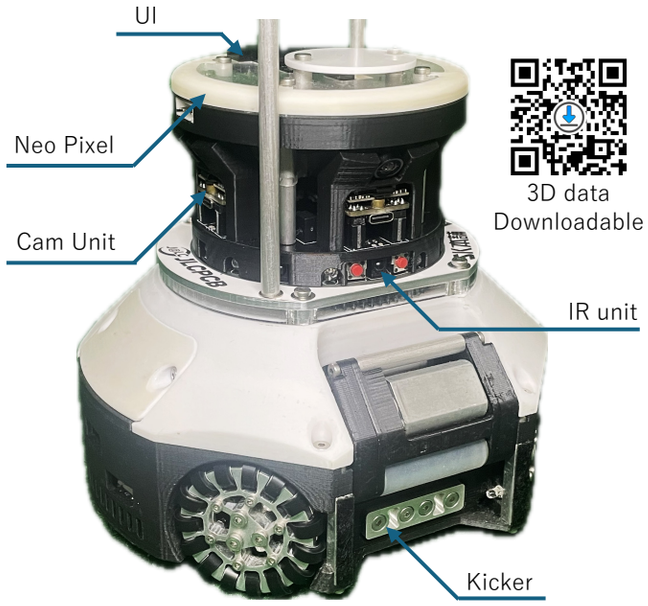
Crescent(Re)

League: Soccer Open
Country: JAPAN
日本

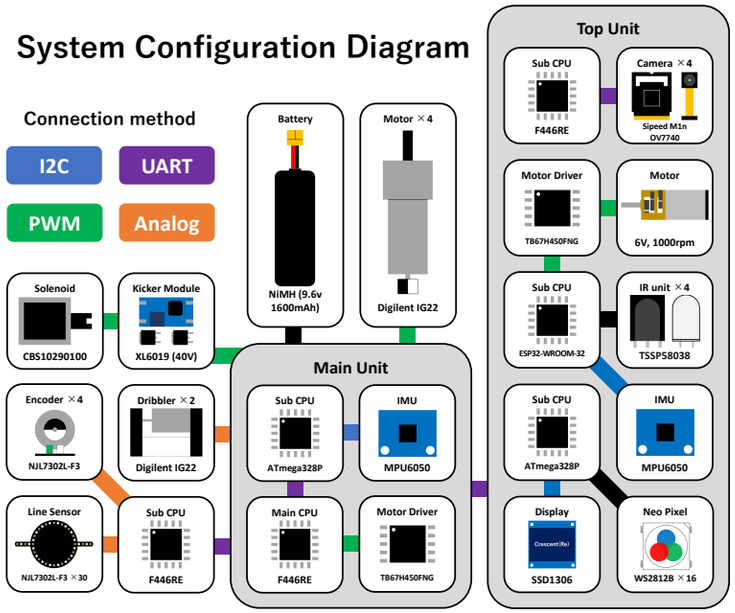
Supported by

X@Takumi X@Yuki Notion site YouTube



3D data Downloadable

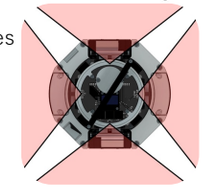
System Configuration Diagram

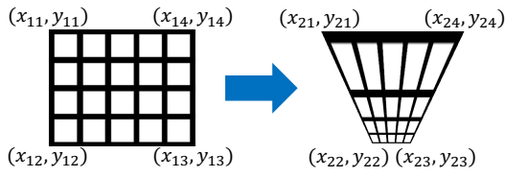


Vision system

-Four eyes to find the ball-

With conventional hyperbolic mirrors, it was difficult to recognize small golf balls placed on opposite corners of the court. Therefore, Sipeed M1n camera modules were installed in all four directions of the robot. This module uses the K210 processor, which is extremely high-performance and cost-effective. It can easily recognize a golf ball at a distance of more than 2 meters from the robot. The coordinates viewed from each camera are transformed using a homographic transformation matrix to derive the coordinates of the ball with the robot as the origin on the court. The calculation process is shown below.





The transformation from the vertices (x_1, y_1) of quadrangle 1 to the vertices (x_2, y_2) of quadrangle 2 can be represented by a perspective projection as shown below.

$$\begin{pmatrix} x_2 \\ x_2 \end{pmatrix} = \begin{pmatrix} \hat{x}_2/\hat{w}_2 \\ \hat{y}_2/\hat{w}_2 \end{pmatrix}$$

$$\begin{pmatrix} \hat{x}_2 \\ \hat{y}_2 \\ \hat{w}_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & 1 \end{pmatrix} \begin{pmatrix} x_1 \\ y_1 \\ 1 \end{pmatrix}$$

The process of finding the elements of the perspective projection matrix below is omitted.

$$\begin{pmatrix} h_{11} \\ h_{12} \\ h_{13} \\ h_{21} \\ h_{22} \\ h_{23} \\ h_{31} \\ h_{32} \end{pmatrix} = \begin{pmatrix} x_{11} & y_{11} & 0 & 0 & 0 & 0 & -x_{11}x_{21} & -y_{11}x_{21} \\ 0 & 0 & 1 & x_{11} & y_{11} & 1 & -x_{11}y_{21} & -y_{11}y_{21} \\ x_{12} & y_{12} & 0 & 0 & 0 & 0 & -x_{12}x_{22} & -y_{12}x_{22} \\ 0 & 0 & 1 & x_{12} & y_{12} & 1 & -x_{12}y_{22} & -y_{12}y_{22} \\ x_{13} & y_{13} & 0 & 0 & 0 & 0 & -x_{13}x_{23} & -y_{13}x_{23} \\ 0 & 0 & 1 & x_{13} & y_{13} & 1 & -x_{13}y_{23} & -y_{13}y_{23} \\ x_{14} & y_{14} & 0 & 0 & 0 & 0 & -x_{14}x_{24} & -y_{14}x_{24} \\ 0 & 0 & 1 & x_{14} & y_{14} & 1 & -x_{14}y_{24} & -y_{14}y_{24} \end{pmatrix}^{-1} \begin{pmatrix} x_{11} \\ y_{12} \\ x_{22} \\ y_{22} \\ x_{23} \\ y_{23} \\ x_{24} \\ y_{24} \end{pmatrix}$$

Based on the obtained parameters, the following perspective projection matrix is obtained.

$$\begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & 1 \end{pmatrix}$$

Abstract

We are a team Crescent(Re) from Japan. We formed our team in a club activity called Sci-Tech club at Ritsumeikan Moriyama High School, and from April 2024, both of us are continuing to develop our robot at Ritsumeikan University. This is the first year we have participated in the Soccer Open League. Our goal of this competition is to make fine plays. We will make the audience excited.

Takumi Bamba(18)
馬場 拓海
Captain, Hardware, Software

Yuki Nakahigashi(19)
中東 祐樹
Camera, SNS management

Pasts results

-2023 Japan Open-
- 4th Prize
- Best Design Award

-2024 Japan Open-
- 1st Prize
- Best Presentation Award
- Sponsor Award

Development environment

Hardware

Software

Communication

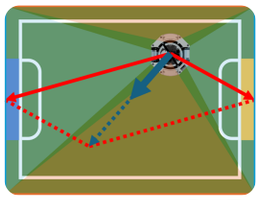
Machine

3DP (FDM)	3DP (SLA)
-Creator3 Pro	-Sonic Mini
-Adventure4	-Saturn3
-Ender5 S1	CNC milling
-i3 Mega	-KitMill CL200

Self-location estimation

-Camera unit is possible to rotate

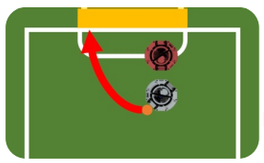
Although it is more optimal to mount a LiDAR for self-position estimation, it will save space and weight if self-position estimation can be done with only a camera. The information obtained from the camera about the position of the boundary line between the green court and the black wall and the position of the goal are integrated to estimate the robot's position within the court. To perform these calculations in a stable manner, the camera unit should always be facing the same direction. For this purpose, we have installed a mechanism that allows the camera unit to rotate. For this purpose, I made a bearing with a diameter of 80mm using a 3D printer and a stainless steel ball with a diameter of 5mm.



Reference Video

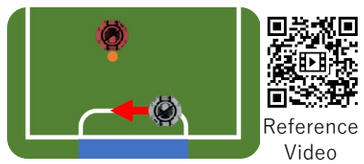
Strategy and algorithm

-Offence-



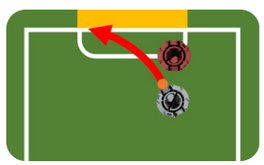
Reference Video

Back-dribble the ball and move along the wall to the front of the enemy keeper while hiding the ball to make a counter-shot.



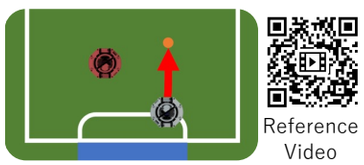
Reference Video

Line tracing in front of the goal at high speed to ensure the goal is protected. At the goal edge, back down from the corner of the court.



Reference Video

By rotating and kicking while moving sideways, the ball shoots a curved trajectory that is sucked into an open area of the goal.



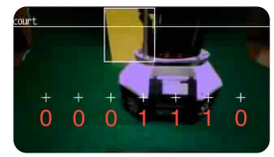
Reference Video

When a certain amount of time elapses with the ball in front of it, it quickly kicks the ball toward the enemy goal.

Obstacle recognition

-Avoid the enemy-

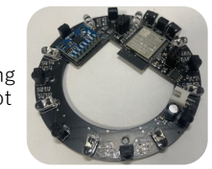
Obstacles are recognized using only a camera. As shown in the photo, multiple cross points are placed horizontally 20 cm in front of the robot, and obstacles are recognized based on whether the points are green. By placing points vertically as well as horizontally, the distance to the obstacle can be measured. It is simpler and faster than machine learning using Yolo and other methods.



Position estimation the robots

-Path the ball to robot-

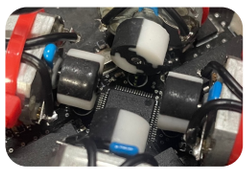
IRLED and IR receivers are mounted in four directions. Using the same principle as determining the position of an infrared ball in lightweight leagues, the angle and distance of a friendly robot can be estimated. The information from these sensors is used to facilitate passing between friendly robots.

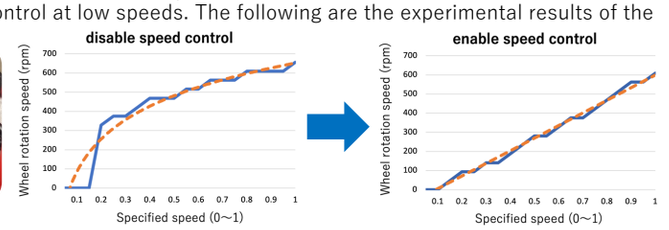


Encoder

-The Age of Speed Control-

Each of the four drive motors is equipped with an encoder that reads the speed of rotation. The motors can be turned at a constant speed even under load. It also allows stable control at low speeds. The following are the experimental results of the difference in the number of wheel rotations with and without speed control using the encoder. It can be confirmed that with speed control, the number of wheel rotations is linear.





Urethane Omni-wheel

-Ultimate grip and durability-

Conventional omni-wheels using silicone rubber wear out quickly and require periodic replacement. We have therefore developed an omni-wheel made of ester urethane rubber (A70), which is more abrasion resistant. Since it hardly wears out, the gripping power remains the same, and periodic replacement of side wheels is no longer necessary.

Double-Dribbler

-Manipulate the ball at will-

It has two dribblers, one on the front and one on the back. The white line around the goal area increases the difficulty of getting around to the neutral point on its own goal side. The ball behind the robot is supplemented by the dribblers behind it, which greatly reduces the time required to go around the ball. In addition, the robot can receive passes from the keeper while facing forward.