## Task Analysis - Patio 1

The car had to follow a specific color route and cross a blue bridge. The blue bridge is 45cm in width and 2.2m in length, with a surface made of wire mesh. Finally, the car needs to find and go through a gate.

## Task Analysis - Patio 2

In the Patio2, the car needs to read, scan, and recognize the shapes on the brackets of the cube to determine the direction of progress and the target location of progress. Once you're done, you need to move to a specific spot and release the ball. After that, the car moves to a specific location to communicate with the computer.

## Task allocation

According to the different nature of the task, we divide the task into trolley construction task, communication task and Clerical task. Accordingly, we divided the team members into automobile construction team, communication team and clerical team. The specific composition of the team members is on the PPT. The main task of the automobile construction team is to realize the mobile function of the car, the identification function and the release function of the ping-pong ball. The main task of the communication team is to realize the communication function between the car and the computer. The clerical team is mainly responsible for writing reports and paperwork.

## System-level approach

The block diagram on the PPT shows the working topology of the entire system. It mainly consists of three subsystems: the sensor, executive control, and wireless communication systems.

## Sensor

The sensor system mainly consists of a visual processor, ultrasonic sensors, and a module consisting of an accelerometer and a gyroscope. The system is used to accept and process the signals of the external environment and then transmit the signals to the executive control system.

## Visual processor

To realize the recognition of the shape on the square and the detection of tiles, our team decided to apply OpenMV4 H7 Plus. Our team decided to use this module by considering the two factors on the PPT. One is its high processing power. OpenMV4 H7 Plus has a powerful processor running at 480MHz, allowing it to perform complex image processing tasks in real-time. The other is its advanced machine vision features. It has a built-in image sensor and global shutter, which enable it to capture high-quality images and videos in a wide range of lighting conditions.

## Ultrasonic sensors

For ultrasonic sensor, our team choose HC-SR04 sensor, which is used to measure the distance between the trolley and the obstacles.

HC-SR04 has several advantages. First, it’s cheap and popular. Second, it has high accuracy and fast response speed. HC-SR04 has a measurement accuracy of up to a centimeter level and a fast response speed, enabling low latency sensing of environmental information. Third is its high stability and reliability. It will not be affected by light interference, which makes it suitable for various lighting conditions. Finally, it has rich interfaces so that connecting it with other electrical components is more convenient and only needs a trigger signal to complete a ranging measurement.

## Accelerometer and gyroscope

For the accelerometer and gyroscope part, our team choose MPU6050 which measures acceleration and rotation with high accuracy. The roll, yaw and pitch angles could be calculated by MPU6050 and then use the attitude demodulation algorithm to process the angle data. Therefore, purpose of turning at a specific angle can be practical. In addition, the module is easy to use and program with its various libraries. That’s the two reasons for why we choose the MPU6050 as the accelerometer.

## Executive control system

The executive control system mainly consists of an MCU, a mechanical arm, and a motor drive circuit. The main function of the control system is processing the signals received from the sensor system, then generating and sending control signals to parts of the car. The mechanical arm is used for holding and releasing the ball. The motor drive circuit receives control signals from the MCU and drives the motor to complete commands. In addition, it is responsible for providing the power.

## Microcontroller Unit (MCU)

NUCLEO-G474RE is the MCU used for processing data and transmitting control signals. The main reason for choosing this board is that it provides rich interfaces which enables it to be connected to a variety of sensors and communication modules. And more interfaces will also allow the car to have more data exchange space, so that the probability of data transmission delay or error is greatly reduced. Additionally, NUCLEO-G474RE is supported by the STM32Cube ecosystem, which provides a comprehensive set of software tools and libraries to facilitate development.

## Mechanical arm

The mechanical arm needs to hold a table tennis ball at the beginning of patio 2 and place the ball in a basket after patrolling. Our team came up with two solutions, one is using mechanical claw bought on the internet shop and the other is using 3D-printed claw. Later, we choose the 3D-printed claw for the releasing task in patio2. There are three main reasons. First, compared with bought one, the 3D-printed claw is lighter, which can greatly reduce the load of the car and its energy consumption. Second, it is easier to complete tasks in the patio2 and does not require complex code to implement. Third, the voltage of the board could not move the mechanical claw and the current allowed through the dupont line was too small, so the power could not meet the demand.

## Motor driver circuit

TB6612FN is chosen to construct the motor diver circuit which is a DC motor driver chip with high efficiency. The two reasons for such a decision are listed on the PPT. First, its high current output capability makes it possible to drive high-power DC motors to meet the needs of high-load applications. Second, its high efficiency and energy saving can reduce a large amount of power consumption compared with a popular alternative, L298N.

## Communication system

The wireless communication system comprises a clock module and a communication module. There are two communication systems, one on the trolley and the other connected to the computer. The two systems can respectively receive and send signals in the form of half duplex. After receiving the communication instruction from the control system, the communication module located in the trolley would transmit the information to the PC end immediately.

## Two modules in communication system

The communication module we choose is HC-12, which is a low-cost, easy-to-use wireless serial port module commonly used for long-distance data transmission. It supports full-duplex communication and can achieve a maximum data transmission distance of up to 1.8 km under stable signal conditions. The HC-12 operates in the 433MHz frequency band and can be configured and controlled via AT commands. It can enable communication between multiple modules. It also has data encryption and verification functions to ensure the security and reliability of data transmission.

The clock module we choose is DS1302 is a low-power real-time clock chip that provides accurate time and date information. The DS1302 chip has advantages such as high accuracy and low power consumption. In addition, the DS1302 can communicate with the MCU, supporting the read and write of clock data and the configuration of control registers, which makes it very convenient to use.

## Current progress

We had already allocated our tasks in the first week. All the materials and components needed for the car were bought in the second week. Over the next few weeks, we worked on the tasks. And now, the tasks in patio1 have been completed, but the car has not yet been tested on the field. We’re trying to figure out how to smoothly transition the cart from task1 to task2 to task3. In the meantime, recognition of the shape, detection of the tiles, robot arm releasing function and communication function which are required in the patio2 have all been realized. But the path planning from task1 to task2 and task2 to task3 is not yet solved.

## Future plan

We plan to solve routing problem in the next few weeks. The installation of the mechanical arm will be completed in the one week, but the specific operation experiment and later adjustment work will be carried out after the landing experiment. Path planning issues for the patio1 will be resolved in the next 2 weeks. For the patio2, path planning is more complicated because there are no landmarks on the ground for the car to recognize, so it cannot rely on visual sensors to control its progress. At present, we do not have feasible idea, we need to find a solution as soon as possible. We expect to resolve them in the next 2-3 weeks. Once they are done, we will experiment with the car in the test site and constantly adjust the various components as well as their respective parameters to make sure that they work together perfectly and accomplish all the tasks.

## Thank you

This is about all our current progress and future planning. Do you have any questions?