P18 Intelligent Motion Control

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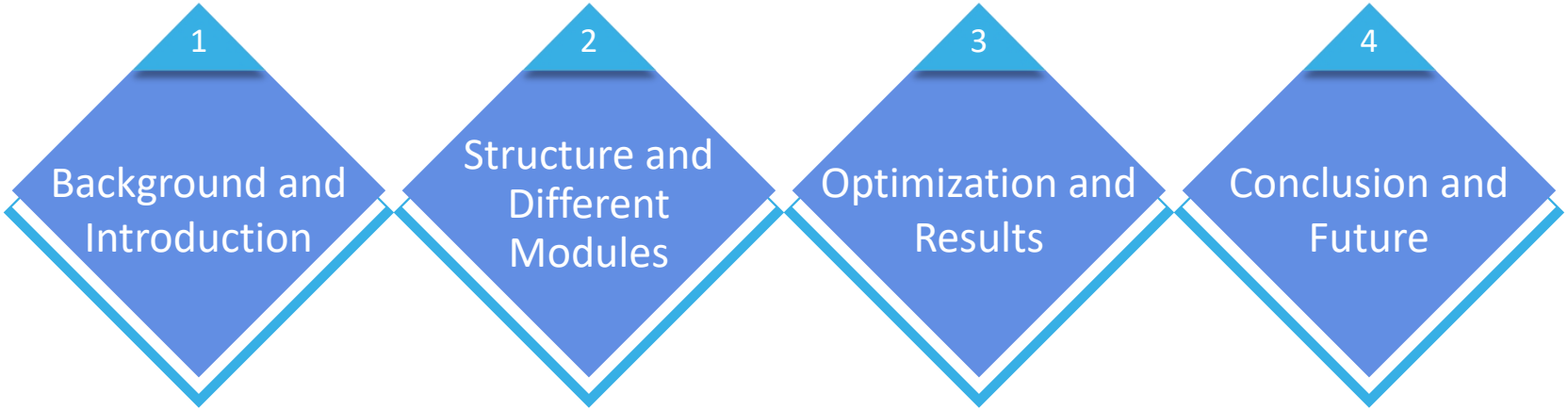
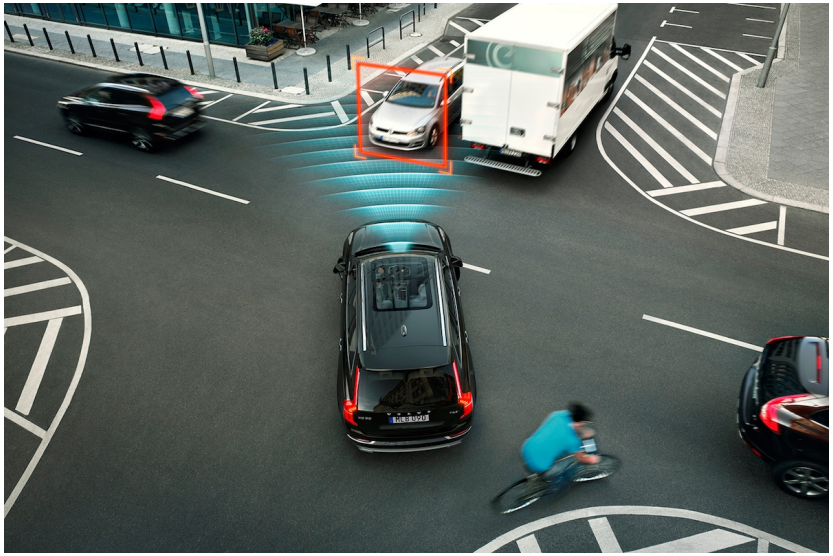
Content


1
Background and Introduction
2
Structure and Different Modules
3
Optimization and Results
4
Conclusion and Future

Background



Autonomous driving, also known as driverless, computerized driving or wheeled mobile robots, is a cutting-edge technology that relies on computer and artificial intelligence technology to accomplish complete, safe and efficient driving without human manipulation.

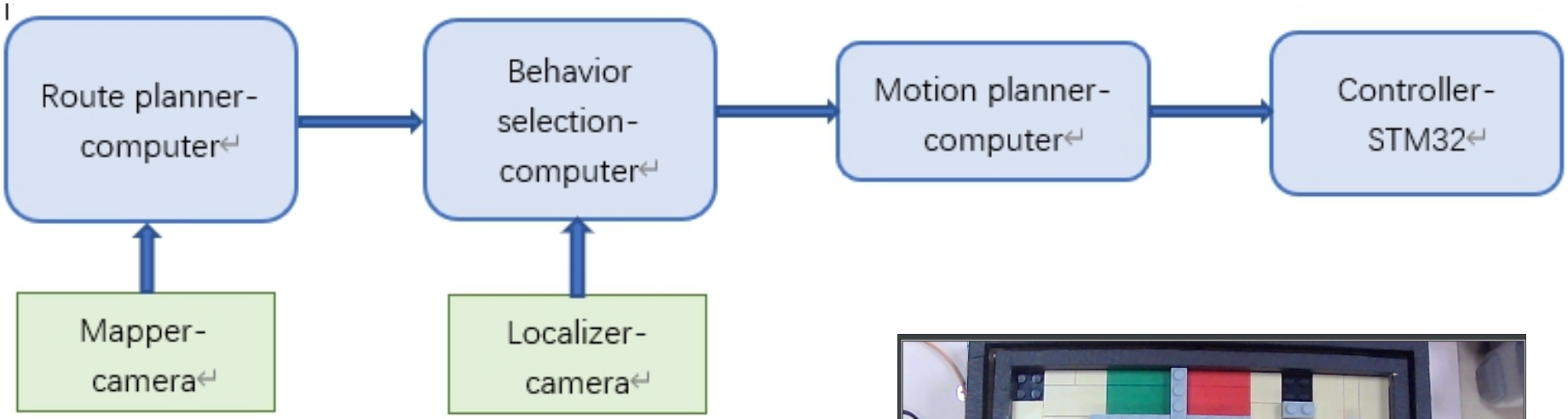
Background

Lego Maze features a customizable maze system, wheel-operated tilt mechanism built-in removable ball container with four orange balls.

This project can be seen as a simple, small autopilot simulation system

Structure and Mechanical Unit

Structure and Mechanical Unit



The picture taken by the camera.

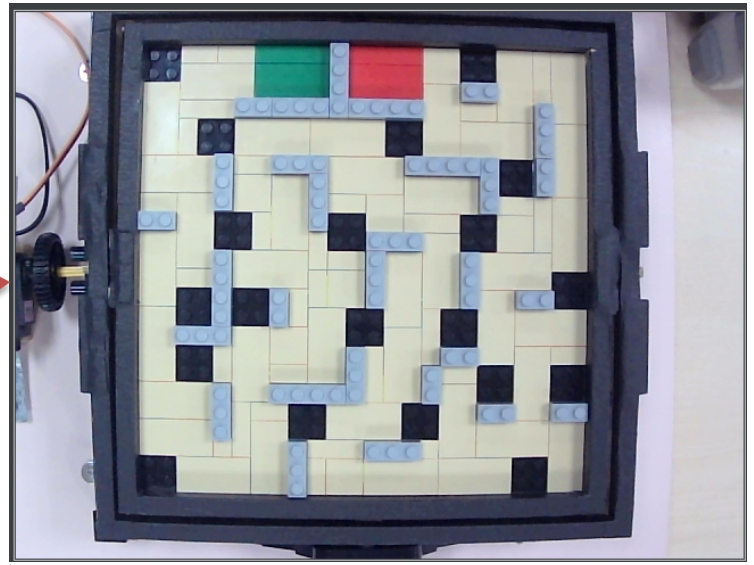
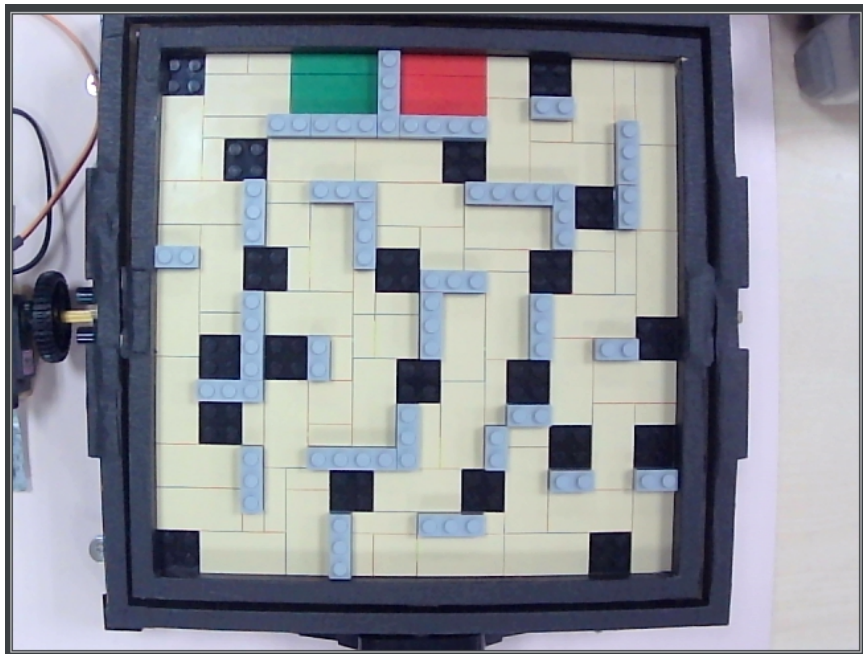
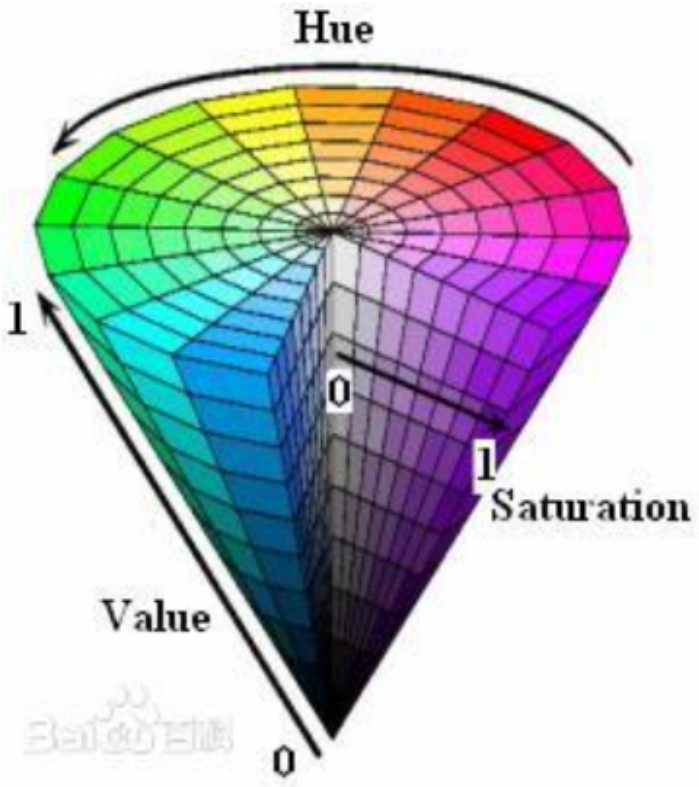


Image Processing

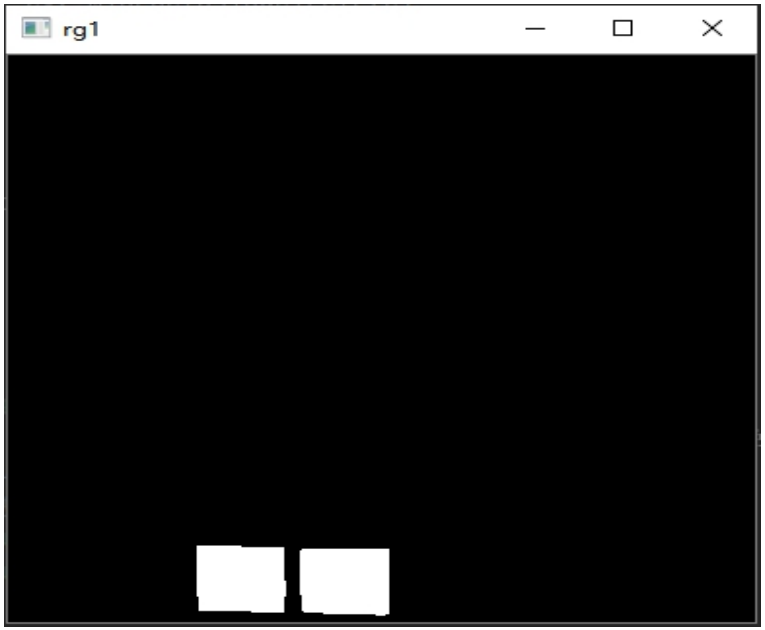




HSV color model

Image Processing

Extract start point and end point.

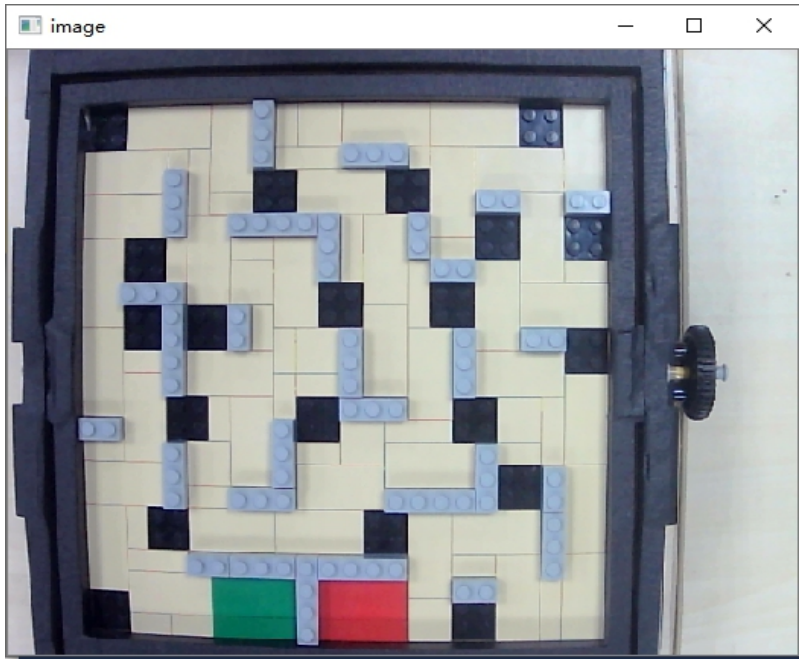


Extract pathway parts.

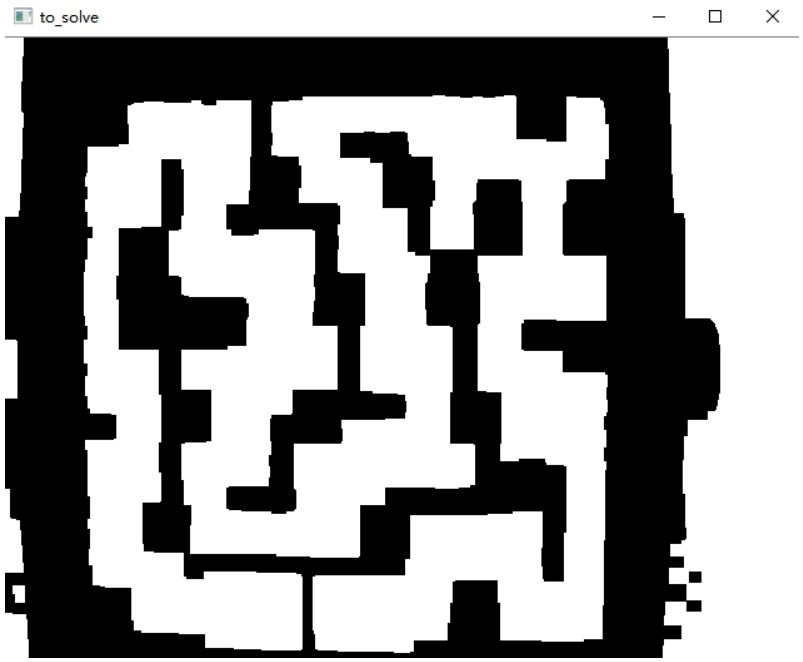
“Add” these two parts to get the final passable area on the board.

Image Processing

The original picture taken by the camera.



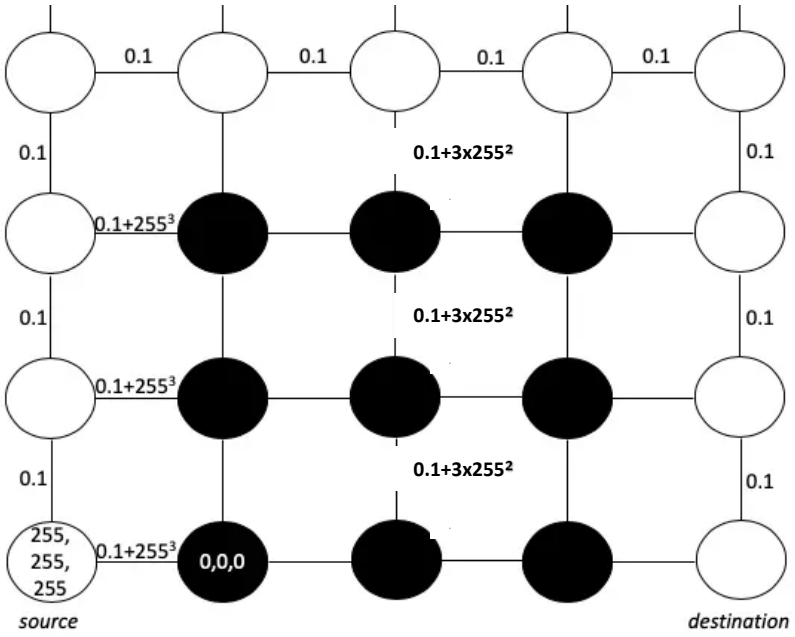
The image after image processing.



Maze Solving

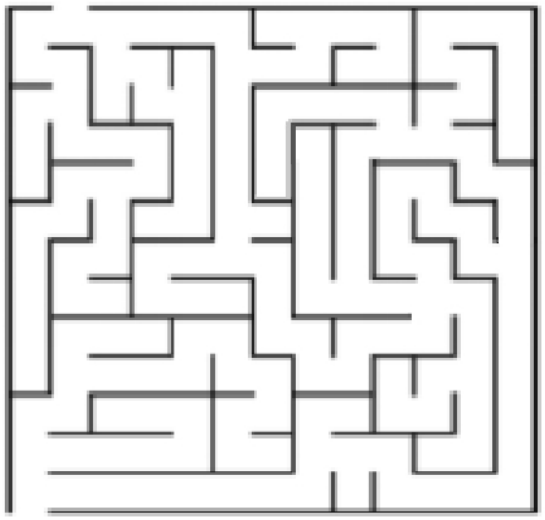
Dijkstra Algorithm:
Dijkstra's algorithm is one of the most popular basic graph theory algorithms, which is used to find the shortest path between nodes.

$$distance = 0.1 + (R_2 - R_1)^2 + (G_2 - G_1)^2 + (B_2 - B_1)^2$$

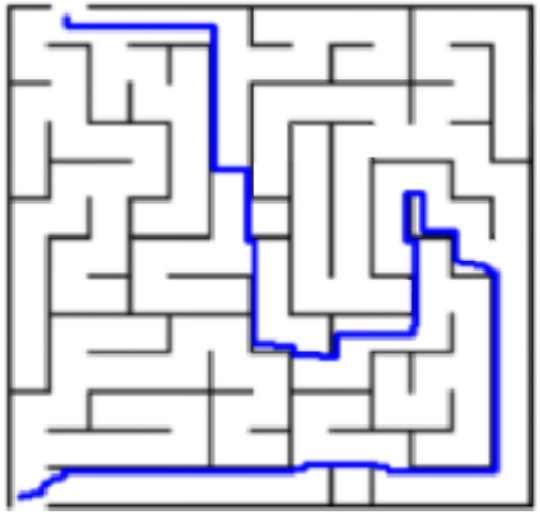


Maze Solving

Test result: With this algorithm we can get the shortest path to solve the maze and this process takes about 10 seconds.



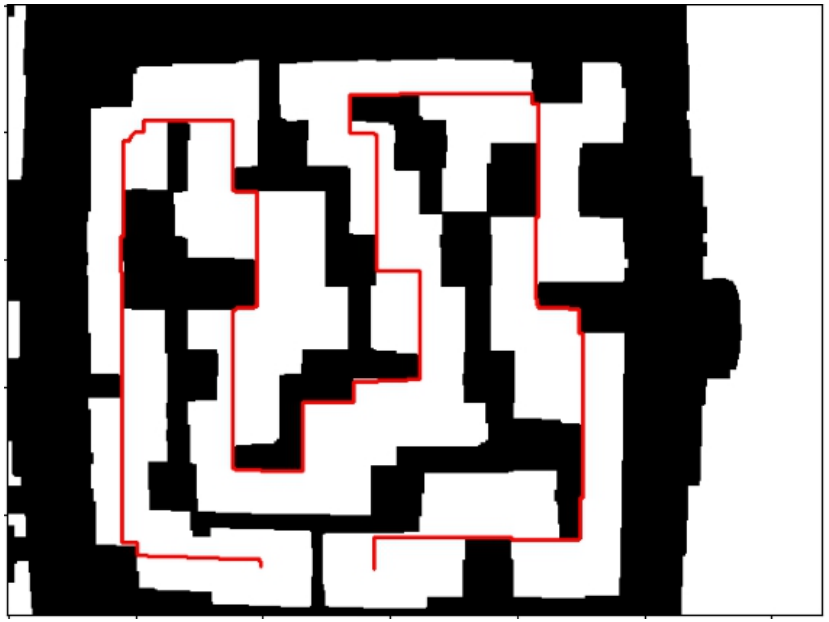
Maze for testing.

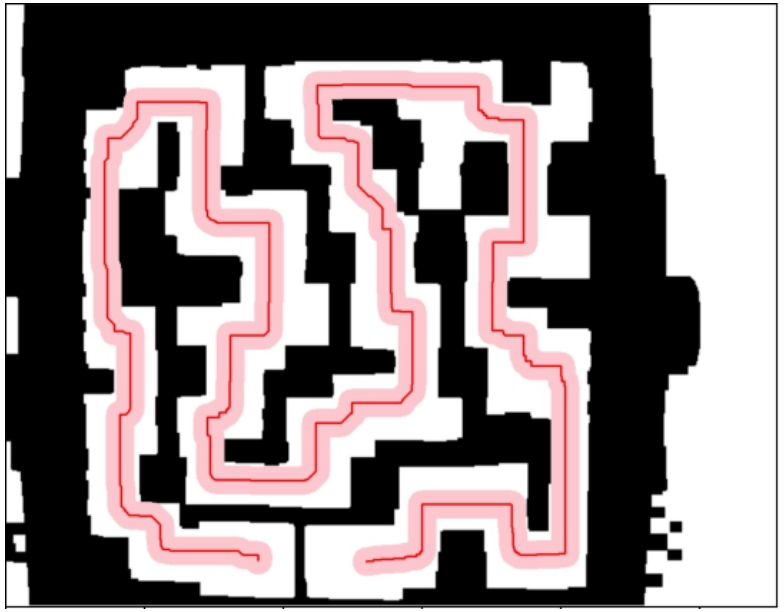


Test result.

Maze Solving

Solve the maze and draw the route on the maze:





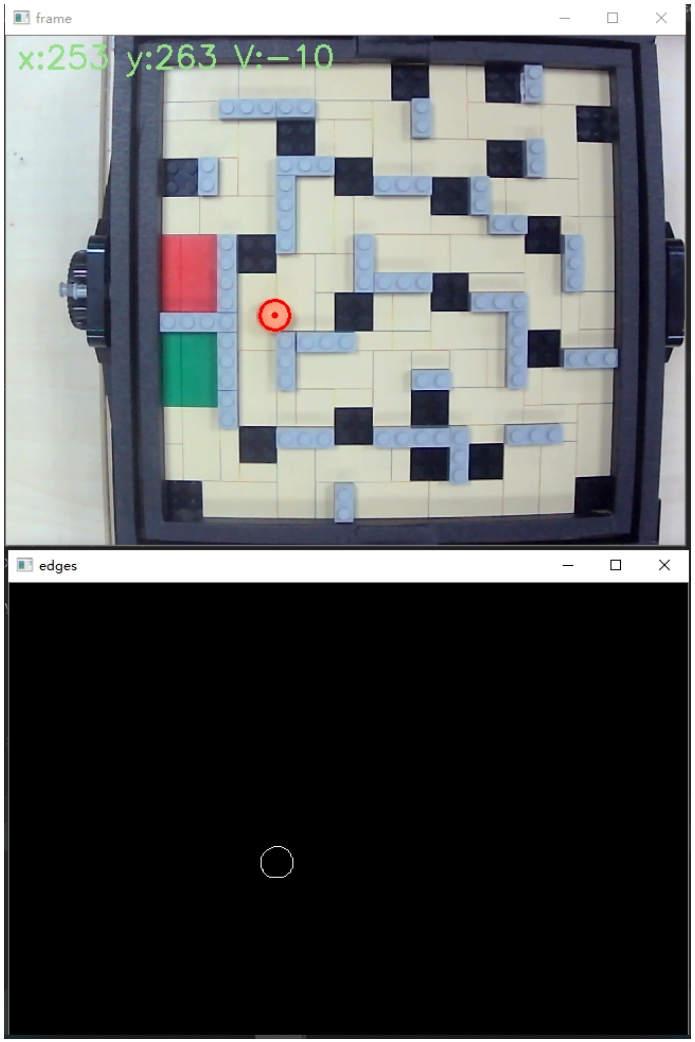
Ball Tracking

Color + Shape Detection:

Set a threshold for the color of the orange ball,convert the RGB image to GRAY :
lower_ball = np.array([0, 100, 200])
upper_ball = np.array([40, 200, 255])

Edge detection:
edges = cv2.Canny

Detect the circle and draw the center and edge:
circles = cv2.HoughCircles

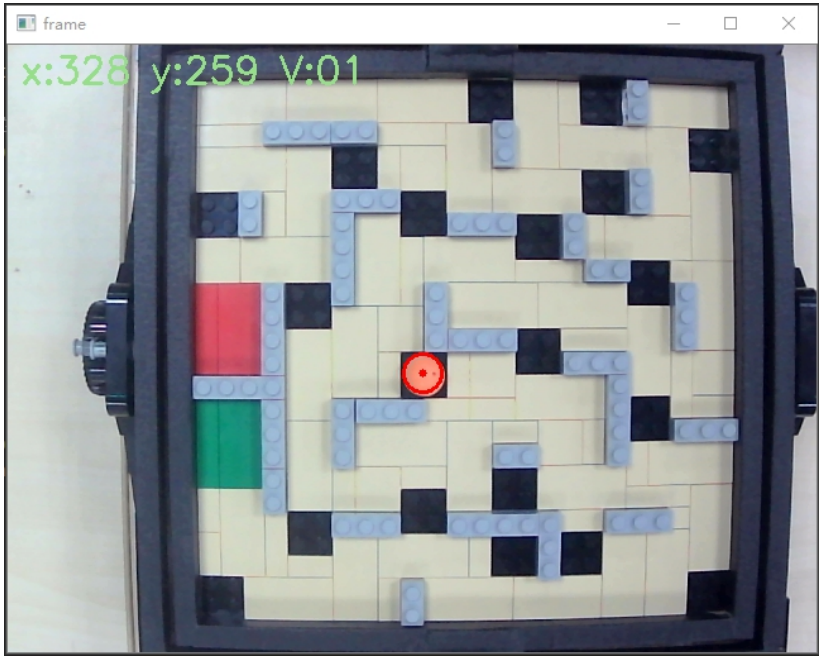


Ball Tracking

Position & Velocity:

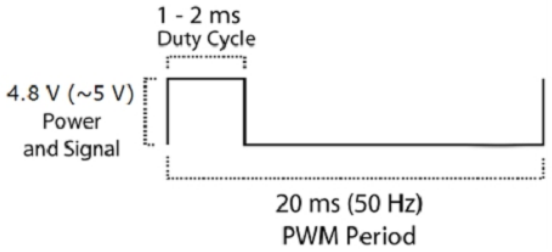
Use the center to calculate the velocity and print both of the center coordinates and the velocity on the frame.

Time interval: 15 ms.
Average speed: 7 cm/s.



Motors and Movement Control

Model: MG996R



PWM Period

Some parameters of the motor:

Operating Voltage	+5V
Current	2.5A (6V)
Operating speed	0.17 s/60°
Gear Type	Metal
Rotation	0°-180°

Motors and Movement Control

Clock Pin Assignment:

TIM1_ETR	PA12	PE7
TIM1_CH1	PA8	PE9
TIM1_CH2	PA9	PE11
TIM1_CH3	PA10	PE13
TIM1_CH4	PA11	PE14
TIM1_BKIN	PB12	PA6
TIM1_CH1N	PB13	PA7
TIM1_CH2N	PB14	PB0
TIM1_CH3N	PB15	PB1

Micro-controller: STM32

Serial communication: USART1

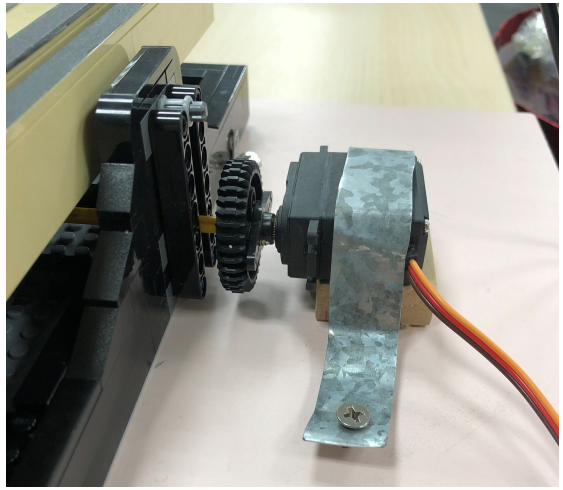
Motors and Movement Control

Use the microcontroller(output PWM) to control the rotation angle of the motors.

Through serial communication, connecting the computer and MCU, the motors can rotate properly.

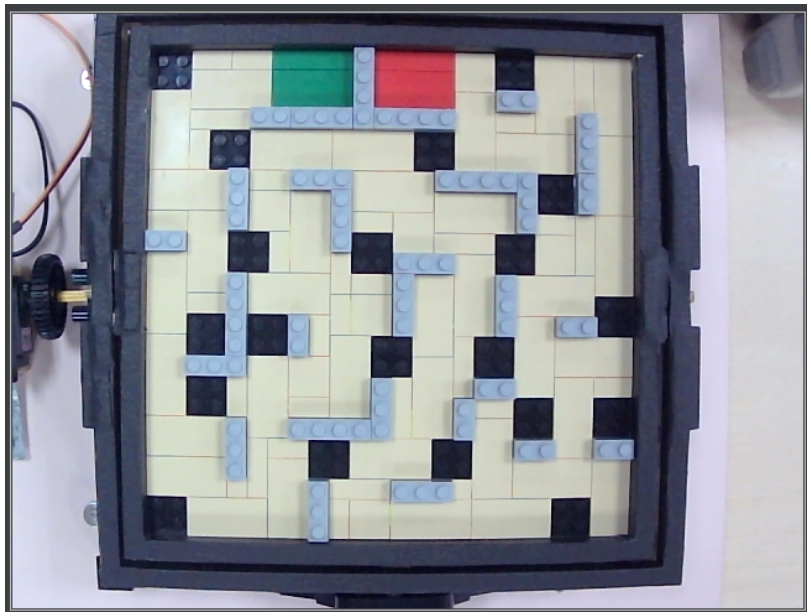
Use nails, iron sheets... to mount the motors on the wheels.

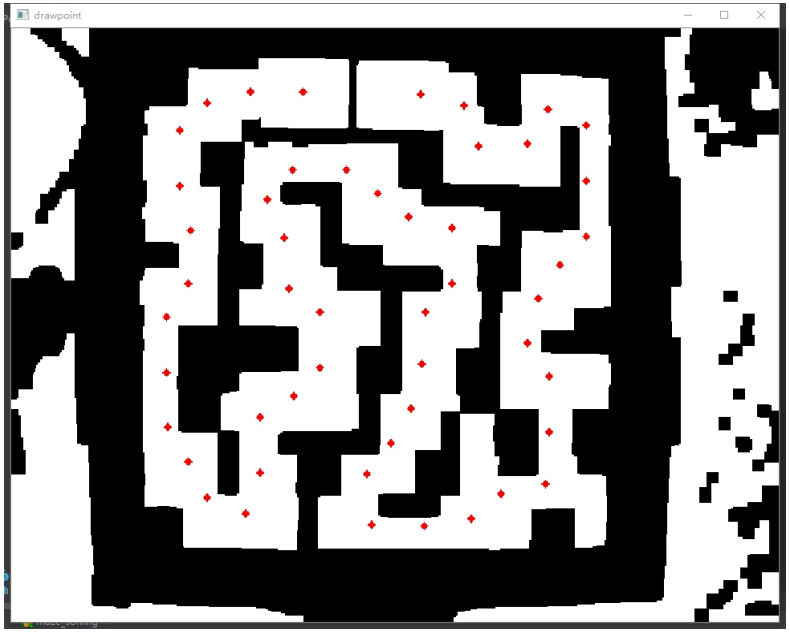
```python
import serial

# 连接串口
serial = serial.Serial('COM2', 115200, timeout=2)
if serial.isOpen():
    print('串口已打开')
```



Motors and Movement Control

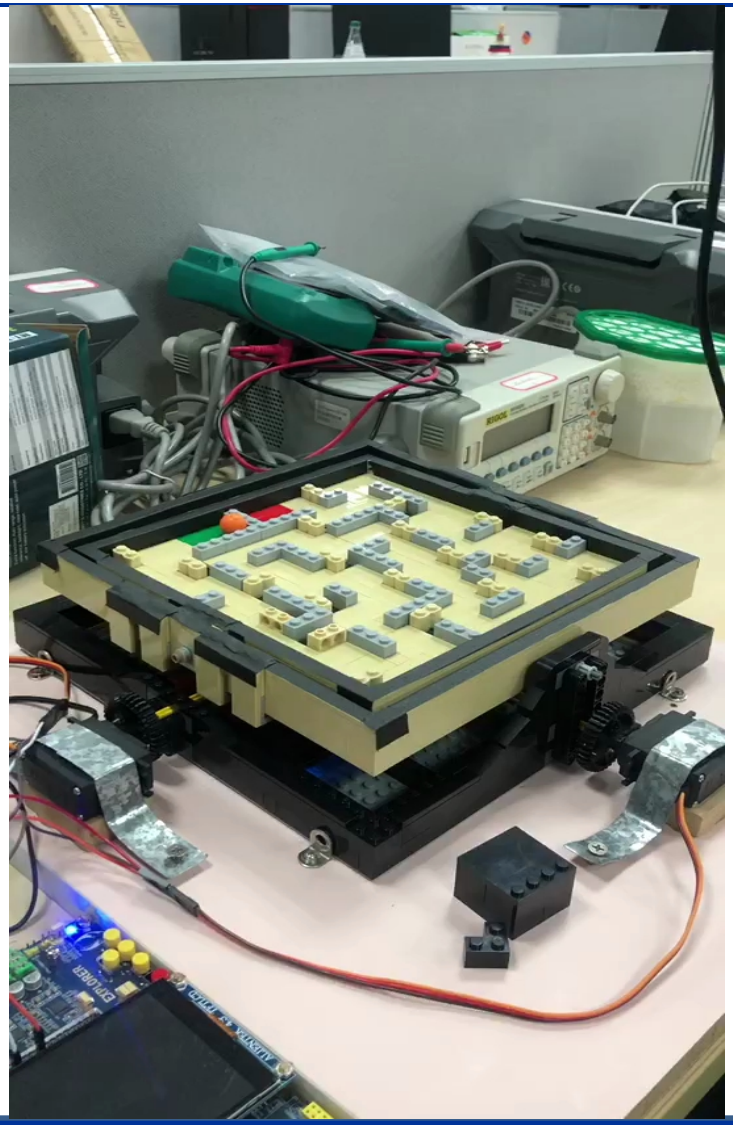
Take the points at equal intervals (diameter of the ball), to make the ball move along the route.





Optimization and Results

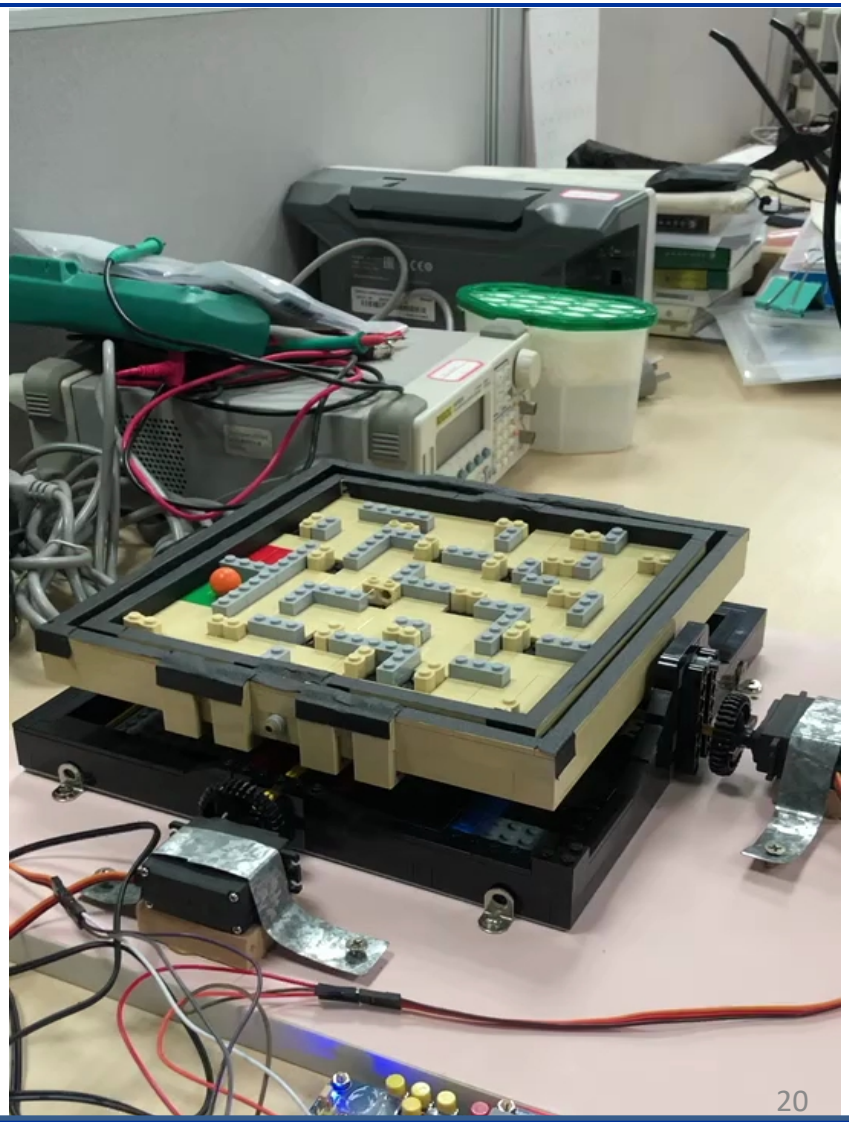
Running the system for the first time:
The ball can basically follow a planned route, and the total travel time is about 40s.



Optimization and Results

(1) Adjust the angle of rotation of the motor to speed up the movement of the ball.

(2) Added module for anticipating. Adjusting the angle and direction of the wheels in advance, according to the planned route.



Conclusion

A) The images of the Lego maze and the ball are acquired through a camera and transmitted to a computer. After that, the images are processed using Python programming to distinguish the different areas of the maze.

B) Use the Dijkstra's algorithm to plans the movement route of the ball from the start point to the end point.

C) Control the movement of the ball along the planned route, and the PWM and micro-controller are used to turn the motor and the plate.

Future

(1) There is still no way for the ball to bypass all the traps. For now, in order to make sure the ball can move smoothly from the start to the end, it still needs to block the traps.

(2) We can try to build different mazes to compare the performance of the system in different mazes. For example, when there are many detours, can the ball pass smoothly, at what speed and in what time?

Thanks for listening