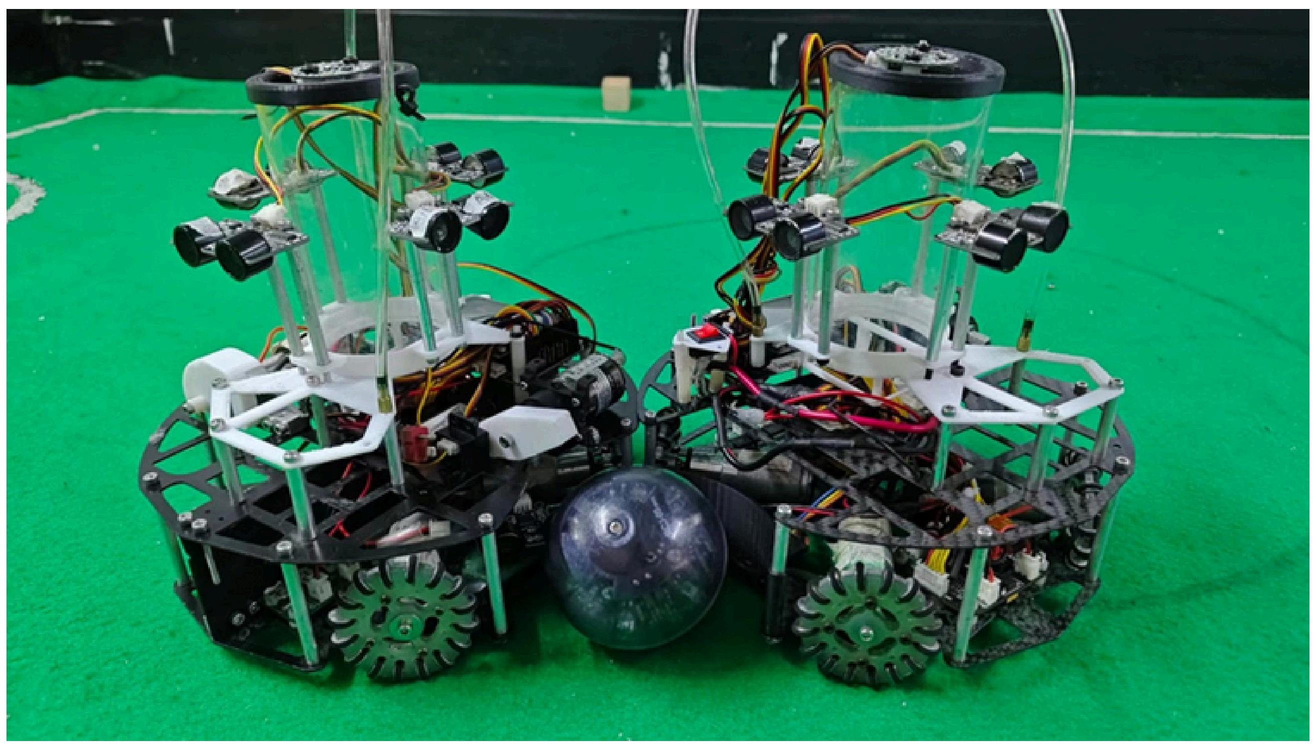

Fig.3 Final Robots

2.Circuit

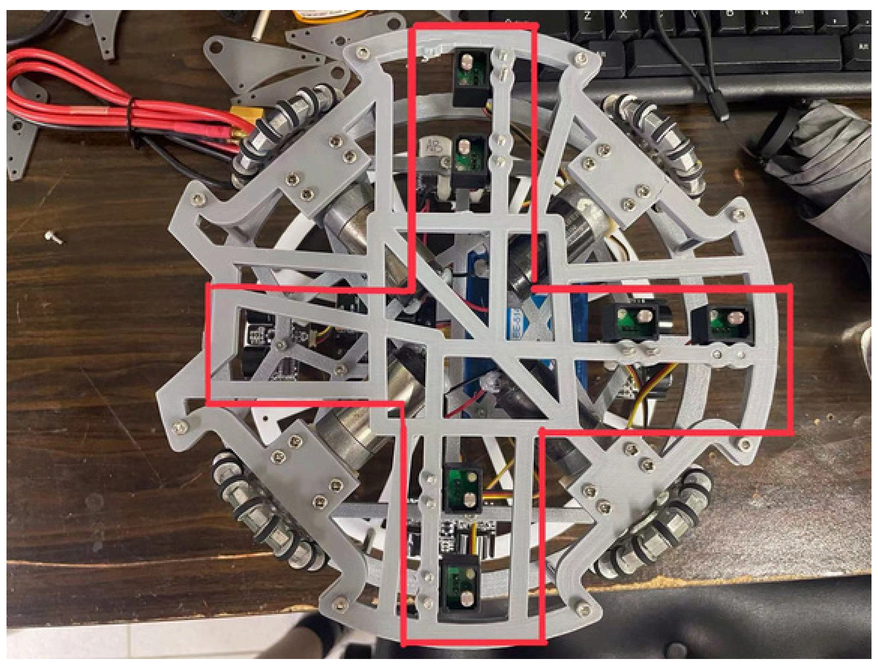

Fig.4 cross line

Cross line can read lines reliably, but they have a limited range of lines, resulting in certain angles not being detected. In the end, a circular line was used.

Fig.5 circular line

The Line Sensor board PCB features a ring-shaped design. The power supply is divided into 3.3V for LEDs and 5V for line sensors, effectively reducing heat generation. Additionally, aligning the pin headers with the main substrate facilitated a neat and organized wiring layout.

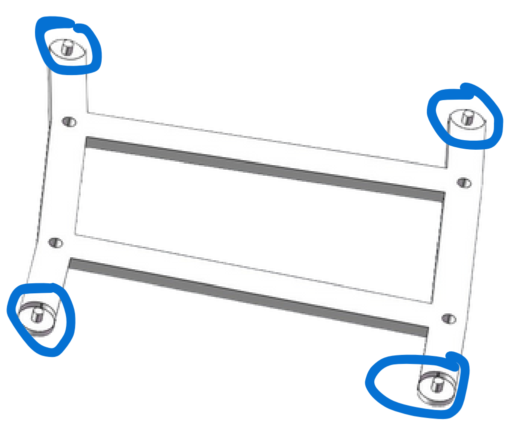

Fig.6 Grayscale support

We designed a grayscale fixator to make the grayscale more stable.

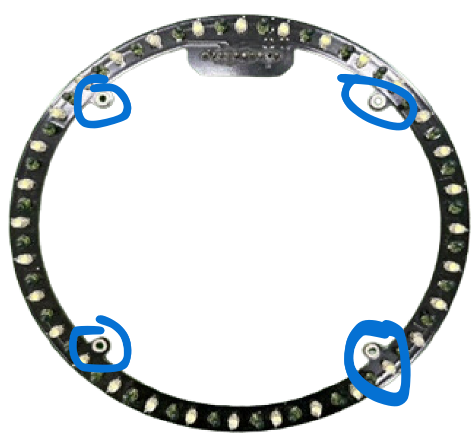

Fig.7 circular line

We circled the four points with a blue pen. They will be combined with each other. The holder is at the bottom and the grayscale board is at the top.

3.Design

Fig.8 3D printer

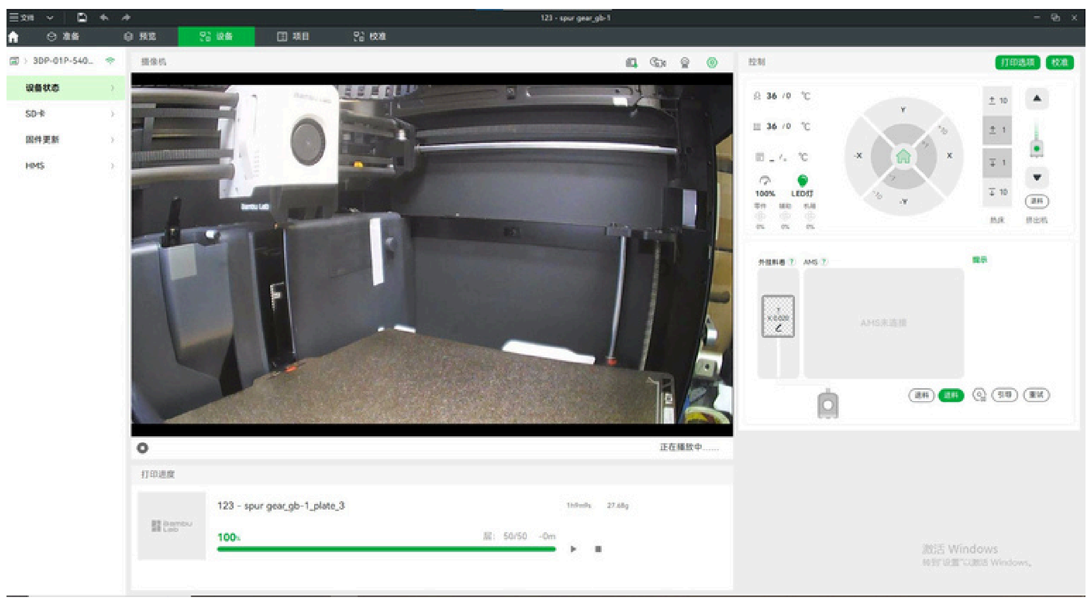

Fig.9 Bambu Studio

We used a 3D printer to test our machine. The PLA material used in the 3D printer is not only environmentally friendly but also safe and rigid enough.

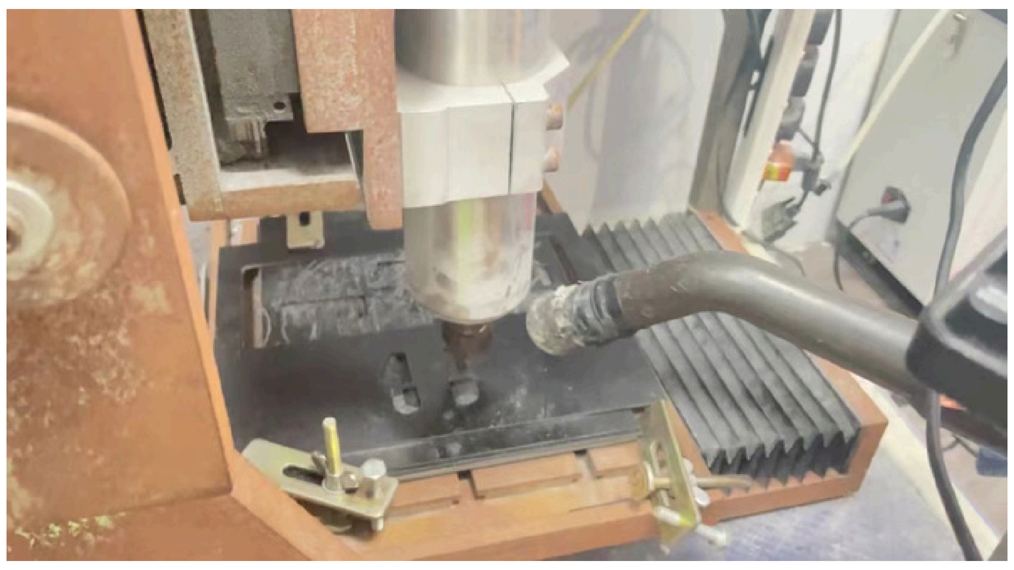

Fig.10 CNC cutting machine

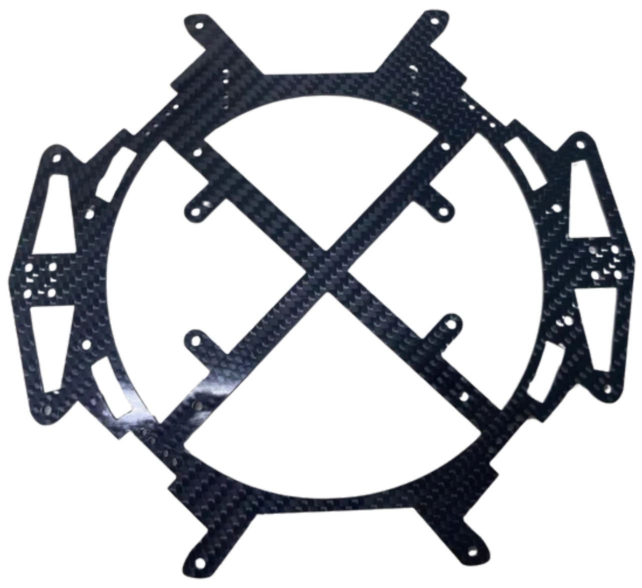

Fig.11 Bottom plate

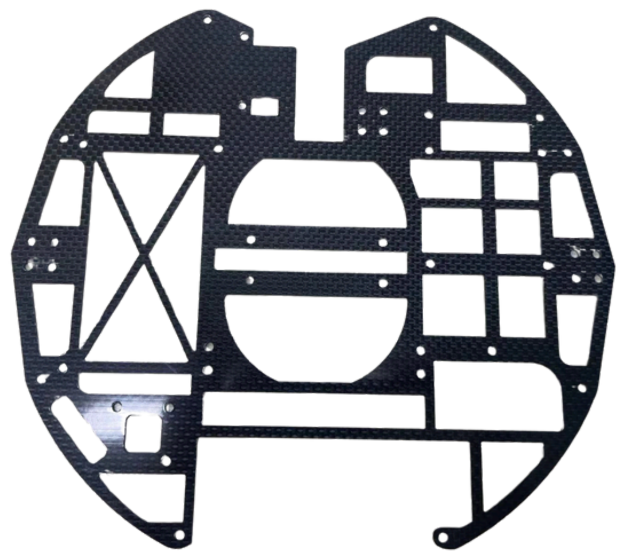

Fig.12 Middle plate

Due to the weight limitation, we finally use CNC cutting machine to cut the carbon fiber board. Carbon fiber boards are not only rigid but also lightweight.

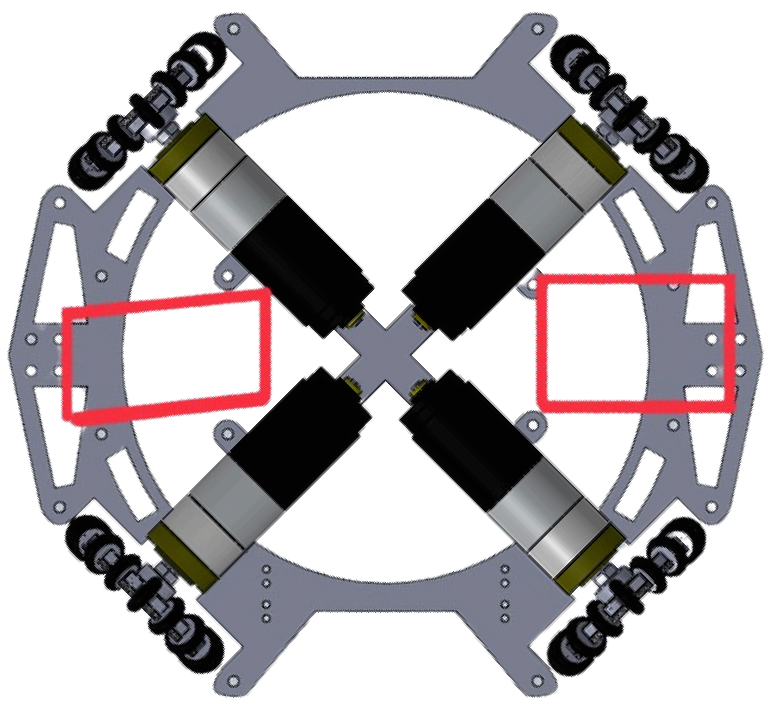

Fig.13 sub board placement location

We put the motor plate and cables on the bottom plate, which not only saves space, but also lowers the center of gravity and makes our machine more stable.

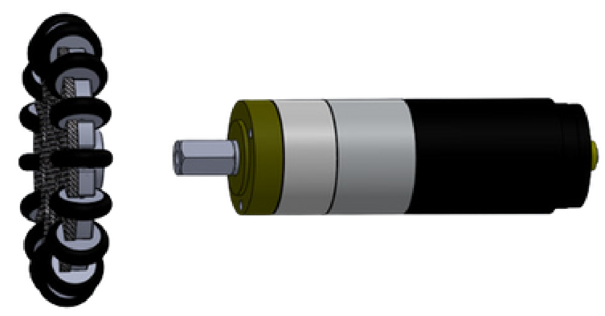

Fig.14 Omni wheel & Motor

Fig.15 Omni wheel

Small wheels
reason: reduce friction

Our in-house made gimbals not only allow flexible movement, but also increase space utilization. In this way the machine achieves more precise positioning.

Fig.16 Omni wheel

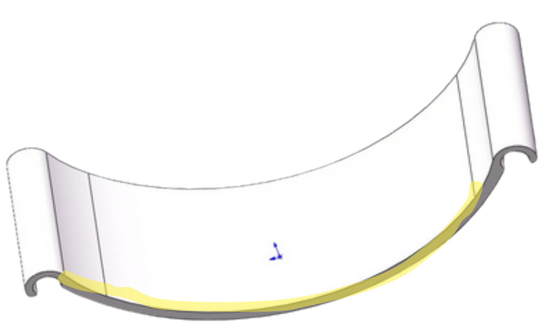

Fig.17 for defense robot

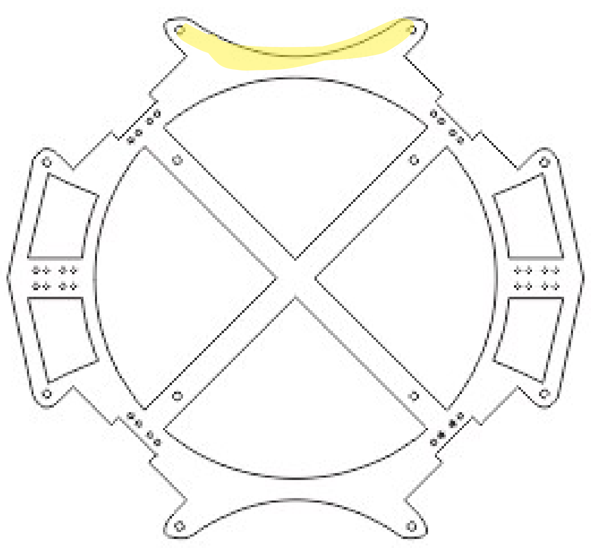

Fig.18 base plate

Installed between the bottom plate and the middle plate

Combine the parts marked with a yellow pen

4.Version modification process

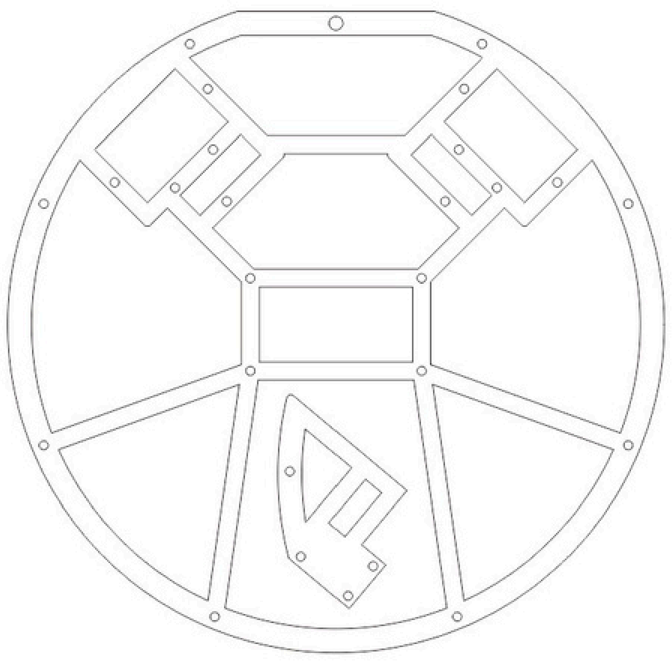

Fig.19 Last year's design

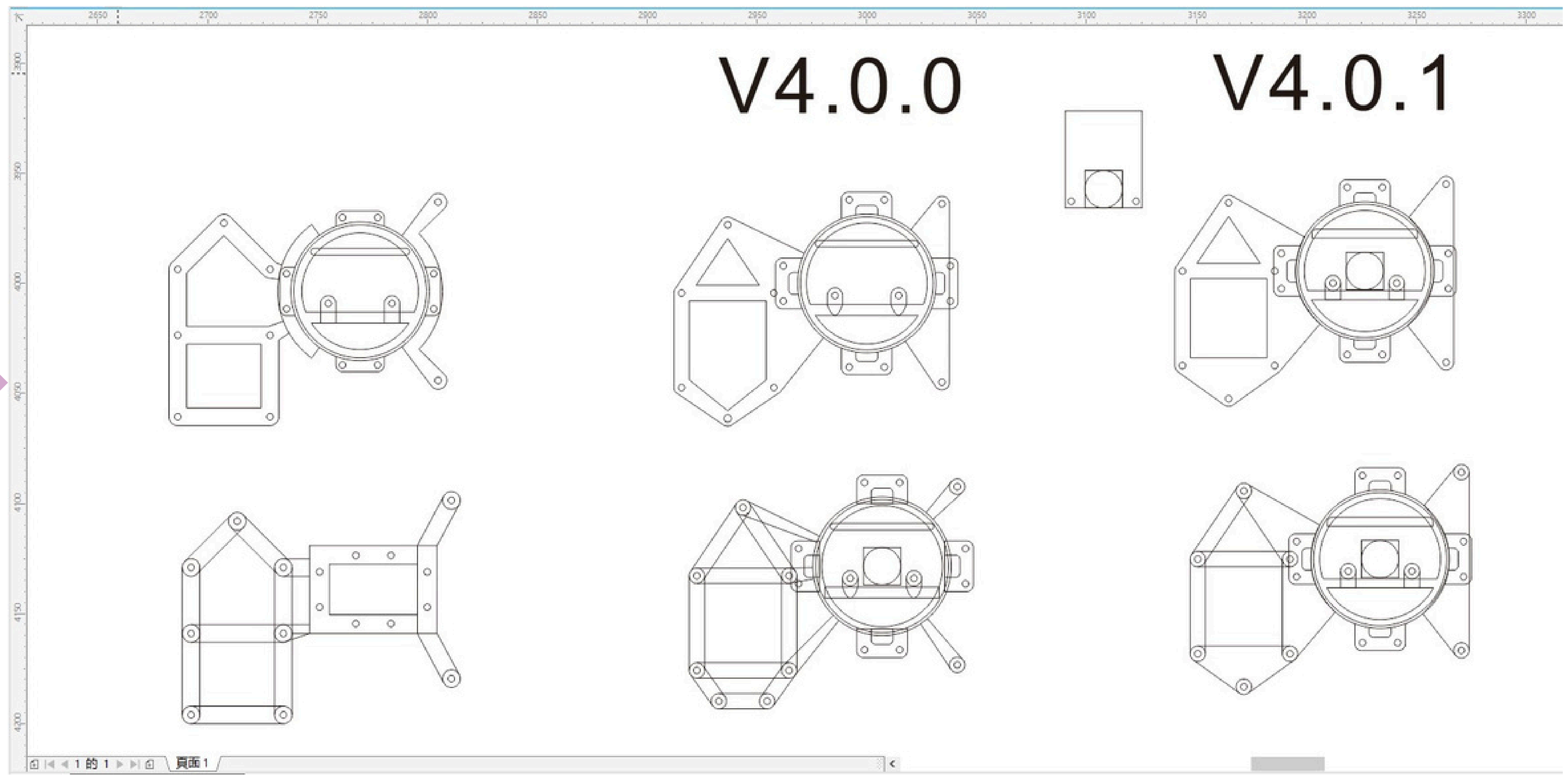

Fig.20 This year's Design

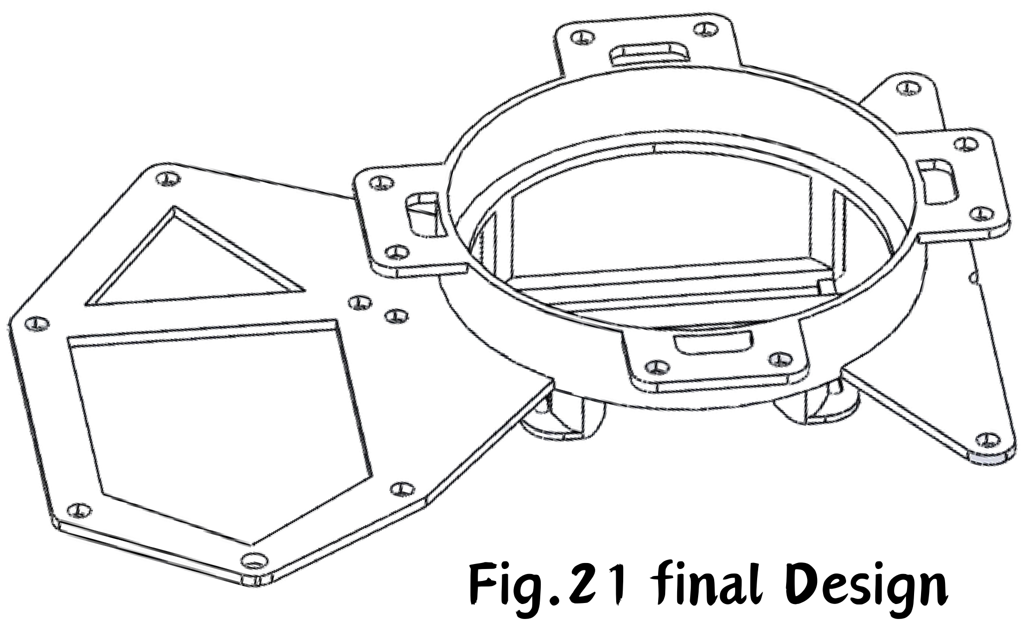

Fig.21 final Design

Our upper plate is designed to accommodate our ultrasound and compass, as well as our batteries. The batteries are specially designed to be easily replaced and secured.

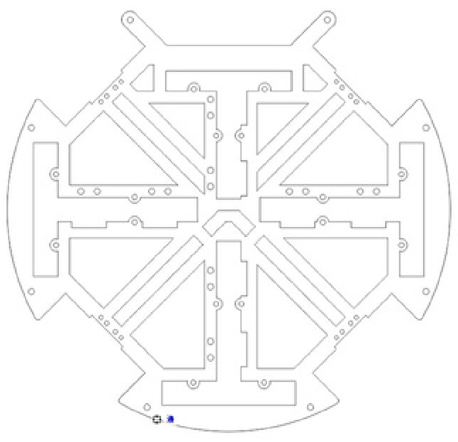

Fig.22 middle plate

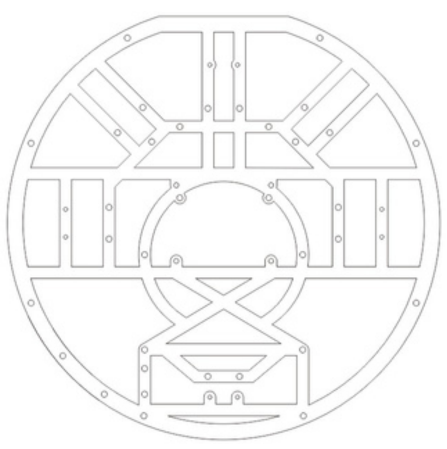

Fig.23 base plate

2023 design

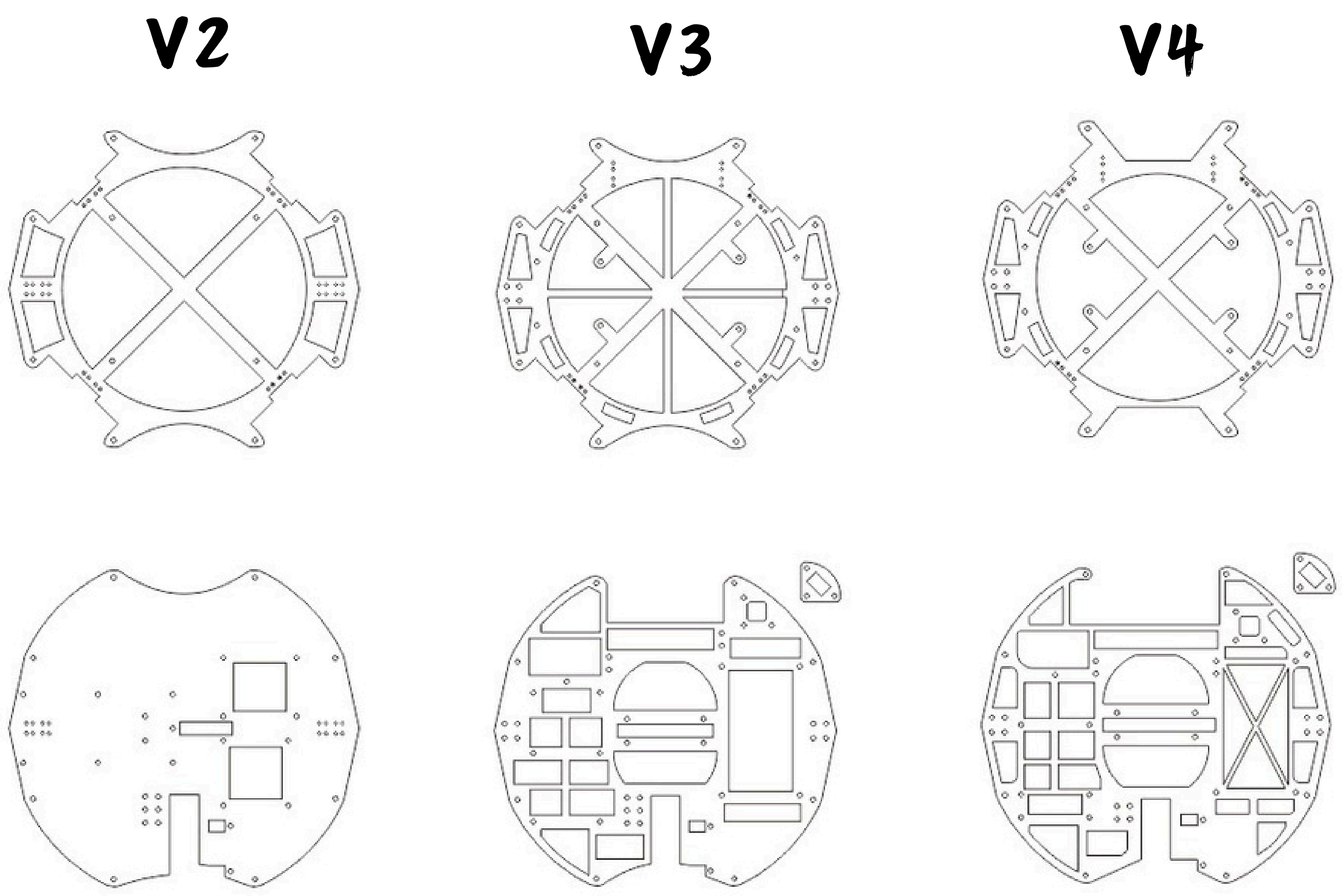

Fig.24 middle plate and base plate

2024 design

Due to the increase in the maximum weight of lightweight robots this year, we have redesigned the bottom and middle plates, adding more functions, making the robots more powerful and diverse, with more attack methods.

JoinMax Digital (x4-RCU)

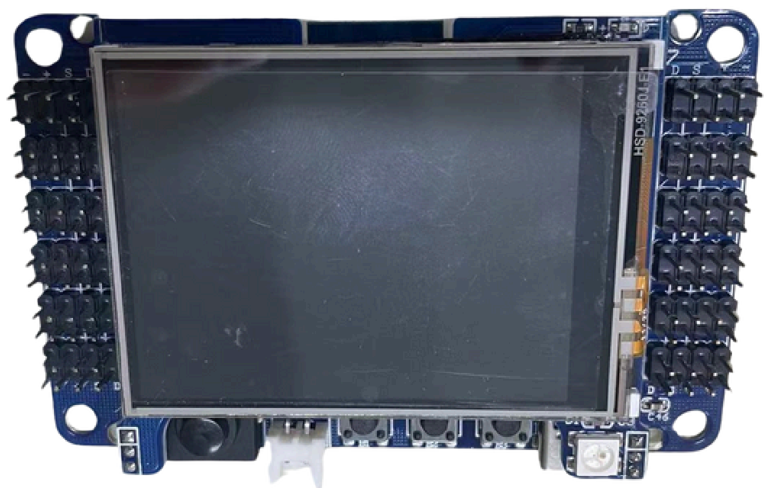

Fig.25 Main board

JMP-BE-5144

Bluetooth Edition

power (6.5-24VDC)

CPU: Cortex-M4

programming language : C language, flow chart

Designed using the STM32F407 series chips of STMicroelectronics' new generation M4 core, it has rich interfaces, compact size, strong performance and extremely low power consumption. The controller runs at a speed of up to 168MHz, has a maximum processing capacity of up to 210DMIPS, and integrates DSP and FPU (Floating Point Unit), which can easily handle various complex computing applications. The newly upgraded 2.4-inch high-definition touch screen and 16MB large-capacity memory bring a good operating experience and can fully meet the requirements of various competitions.

It has the capability to convert digital signals into motor control signals, facilitating motor control. Despite its compact size and lightweight design, it possesses the limitation of being able to control only two motors simultaneously.

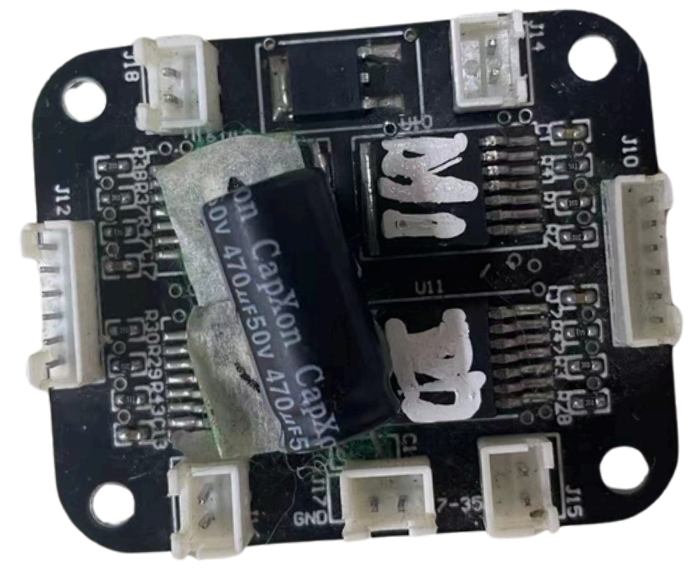

Fig.26 sub board

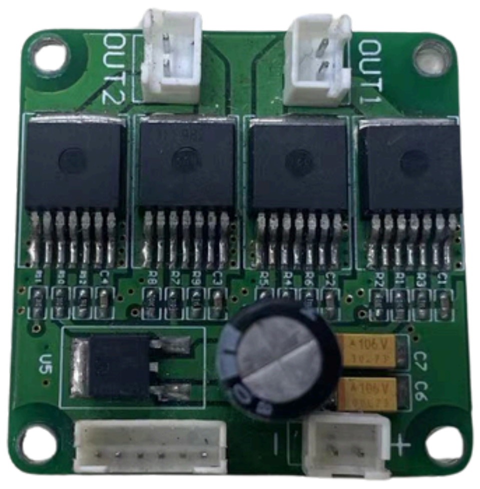

Fig.27 Sub board

It is capable of transforming digital signals into motor control signals to facilitate motor control. Notably, it is designed for larger applications, with the ability to simultaneously drive up to four motors.

The OpenMV Cam H7 utilizes the OV7725 camera module to enable the capture of 60 frames per second at resolutions of 640x480 for 8-bit grayscale images or 16-bit RGB565 images. It can also achieve image capture at up to 12 frames per second at a resolution of 320x240.

Fig.28 OpenMV camera

Fig.29 connecting column

+

Fig.30 compass

Installed above the upper plate.

The compass is held in place by a black 3D print below.

5.Kicker

Compared to the previous year, we have added the design of kickers to enhance the attacking ability of robots.

The kicker consists of a motor and a hitter, which rotates at high speed to kick off the football.

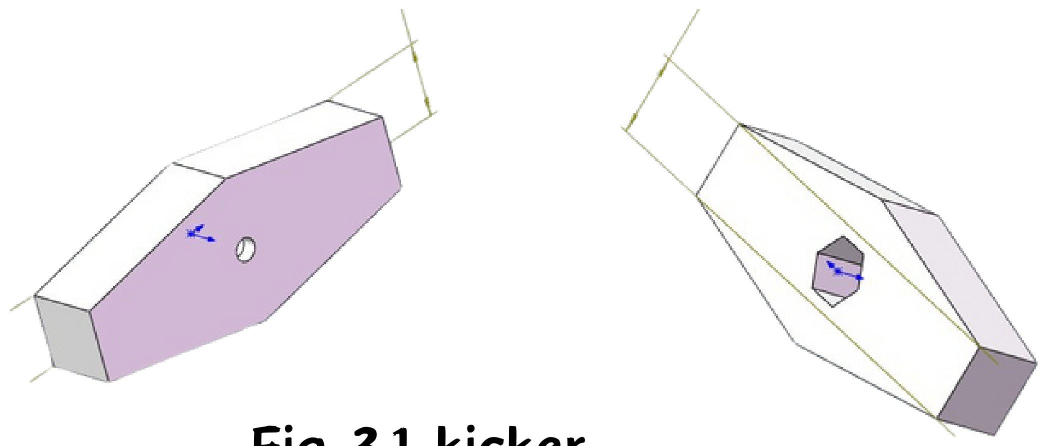

Fig.31 kicker

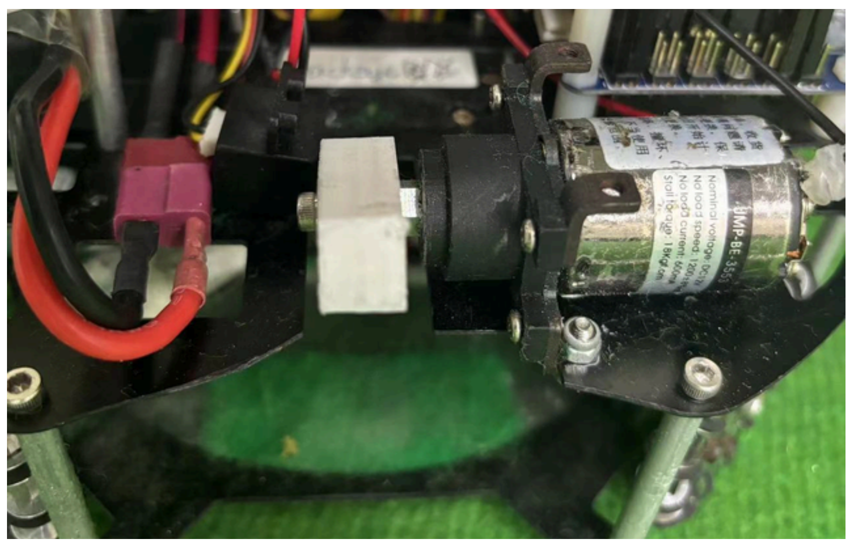

Fig.32 Motor for kick

6.Dribbling device

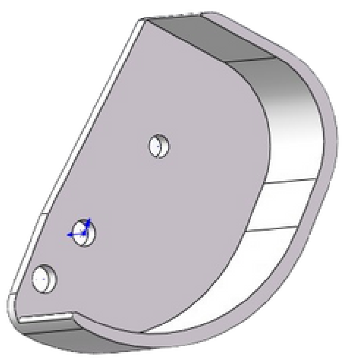

Fig.33 Fixers on both sides of the dribbling device

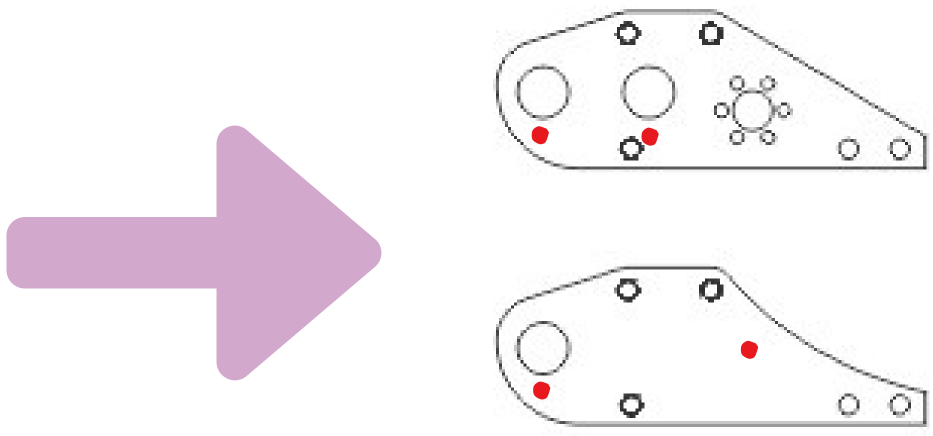

Fig.34 3D board for dribbling device

The points marked with a red pen will add bearings to make the ball rolling device rotate more smoothly.

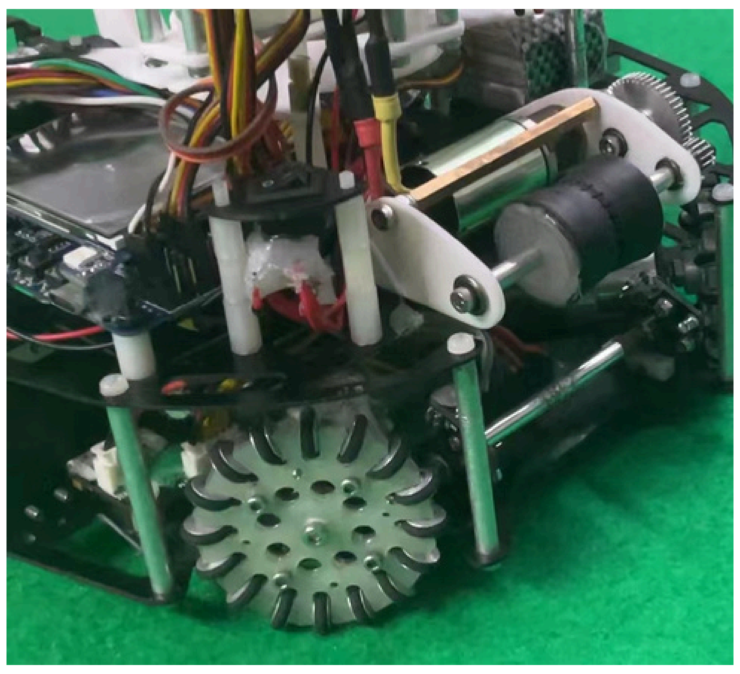

Fig.35 dribbling device final

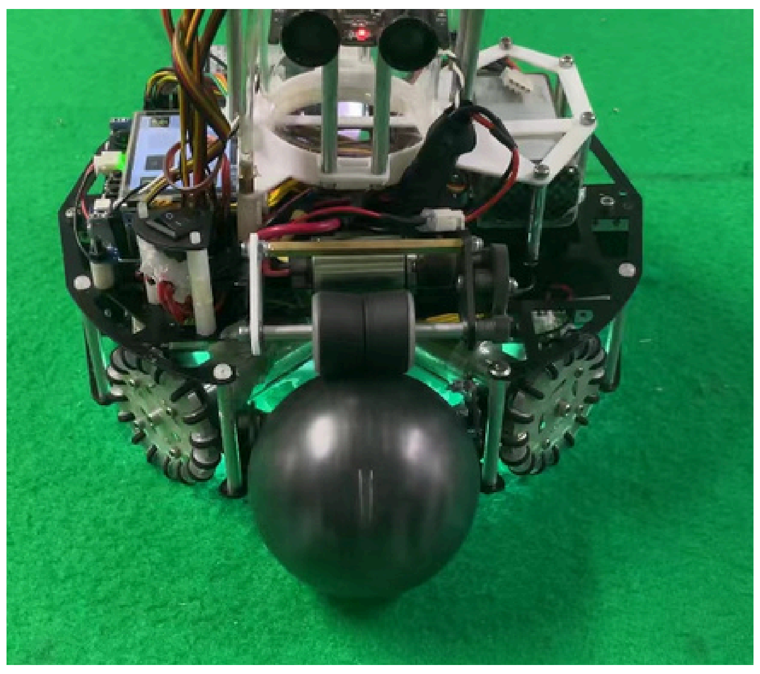

Fig.36 dribbling device front view

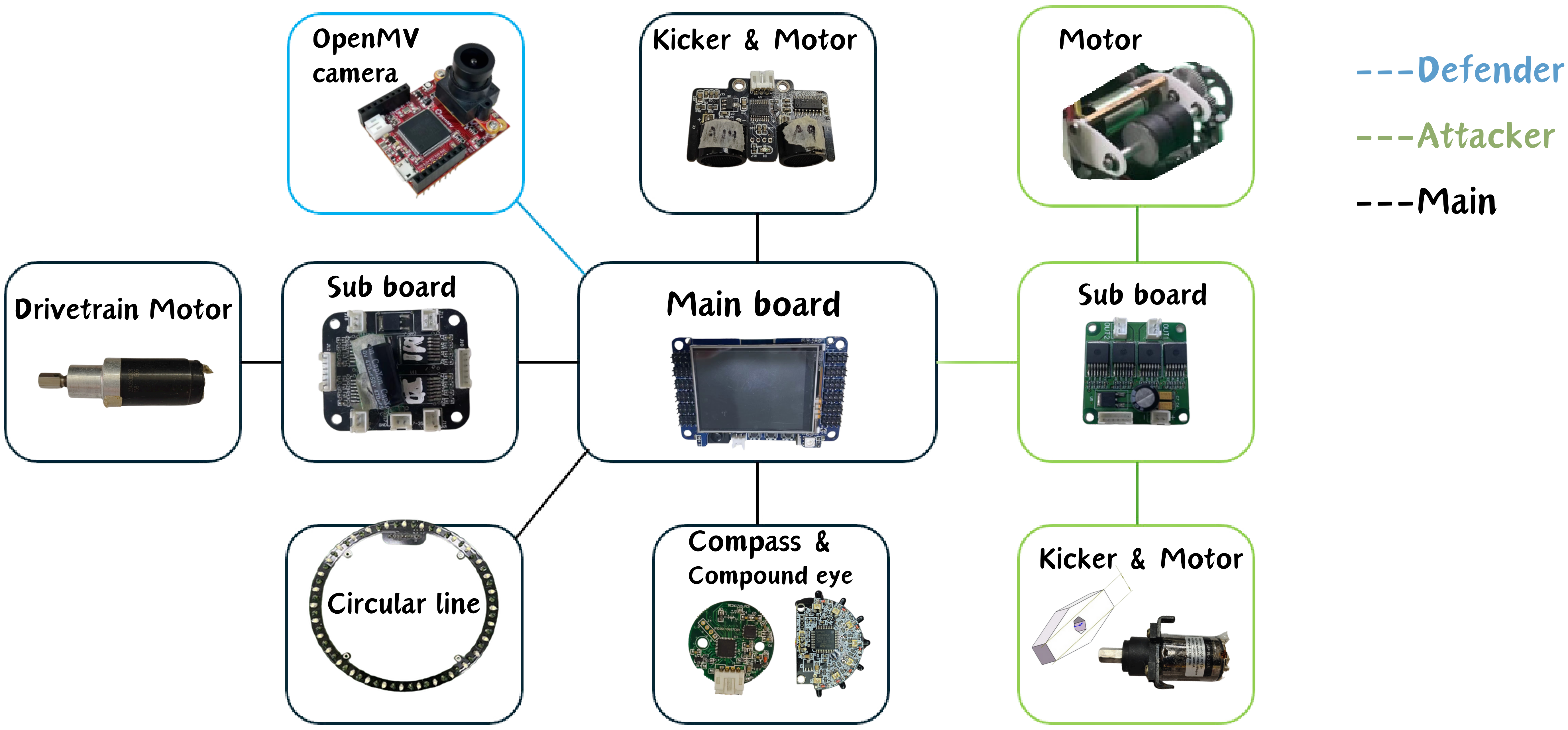

Fig.37 System sketch

software

1.SoftWare used

We use C++ for progressive programming. OpenMV is the development environment required to merge color tracking software.

Fig.38 OpenMV Fig.39 C++

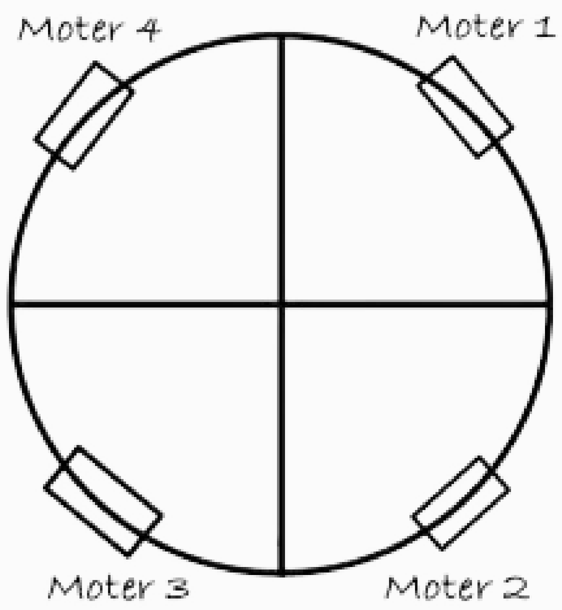

Fig.40 Motor location

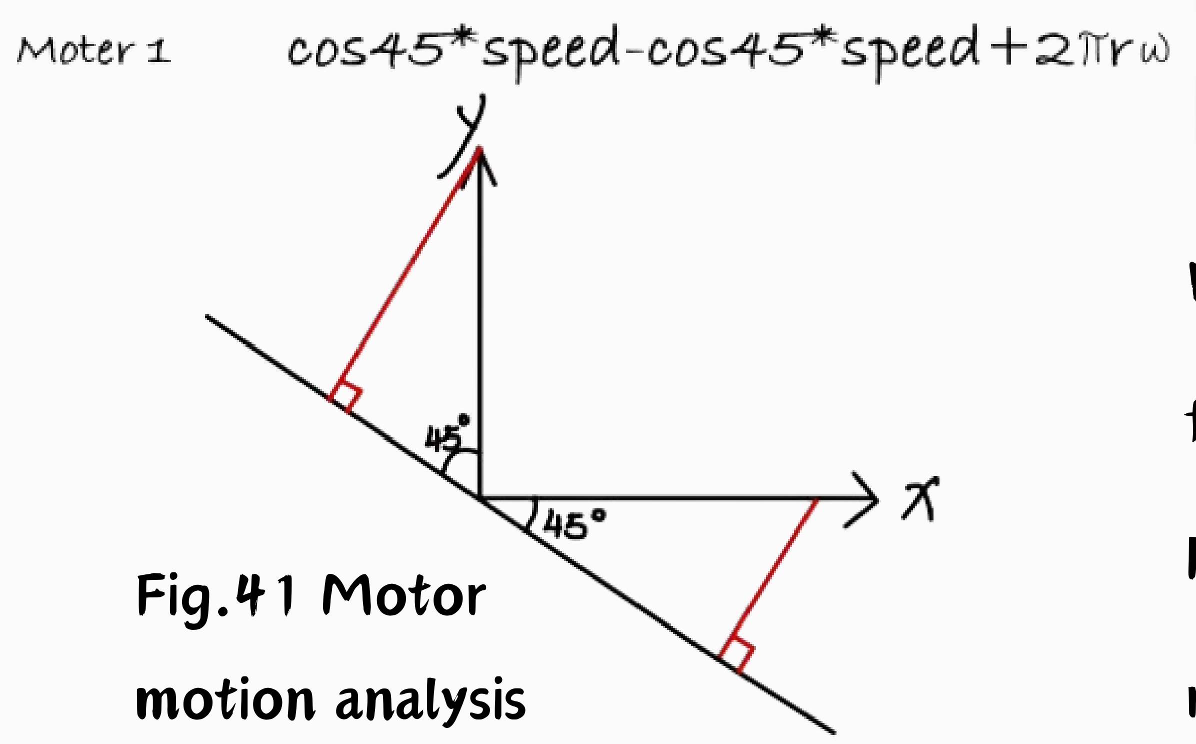

Fig.41 Motor motion analysis

We used the trigonometric functions we learned to design a kinematic equation to make our robot move.

2.Motion around the ball

in order to achieve approximate tangential motion, we write a functional relationship through the strength of the ball.

Left:path=fc-90*f/110;

Right:path=fc+90*f/110;

-->f:light value intensity(distance)

-->fc:light value angle

-->110: light value intensity maximum

the logic of the whole equation is mainly to use the light value intensity percentage to control the size of the tangent line, the greater the distance, the smaller the tangent line, the more like a straight line; and vice versa.

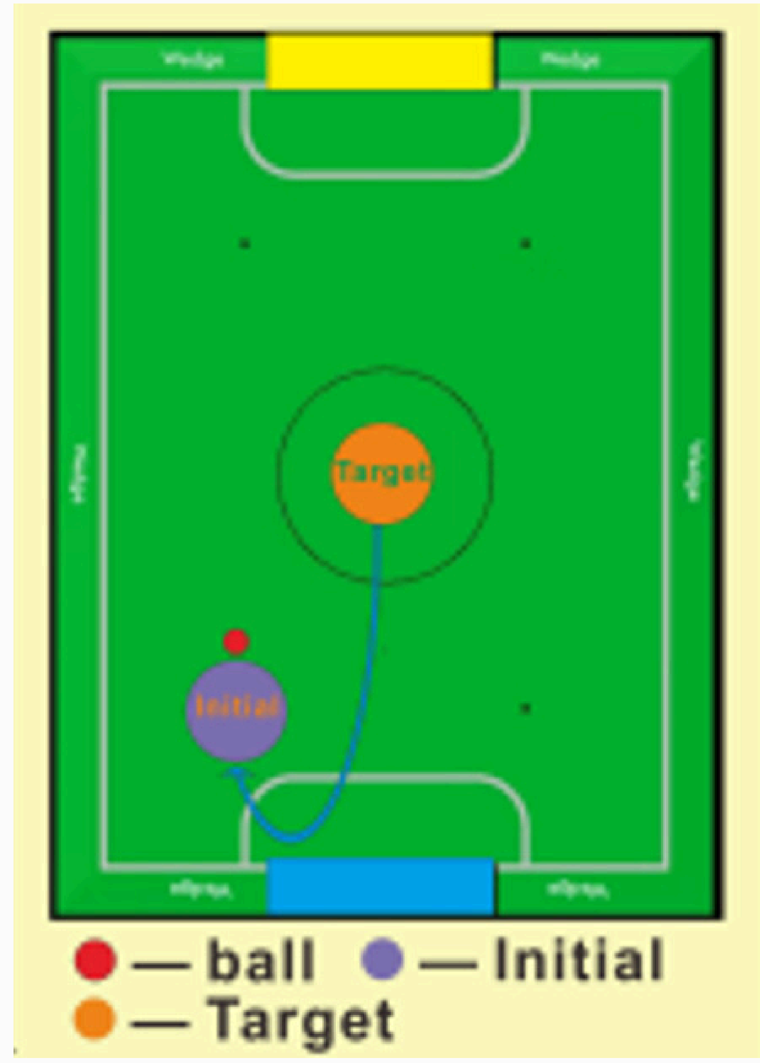

Fig.42 motion around the ball

3.Back to initial postition

goal:know where robots are on the court, and be able to return quickly in certain situations. The data we want to know: the distance between the machine and the target point, the kangle of the target point relative to the machine(angle)

1. we establish a plan Cartesian coordinate system,the angle is the origin and the value dreturned by ultrasonic sensor is used as the distance.
2. define the abscissa and ordinate pf the target point, the obtain the abscissa and ordinate og the machine through the ultrasonic sensor, subtract the abscissa and ordinate of the machine and the target point to obtain (as shown in the figure)
3. use dx and dy through the Pythagorean the orem to find the hypotenuse(distance) when calling the atan2 function, find the angle of the target point relative to the machine(angle)
4. set the motion direction to anglr and judging the value of distanced to relized to the reset function.

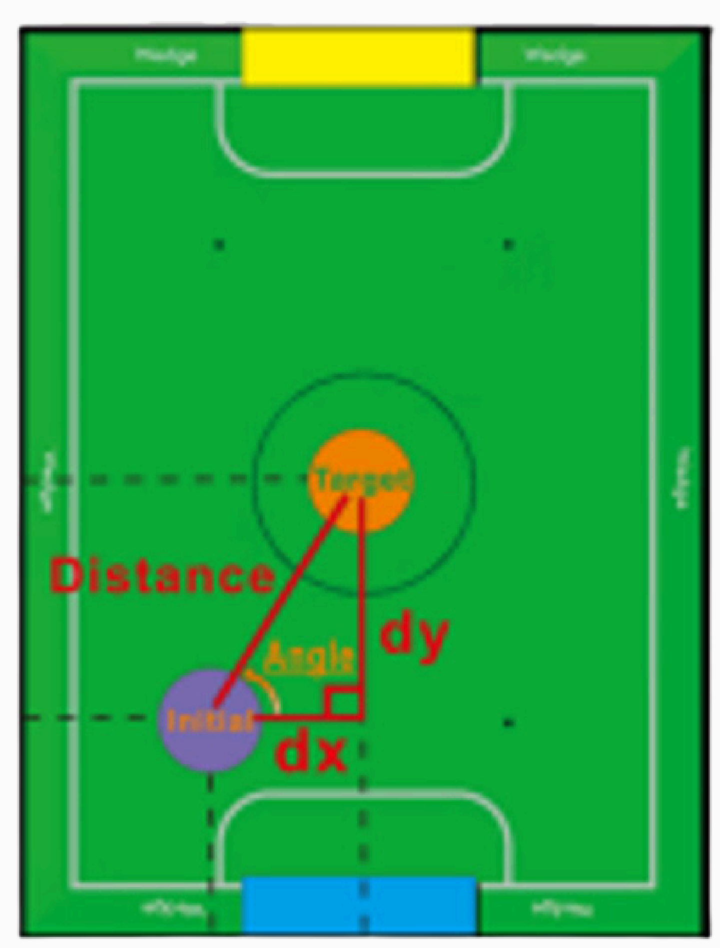

Fig.43 back to initial postition

4.Application of ultrasound

We use ultrasonic ranging to know the position of the robot on the field. We use ultrasound to know the position of the robot on the field, and to complete the locking of the robot at the beginning of the course so that the front of the robot stays oriented as it moves.

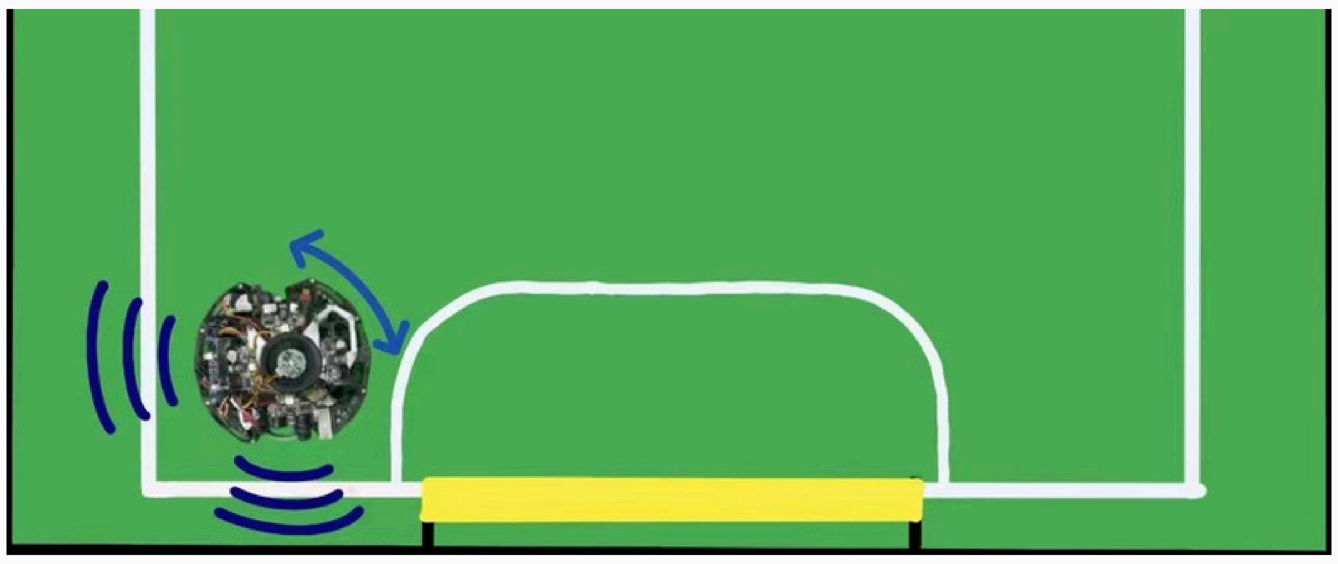

Fig.44 Ultrasonic lock

We also use ultrasound to divide the field into four zones so that we can better determine the approximate position of the robot on the field.

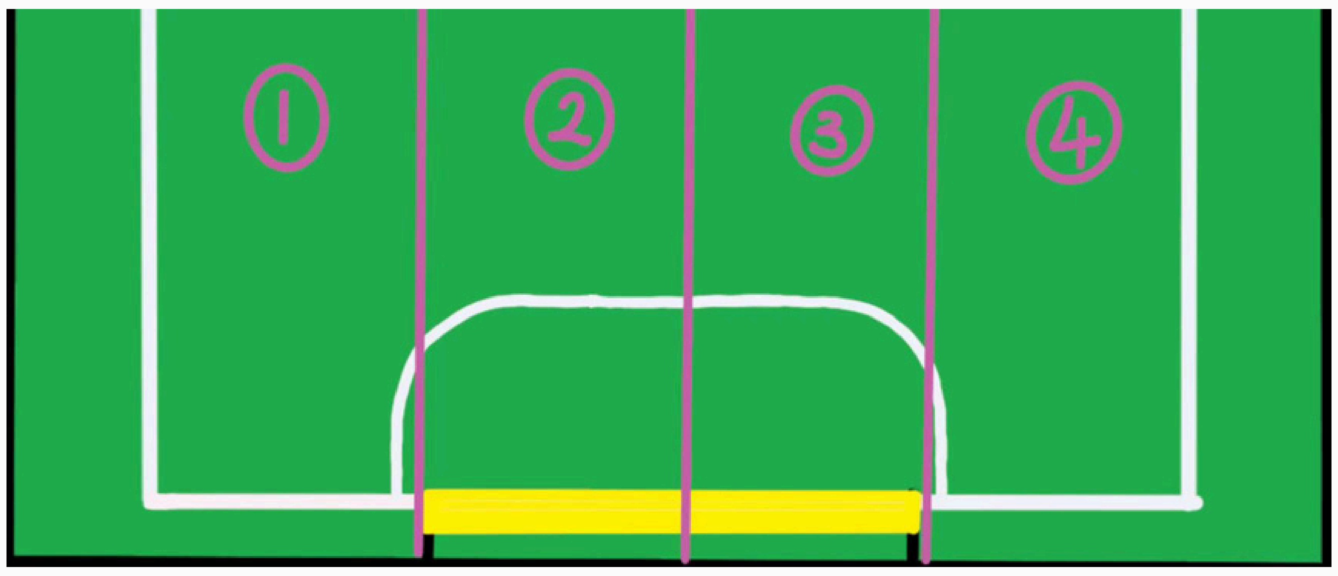

Fig.45 Partition

5.Application of camera

Our camera software combines very accurate positioning of the ball and goal with low latency and high refresh rate. All operations on the image are done through a combination of python and OpenMV to get a repeatable and fast analysis of the surroundings. The structure of the operation is relatively simple, starting from the acquisition of the image by the camera, we only need to threshold the whole image using a calibration sphere and a range around the target color. This makes it easier to reposition the goalkeeper, which is beneficial when using superteam.

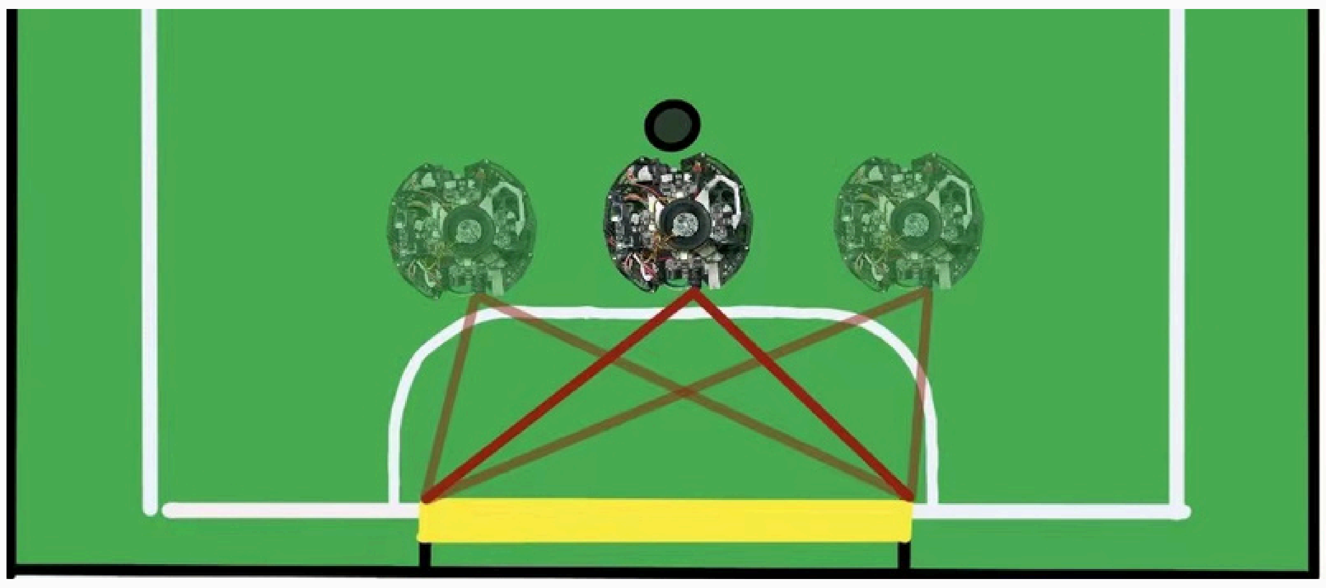

Fig.46 Using lens reset

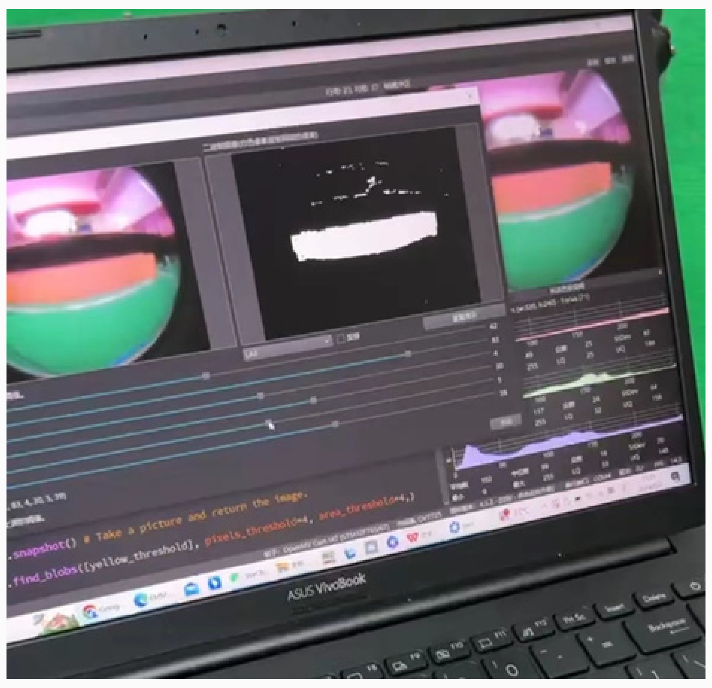

Fig.47 OpenMV

Fig.48 Python

STRATEGY

We once used two attacking machines which led to a clash during the attack. So our strategy is to use one attack machine and one defense machine. The attacking machine is equipped with a kicker and a puck so that we can shoot better. The defense machine is equipped with camera for better defense.

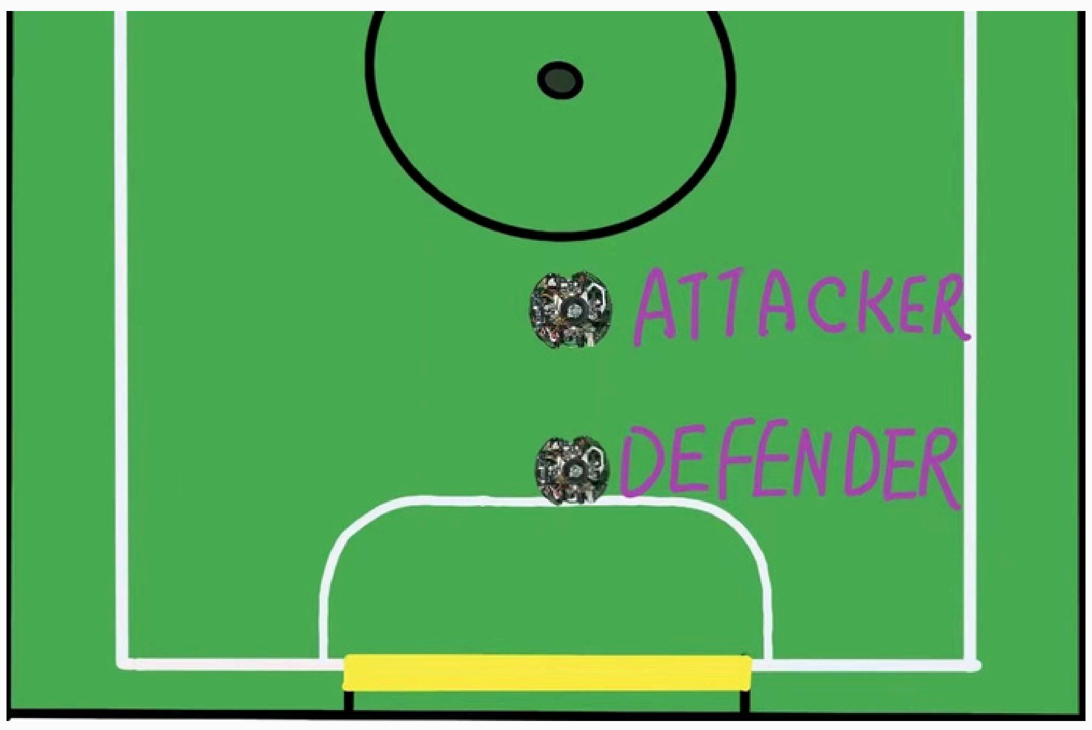

Fig.49 ATTACKER & DEFENDER

Conclusions and Future Work

1.What we learned

At RoboCup Junior, we have acquired extensive knowledge in robotics technology. Engaging in communication and competitive events has facilitated interactions with diverse individuals and methodologies, resulting in invaluable experiences. We extend our gratitude to the RoboCup Junior conference for providing us with a platform to share ideas and insights.

In summary, our project has provided us with invaluable experience in electronics, design, planning, management, coding, and various other domains. We aim to leverage these experiences in our future endeavors, furthering our knowledge in robotics and aiming to engage in soccer competitions in the coming years.

Fig.50 our pictures

2.What we would like to try in the future

In our future strategy, we plan to introduce a transition system between the goalie and strikers to enhance our goal-scoring potential and fortify our defense. The transition from goalie to striker will be initiated when the goalie is in possession of the ball, allowing the goalie to capitalize on scoring opportunities instead of solely clearing the ball. Conversely, the striker-to-goalie transition will be activated when the goalie is involved in offensive plays or is out of position, ensuring defensive coverage near the goal.

These tactical adjustments will necessitate the use of Bluetooth communication technology to facilitate seamless coordination among players. Furthermore, specialized training sessions will be conducted to equip players with the skills required to switch between roles smoothly, maintaining performance levels. By implementing these strategies, we aim to optimize our offensive prowess and bolster our defensive capabilities, rendering our team more adaptable and unpredictable on the field.

This innovative approach is designed to elevate our team's competitiveness and effectiveness during matches. Moving forward, a continuous cycle of feedback and fine-tuning will be imperative to refine these transitions, fostering a dynamic and harmonious team dynamic.

3. about us

https://www.youtube.com/watch?v=ptidcX02Efc

https://www.youtube.com/watch?v=SQ8_HQIhk1k

https://www.youtube.com/watch?v=VWlx7gAgrks

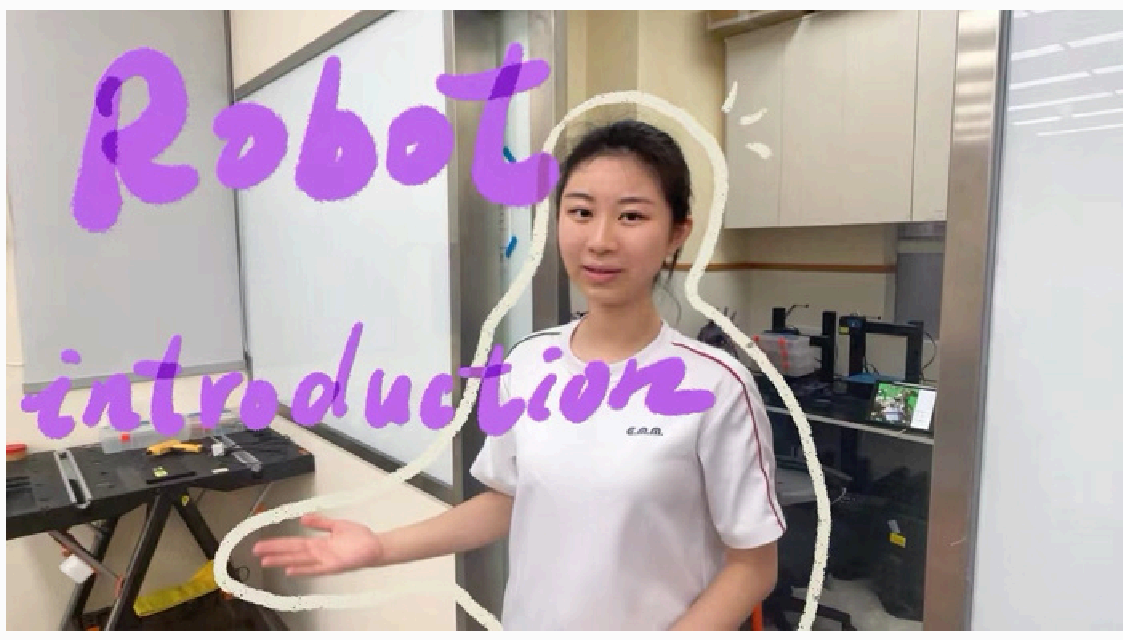

Fig.51 YouTube video

References

https://www.robocup.org/

https://docs.openmv.io/reference/constrained.html

https://www.softbankrobotics.com.cn/en/mediumArticle/detail/304.html

http://robocup.drct-caa.org.cn/index.php/category/view?id=1009

http://caa.org.cn/Content/33.html

https://2024.robocup.org/