ROBOVY

Science and Technology Ltd

CarBuilder Robot & Server

Technology Report

DIRECTOR Prof. Yahui Chen

GROUP 1 B39VS SYSTEM PROJECT

www.rovovy.com

GROUP 1 _MEMBER LIST

NAME	POSITION & TASK
HAN LI	Managing Director Chief Software Engineering Workshop Engineer
KAICHENG ZHANG	Chief Mechanical Designer Chief Digital Systems Engineer Electronics and Wiring Engineer Workshop Engineer
YIBING LIU	Workshop Engineer Electronics and Wiring Engineer Mechanical Designer
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1. Introduction

1.1 company introduction

ROBOVY is a technical company devoted to design a interaction system for people in queue, especially in theme parks. Our company has an efficient and effective team, the Marketing Department is committed to creating the most comfortable and intimate interactive experience based on users' demands and feelings, and the technical department has already had a considerable scale and strength to provide professional hardware and software technical system.

In the recent project, the members of ROBOVY technical company worked together in order to design and complete the interaction system which we will introduce later in detail, the robot that we produced participated in the commercial performance at the end of November.

1.2 product introduction

Concept of product

'Vehicle designer' is an entertaining and intelligent robot which provides the opportunity for customers who are in queue to design a car depended on some modules and components we supply. The car can be exquisite, and wield one is also acceptable as long as it has a reasonable and appropriate structure. The two key factors we mentioned above will be linked to the marks that the car get, and customers will receive a handmade card with the car of their own design.

Feature of product

1. entertaining

Users can design cars of any styles and functions by themselves. We provide a lot of virtual scenes to provide simulation operation. Therefore, users merely need to communicate with the robot of building cars and make every efforts to design machines with atmospheric style and reasonable functions.This creative model is attractive to users waiting in queue.

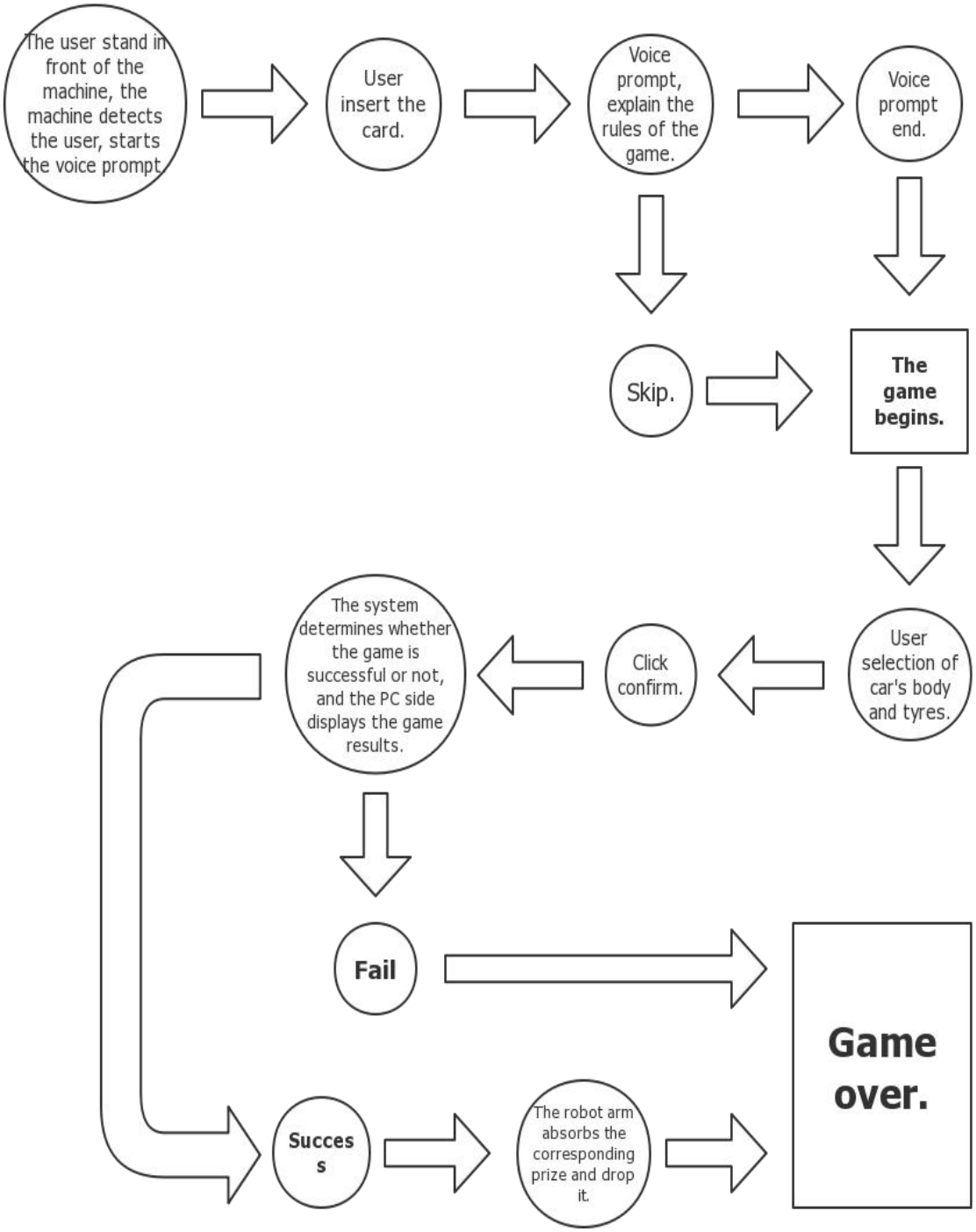
2. Intelligent

The robot has a lot of virtual auto spare parts in the software, so customers don't have to design a whole car ,all the things they need to think about is how to apply their

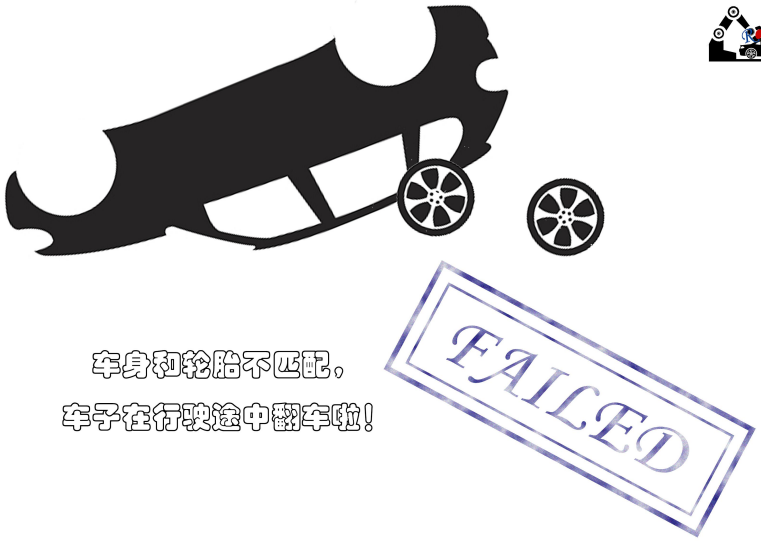
function and match them properly.

This robot has a fully-automated service system, so customer will receive a gift sending by Intelligent mechanical arm.

Game process



If Game over:



1.3 Achievement

1.3.1 Market analysis

At the beginning of our project, we took some measures to analysis the market and demand in theme park in order to figure out what and how to design our interactive robot. During this period of time, the secretary collected some statistics and suggestions about the consumer confidence index (CCI) about 3 blueprints of our products from the internet. It is reported that people briefly focus on the entertaining and the Time-Weighted Rate of Return (TWRR). This concept can be understood easily by a opinion of the interviewee. ' we all know that it is boring when we are in queue, but I prefer to stare at my mobile phone. It is better for you to design a amusing and meaningful system.' Then we held a meeting in order to make sure the potential achievement. Therefore, in this meeting, we decided the direction of the project and focused on the entertainment and functionality of the product.

1.3.2 Mechanical design & Demo & Manufacture

The overall structure of the product is a one-armed robot whose base is a cube. In this cube, We designed some internal orbits so that the eggs caught above the cube could reach the exit smoothly from the hole on the surface.

On the top of the cube, we placed several pallets to restrict the position of the presents accurately so as to facilitate the grasping and positioning of the mechanical arm. The outer shell of the product is build in acrylic sheet.
The most important and complex mechanical structure of our project is the robot arm which is responsible for grasping Easter eggs in the center.For this reason, we designed and produced several different versions of mechanical arm,wood,acrylic, cardboard.then we find acrylic is the best one.

1.3.3 Software design & implement

Necessary and intelligent code needs to be very reasonable to support serial communication. Meanwhile, in the process of interacting with robots, the aesthetics and convenience of C# Windows are also important, so beautification technologies such as WPF ,Photo shop and etc are very important.

In the window program, we designed the option of switching between Chinese and English, so as to achieve rapid synchronization of voice text and customer idioms.At the same time, window programs have two modes: administrator mode and user mode.The former has the function of accessing serial communication of mechanical arm motor, while the latter pays more attention to user experience and service friendliness.

Besides, according to the identification of the user id card by the photoelectric gate, the software will receive a scanning result, which corresponds to a user's identity in binary code. When the user inserts the id card, the database will be updated synchronously.

1.3.4 Debugging between software & hardware

As the hardware and software synchronized, numerous tests were performed on each section. Then we successfully solved several bugs caused by various external reasons, as well as some problems of the code itself. Ensure the stability and success rate of the product, and pave the way for the achievement of the best user experience.

1.3.5 Capital investment

In order to reduce the risk of failure, we made several demos in the early stage of the project, which cost us more than other teams. However, these materials were relatively cheap. In addition to several sensors and servo motors of MBED FPGA, our total cost was controlled below 500 yuan.

STUFF	COST (¥)	TOTAL PRICE(¥)
Fpga &Mbed board	Provided by Xidian University	**0**
20kg/cm servo motor 20kg/cm Digital servo motor	78*2 36*2	228
Wire&Bread board	6*4+1.39	26
Electromagnet	14.5	14.5
LED	2.61	2.61
Transformer 12V 1A Transformer 5V 2A Transformer 5V 3A	12+17+18*2	65
Little bottle 15 Colour Card 19.99 Photo Electric Gate*4 4.9*4	15+ 19.99+4.9+4	55
Raw material of the structure	93	93
total		**484.11**

1.4 Marketing & technology Consultant

We sincerely thank the following expert groups for their suggestion, assistance and guidance in the development stage of Robovy company.In global concept, they gave the key on the decision to the direction of the project, the guidance of the technical level, they help us introductions to the c #, mbed, fpga etc, hardware and software technology, such as product function and technical realization. In the business market, the experts through many times team meetings, corrected us a lot of unreasonable business model, making every efforts to improve the Return Over Investment (ROI) of the product.

The **expert group** includes:

Prof. Yanhui Chen Project Manager and Superintendent.
Weidong Xu Instructor Of Project Management and Technology.
Huanfeng Liu C#, MBED, Sensor Lecturer (giving the technical assistance)
Jing kang Quality Supervisor (providing technical supports and suggestions)

1.5 Document Overview

The technical report of ROBOVY company is a combination of business analysis and technical detail which will provide concrete technical components and the mechanical structure of our product. Meanwhile, It will display the process of the mechanical, software design, the digital and sensor system.besides, market and project management will be spotted at the end of the document.

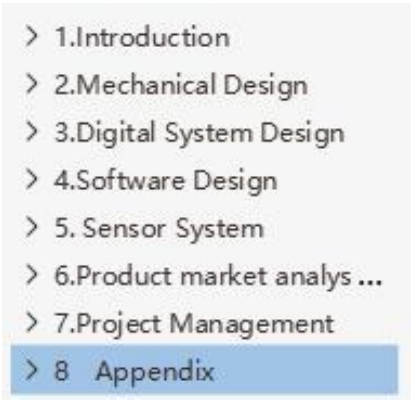


Figure 1 the catalog of report

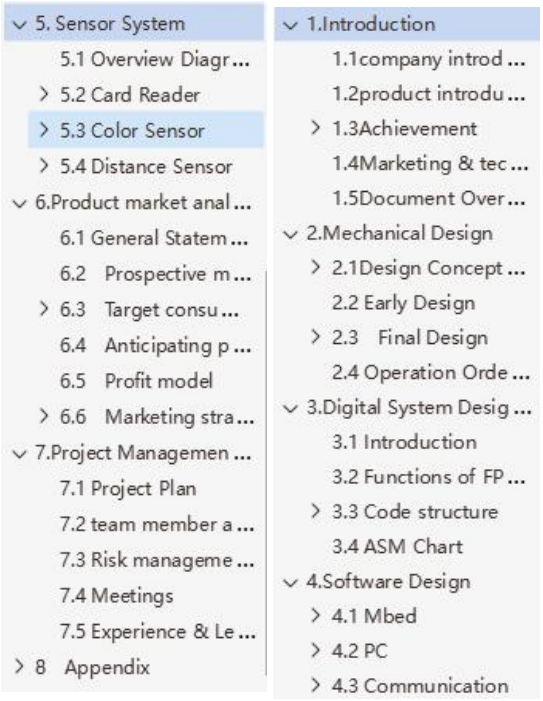


Figure 2 the overview of report

2. Mechanical Design

2.1 Design Concepts

2.1.1 Requirement Specification

At beginning, our group decided to make a prototype of the robotic arm, which is the key part of our product. After finishing it, we considered the idea of robotic arm is workable. We also had meetings discussing what should the structure be. Design the structure is a very hard task because we need to fit all our customers' needs. In all, we thought we should satisfy customers' needs and then based on the needs we can design the structure. Here are the customers' needs:

- Design a product which can interact with customers, and it can sense whether there is a customer coming. The product should also tell people how to play the game.
- If the customer failed the game, the system should tell the customer and do some actions.
- If the customer is playing, the system should run the program without ours intervention. And the LED should also provide information to the customer.

2.1.2 Design Concepts

Basing on the requirements and our expectations, the design concepts were determined as Following.

Reliability

The overall machine must be strong enough. It should be able to deal with most situations.

Simplicity

The simpler structure means low cost, easy maintenance and low fault rate. It will also facilitate our developing speed and reduce the assembling time or debugging time.

Extensible

Without too much changes or modifies, our system can adjust to various of situations.

Safety

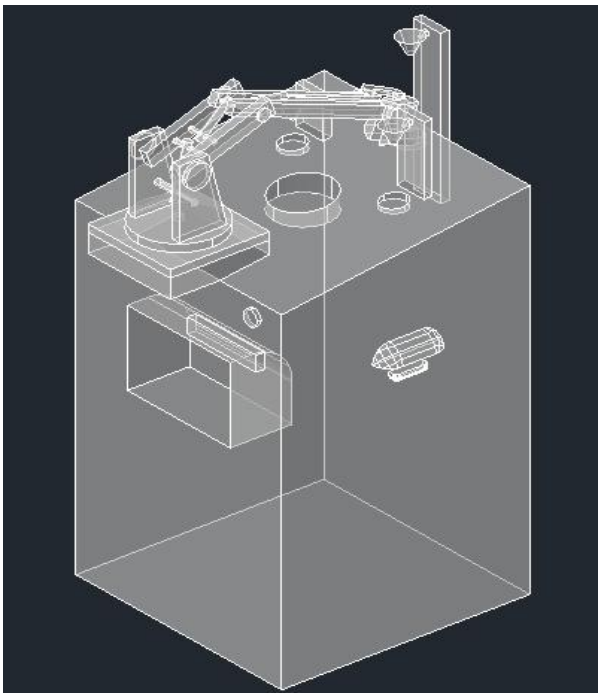
The machine should be designed to prevent dangerous situation happening, such as electric shock and fire.

Outlook

The outlook must be attractive so that customers would come and play our product.

2.2 Early Design

In our initial plan, we plan to just grab the ball with a robotic arm and throw it into a fixed ball box.



The most important is the robotic arm. Use different sizes of cubes and cylinders within the size requirements. The upper surface area of the overall machine is 300mm*300mm, so the arm should be able to reach up to 300mm.

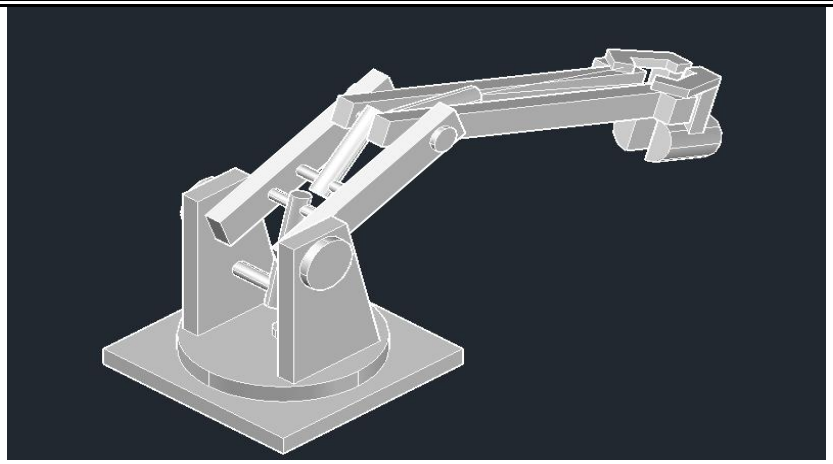


Figure 3 Initial design of the robotic arm

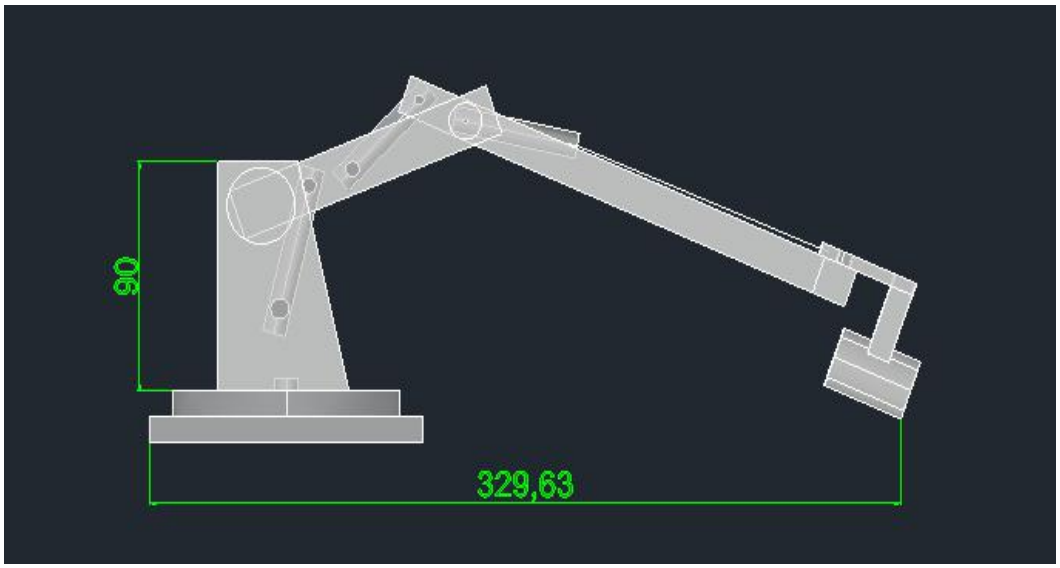


Figure 4 The arm should cover a range of 300mm

And as for the size of each specific device, we have:

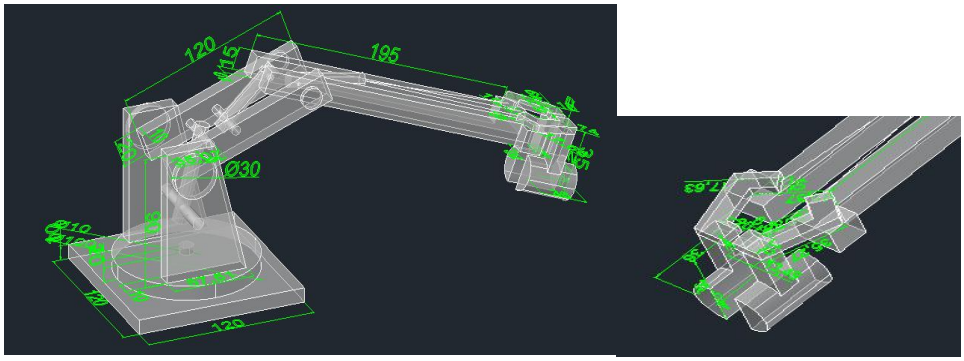
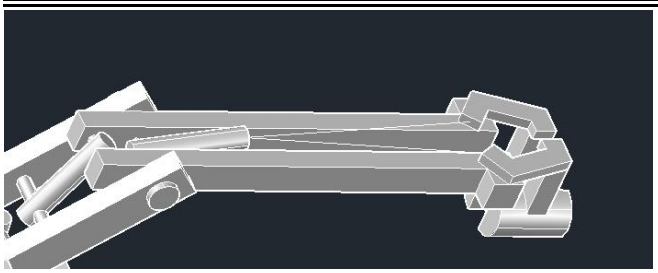


Figure 5 Specific size of the arm

(a) (b)



Here are wires which are connected to the syringe to control the clamping device of the front section

Figure 6 The position of the syringe in the arm

The cylinders in the picture are the syringes filled with water.

We made the first and second robotic arms using the above drawings.
And the materials are both cardboards, so when using hydraulic, the reliability is too low. During the test, water spilled out of the syringe several times.

We display the process of manufacture of mechanical arm (3 kind of materials) in detail below. ↓

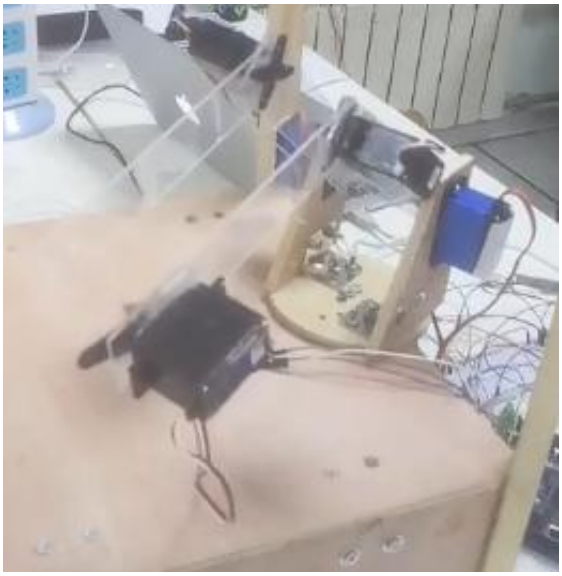
Concrete Process

For Talent CARcarft, our first product of Rebovy Technologies, The core of the mechanical part is a mechanical arm with a very high degree of freedom. In the process of continuous design and improvement, we have made four generations of mechanical arm.

In the original design, we connected two syringes with plastic hoses, filled the syringes with water, and controlled the movement of the mechanical arm through three to four such groups of hydraulic pressure. The first generation mechanical arm was used to verify the feasibility of our first version of the product plan. Therefore, the first generation of mechanical arm requirements is simple, easy to process. In this way of thinking, we bought some corrugating paperboard and syringes from the Internet, and bought some toothpicks, glue, straps and plastic pipes on campus.

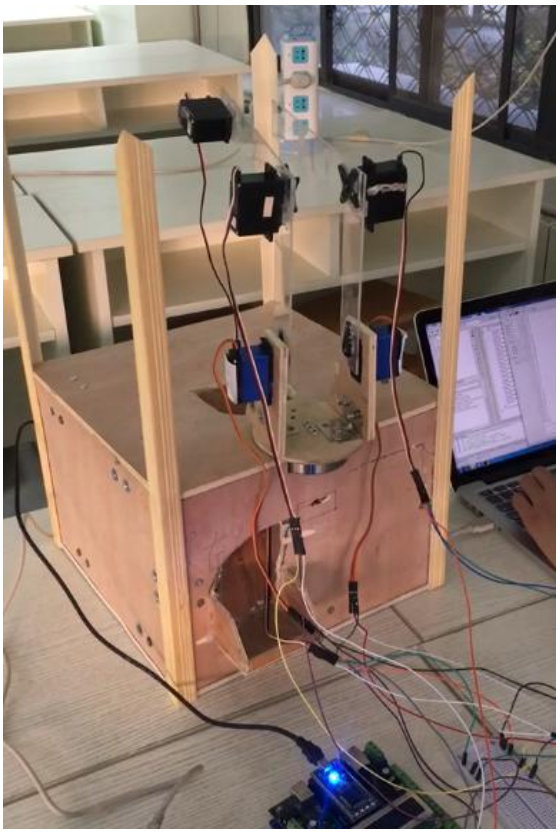
The final first mechanical arm is as:

With the first arm, we realize that it is possible to control the manipulator with four degrees of freedom through hydraulic control. Then we began to use higher quality grey cardboard to make mechanical arms. In addition to using more reliable materials and replacing toothpicks with thick wire, the second arm is made in the same way as the first one. But in the concrete practice, the shortcomings of using cardboard to make mechanical arm are revealed. The hydraulic device is filled with water. When pushing and pulling the outer end of the syringe, the distance of movement is very difficult to control, the syringe connected directly with the mechanical arm is easily pushed out and water is thrown out, and the paper mechanical arm is wet. From a reliability point of view, we abandoned the use of cardboard to make mechanical arms in favour of wood materials.

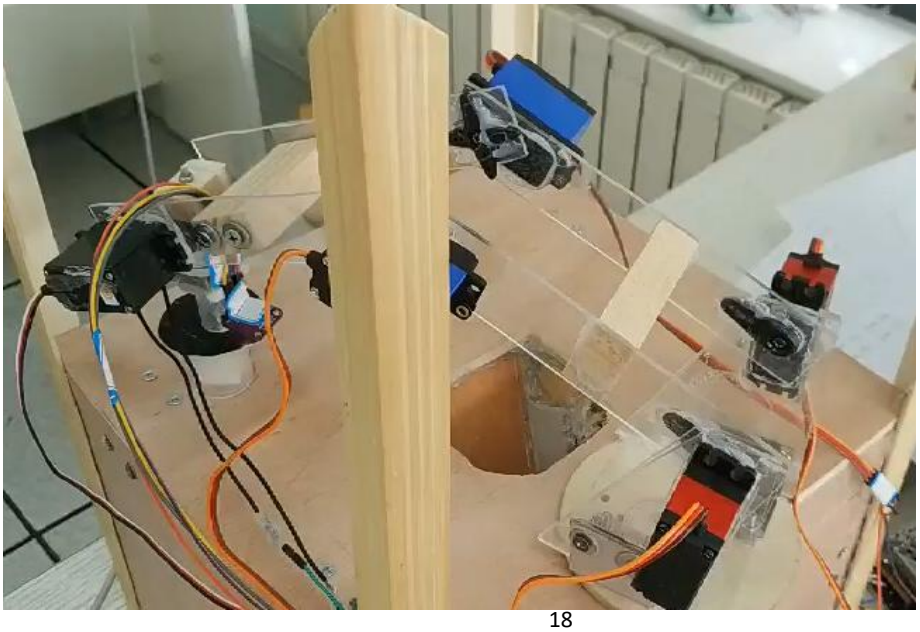


The third mechanical arm is made from 3mm thick plank. In order to further improve the reliability, we abandoned the hydraulic device and fixed the servo motor directly at the joint so that it could satisfy the four degree of freedom movement. In order to further improve the reliability, we abandoned the hydraulic device and fixed the servo motor directly at the joint so that it could satisfy the four degree of freedom movement. With the success of the plank its own shortcomings also revealed. According to the relevant information, the servomotor issued by the school has an effective load of about 3.5 kg. When mounted at the joints of the manipulator, the motor is unable to provide effective power because the arm is too long and the friction is large.

In view of the problems existing in the third type of mechanical arm, the fourth type of arm has been improved. On the one hand, we bought more heavy-duty servo motors on the Internet; On the other hand, we buy smaller friction, lighter quality, more beautiful appearance of acrylic for production. When the production is finished, we find that the motor will still be underpowered when FPGA is directly used to power the motor. After analysis, we found that the higher power motor needs more current, and the FPGA board can not provide enough current for all the high power motors. So we bought some student transformers and used the external power supply directly to supply energy to the high power motor. The FPGA only played the role of signal control.



And further, we started making clamp devices. In the original scenario, we used the simplest two hemispheres to pick up objects directly. However, in practice, we found that since the effective volume required by the title is 300mm*300mm*500mm, given the circumstances of our project, the only area in which the arm can move is 300mm*300mm. If clamped, the clamp itself occupies too much area. In the improved scheme, we began to use electromagnets to absorb the target block by magnetic force. Through the application of electromagnet, not only the effective area is saved and more blocks are placed, but also the reliability of the arm is greatly improved by controlling the current.



2.3

Final Design

To improve the design, for the third robot arm, we placed the servo motor directly at the joint of the robot arm and we use thin wood to make the robotic arm, so we didn't need the syringes any more. In addition, we understood the role of electromagnets and apply them to our robotic arms.
this is the final design, we used this drawing made our third and final robotic arms.

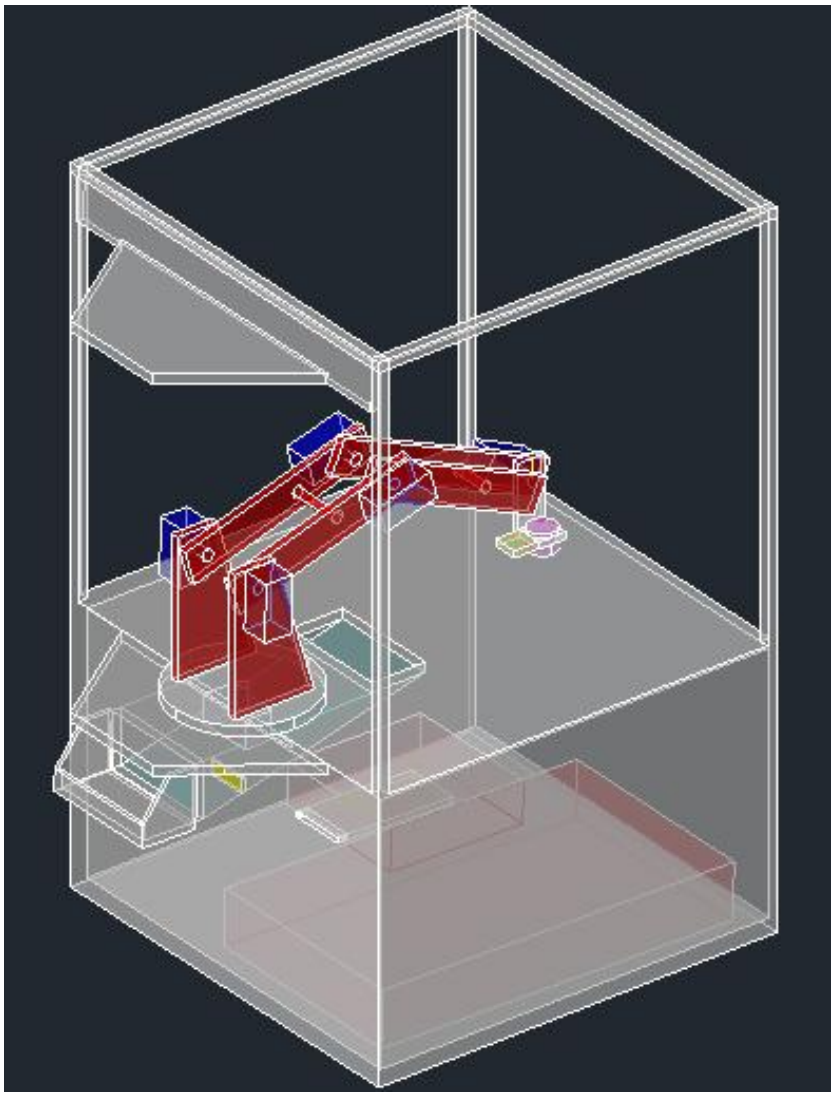


Figure 7 The final design

For the robotic arms, the drawing is as follow

2.3.1 Robotic Arm Subsystem

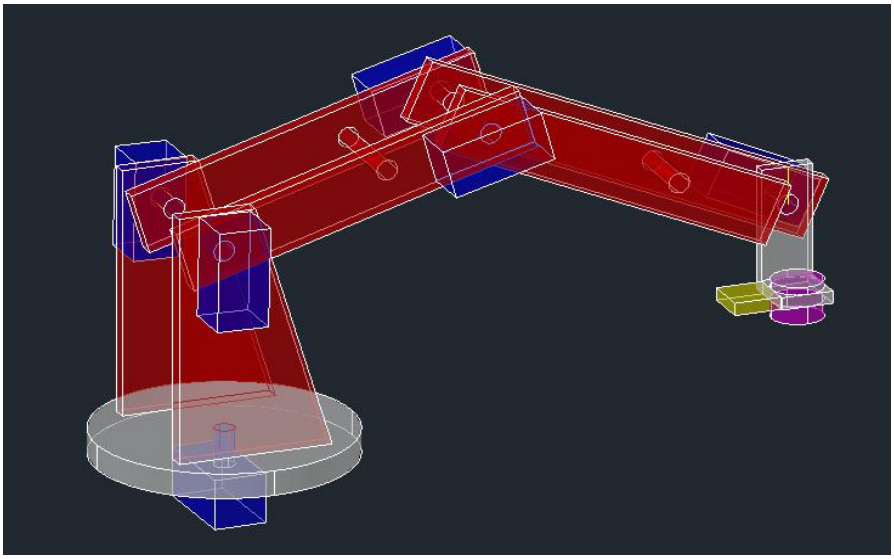


Figure 8 The final design of the robotic arm

The blue part is the servo motor, we divided the six servo motors into four groups to meet the four-degree requirement of the robot arm. The bottommost motor controls the movement of the robot arm in the left and right direction, the middle four motors control the movement of the arm up and down, the front motor control solenoid swings back and forth to ensure that it can just attract the object.

The yellow part is the color sensor, which is used to determine if there is an object at a certain location and select the object.

For the grey disc, we planned to use a properly sized bearing. Putting the bearing on one side of the overall machine, which can make sure the bottommost motor has enough power to control the whole robotic arm.

The joints in the middle are controlled by two motors to provide enough power.

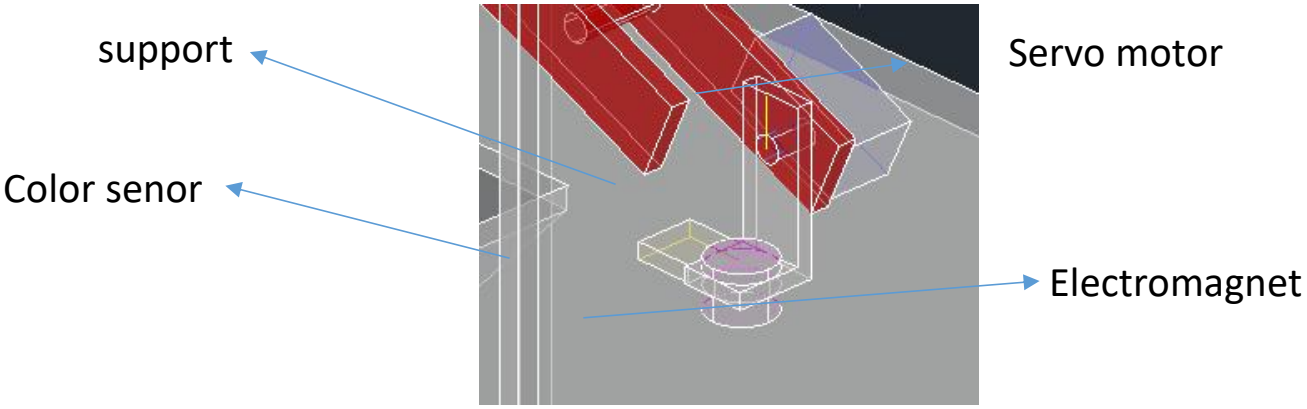


Figure 9 Suction device

For servo motor, color senor and electromagnet, we can use industrial rubber, screws or straps to fix them.

Here is the assembly drawing of the robotic arm:

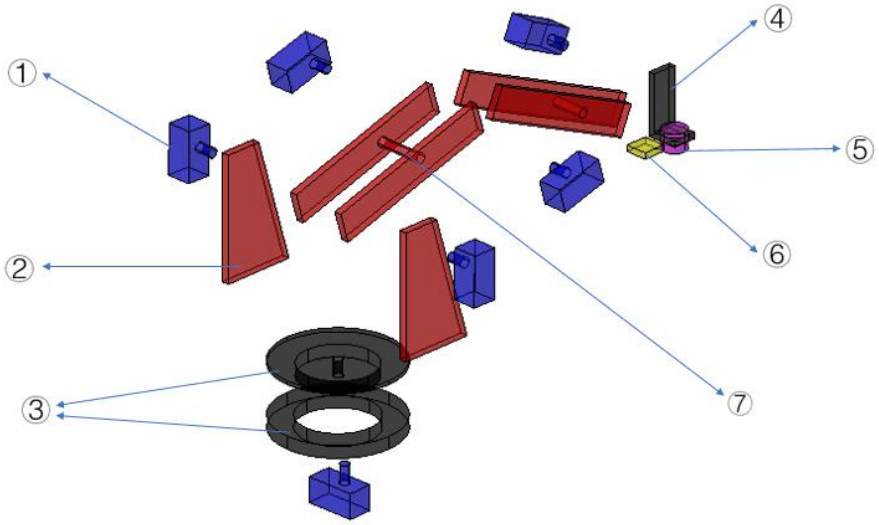


Figure 2.9. The assembly drawing of robotic arm

PART LIST			
Item	Quantity	Name	Description
1	6	Servo motor	The motor is fixed to the board with glue and screws
2	6 (different size)	Wood board	The blade is fixed on the board with glue
3	1	Bearing	The upper and lower surface of the bearing are fixed with robot arm base the side of the wooden box
4	1	Bracket	The bracket is glued to the motor blade at the front end
5	1	Electromagnet	The electromagnet is placed in the groove of the bracket and fixed with glue
6	1	Color sensor	The color sensor sticks to the side of the bracket
7	2	Small wooden block	Screwed between a pair of wooden strips to make it a whole

Figure 2.10. The part list of robotic arm

2.3.2 Box Subsystem

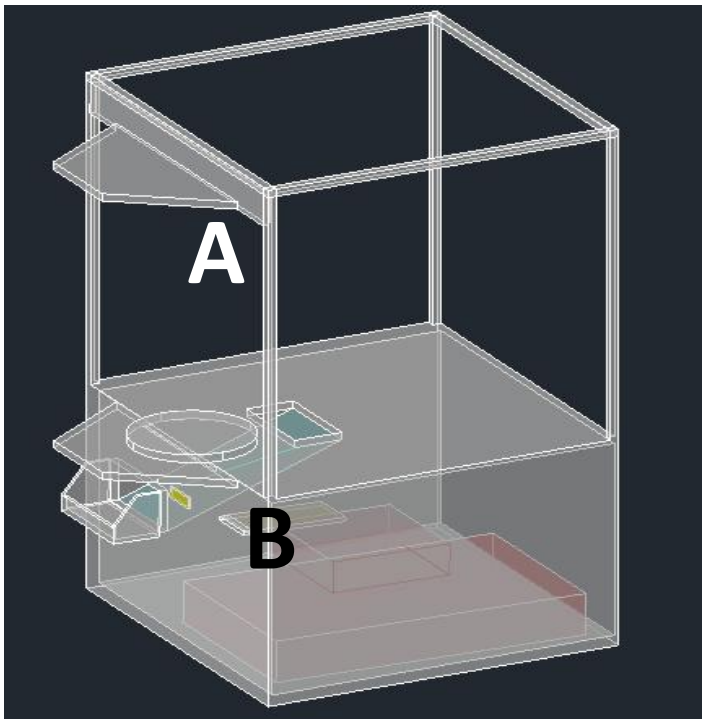


Figure 10 Overall outer casing design

The lower part is made of wood, in the lower box, we place the board, the track that the object needs to ship, and the card slot required for the photoelectric sensor. The upper part is made of acrylic, and the bracket is made of fine wood to support the acrylic.

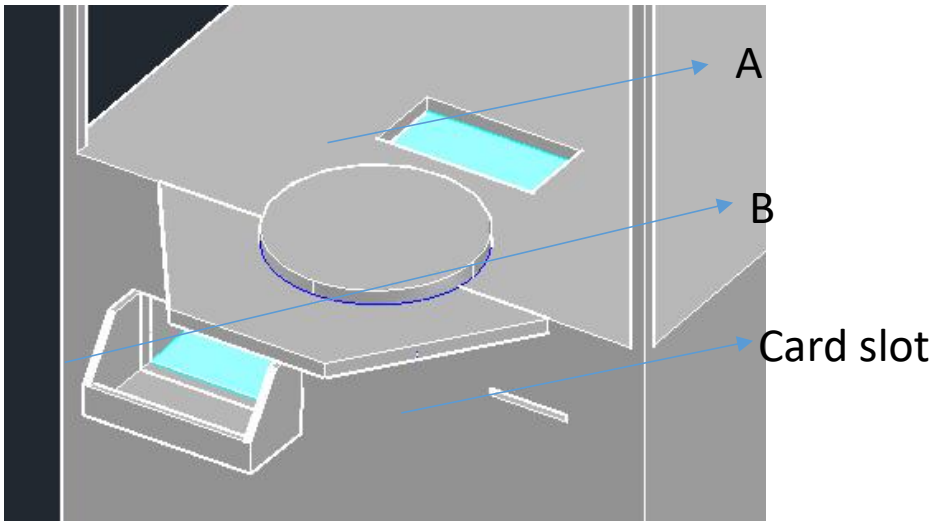


Figure 11 The hole of the wooden box part

After the robotic arm grips the object, it will move over A and release the object to roll it out from B.

2.3.3 The assembly of the structure

Robotic arm: The robotic arm was made of acrylic. We used the cutting machine to make 4 same acrylic strips for the arms and 4 same right-angled trapezoid acrylic boards for the bottom (2 for each side to make the bass more stable).

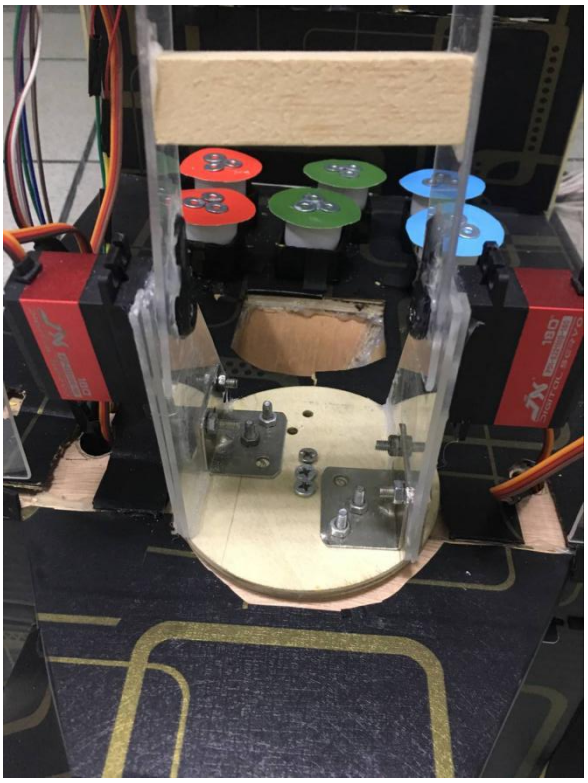


Figure 12 The base of the robotic arm

Then we used the puncher to make 9 holes so that the motors can stuck on the acrylic boards. Then we put on the motors and glued to stable them. We already bought a circular wooden broad with 10cm diameter. We used 2 L-iron to fasten the wooden broad and the right-angled trapezoid acrylic boards. Thus, the robotic arm was complete.

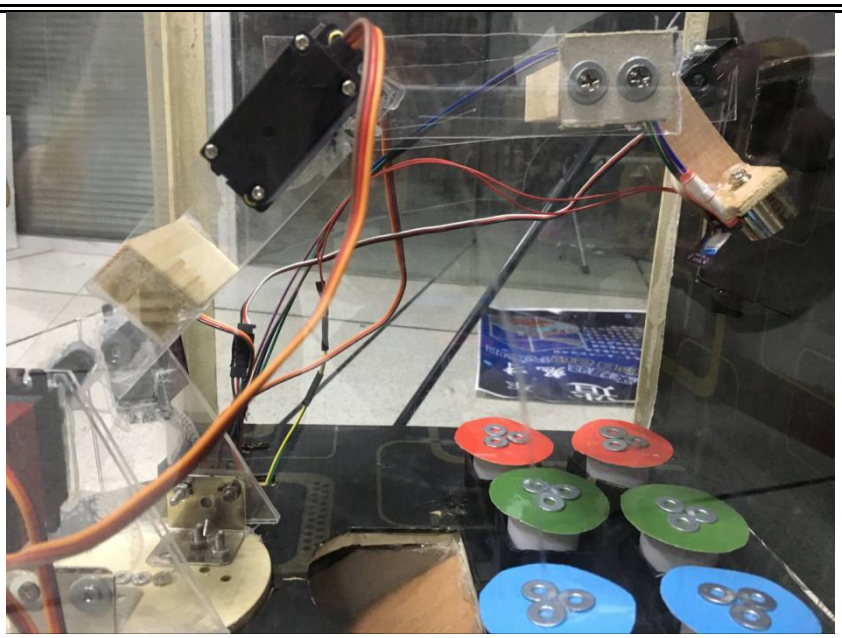


Figure 13 The robotic arm

Electromagnet: This device is very small and it cannot put on the motor directly. So we came up an idea to fasten it on the top motor by making a L- structure. The electromagnet was put on the bottom of the "L", while the side of "L" was used to connect with the motor in the top of the robotic arm (motor4).

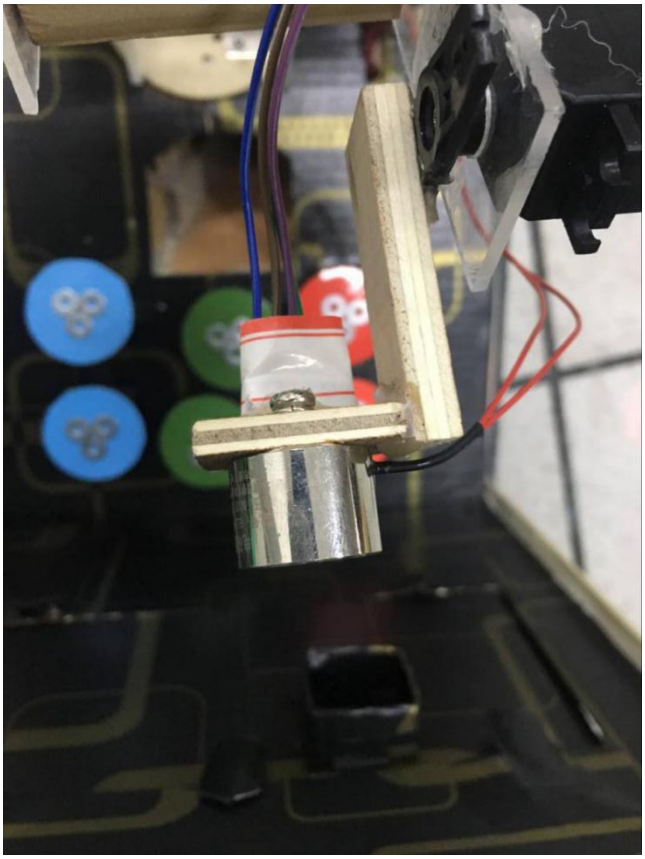


Figure 14 The L structure and electromagnet

The color sensor was glued with the "L" structure, just beside the electromagnet. Due to the working temperature of electromagnet is too high, we used stickers to cover the color sensor to resist the high temperature.

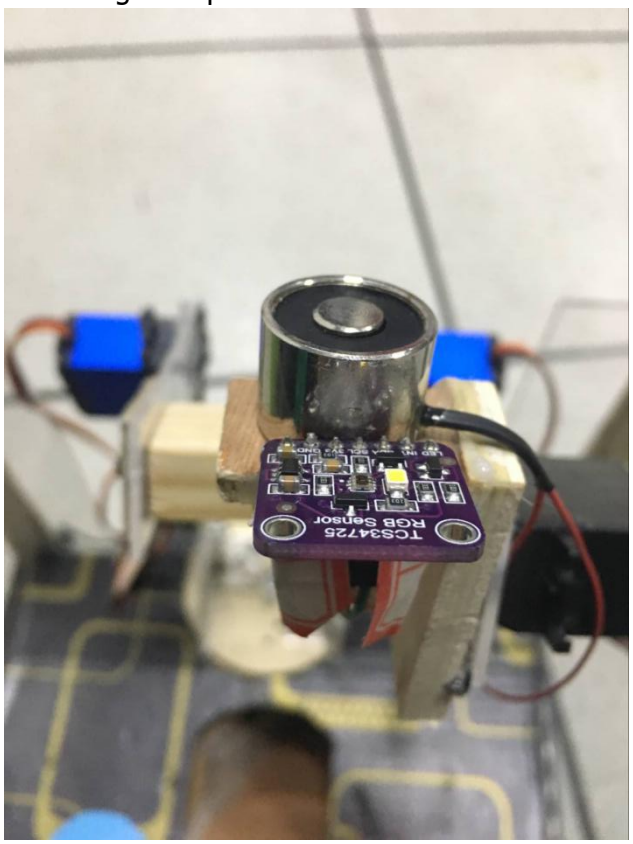


Figure 15 The color sensor

The box

The box was made of wood. We used the cutting machine to get 4 30cm*20cm and 2 30cm*30cm wooden boards. Then we insert a hinge in one 30cm*20cm board to form the door in the back. We put all the boards together by using L-irons and screws to form a 30cm*30cm*20cm wooden box with a 30cm*20cm door which was used to contain electric devices. In the front of the box, we made a hole in the left (used to let the goods come out), one small gap in the middle (used to let the pins of distance sensor to pass through) and one 10cm long gap in the right (used to insert the card).

Figure 16 The distance sensor

Behind the 10cm gap was 4 photoelectric sensors insert in a hollow wooden box so that the card can insert in (This is the card reader system).

Thus we put the distance sensor on and fasten it.

On the top of the box, we made a big hole to form a way to the front board. There were also 6 cells to place the goods.

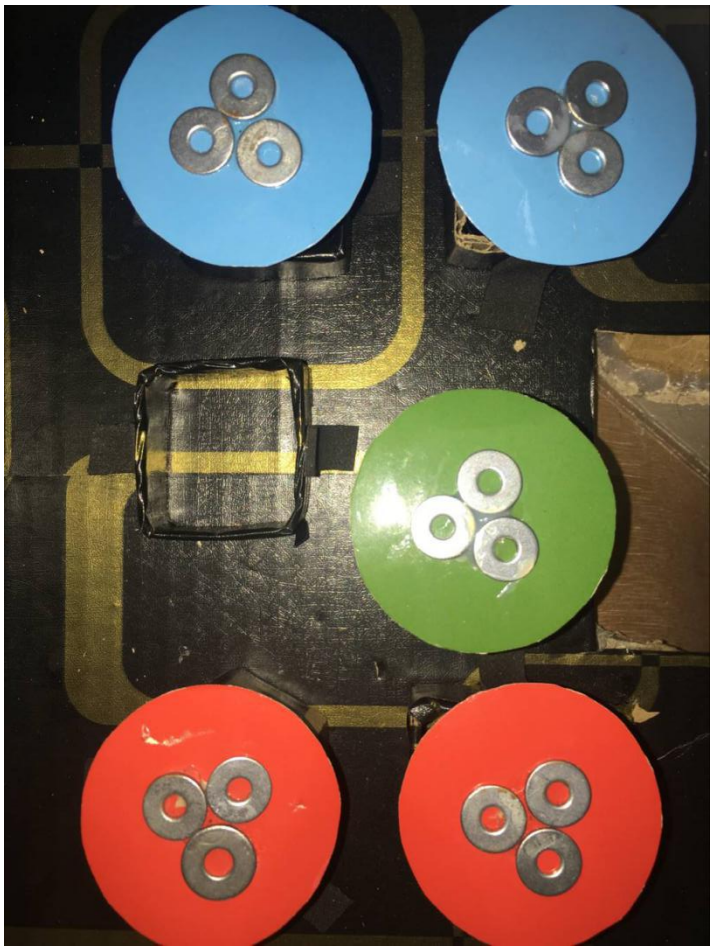


Figure 17 The cells and goods on the top of the box

On the left side of the top, there is a small hole to put in the LED, which was used to present the same color of the good the robotic arm grabbed.

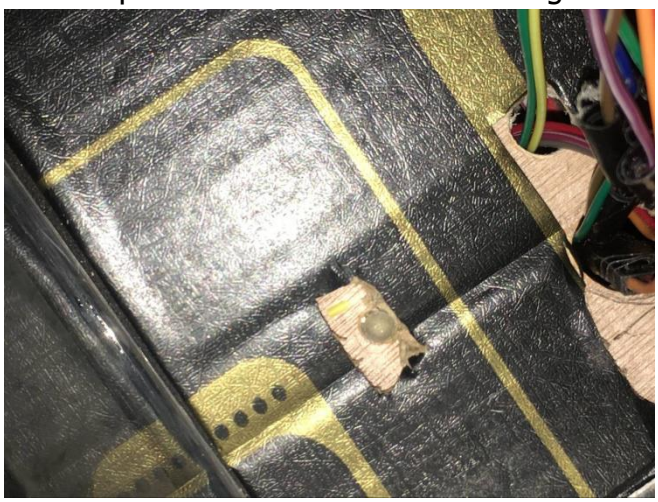


Figure 18 The LED

Above the box, we cut 4 wooden strips to form the bracket and put on 2 30cm*30cm acrylic board between the strips to form a transparent frame.
Then for the back, we used a 30cm*30cm wooden board which has a door in it so that we can put in goods from outside. The door can open from upwards to downwards.

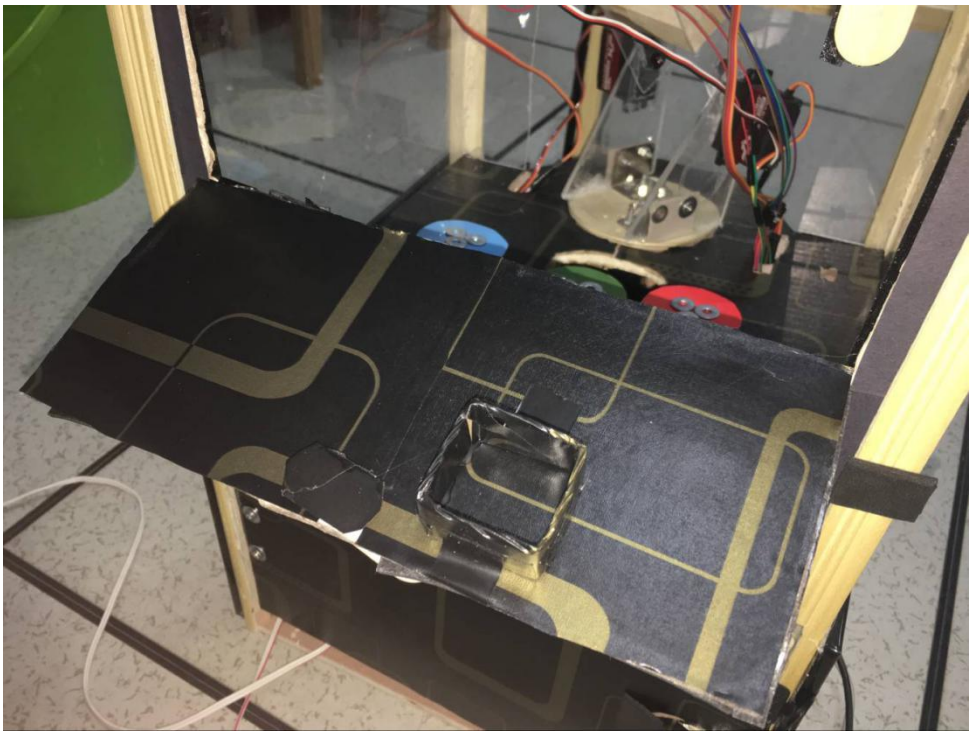


Figure 19 The back door of the frame

On the top of the frame we used a 30cm*30cm acrylic and used 4 wooden strips covering the edges so that it can place on the frame.

We also used an isosceles trapezoid wooden board with 3 plastic clothes attached to make a space for the robotic arm, and customers can also watch the robotic arm moving. In the front of the frame, due to the robotic arm is half outside, so we only used 2 acrylic strips on two sides so that the arm can move freely.

Then we can put all these stuffs together to form the whole structure.

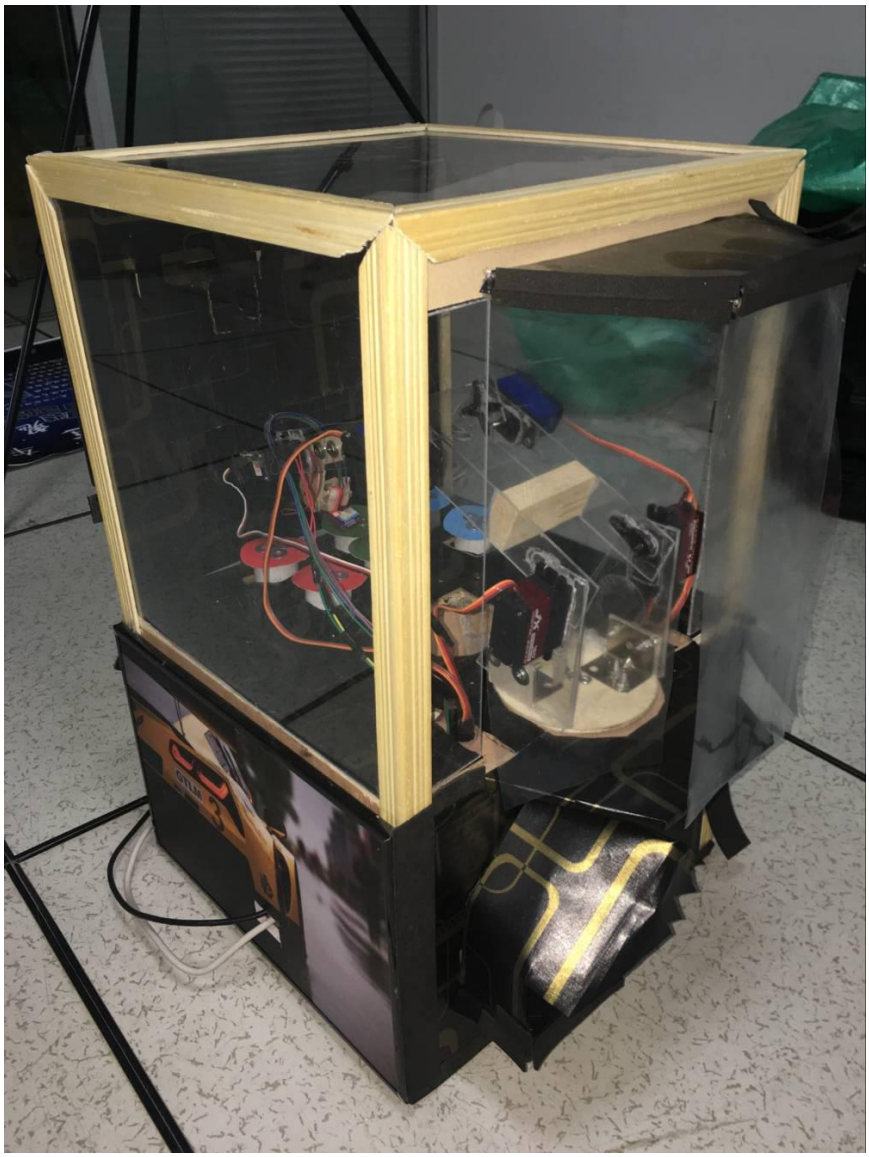


Figure 20 The whole structure of our product

2.3.4 The arrangement of devices

Due to the robotic arm is very complex (each arm need 2 motors to support), our product used 6 motors, 1 electromagnet, 1 LED,1 electric relay, 2 breadboards,1 distance sensor, 1 color sensor, 4 photoelectric sensors and 4 voltage transformers. Thus the arrangement of devices is difficult. The devices is too many and the space of the box for devices are just 30cm*30cm*20cm. It was a chaos when we finished our first trial. And when we connected the FPGA and Mbed to PC, The robotic arm couldn't move as expected. After checking the connections and the wires, we figured it out. This is because the connection between dupont lines is very loose and if you put a little pressure on it, it will break. To make sure we could check more quickly. We decided to arrange these wires first. We used lots of labels. Each label represents a device. For example, the wires of the LED called LED Light, thus we label it.

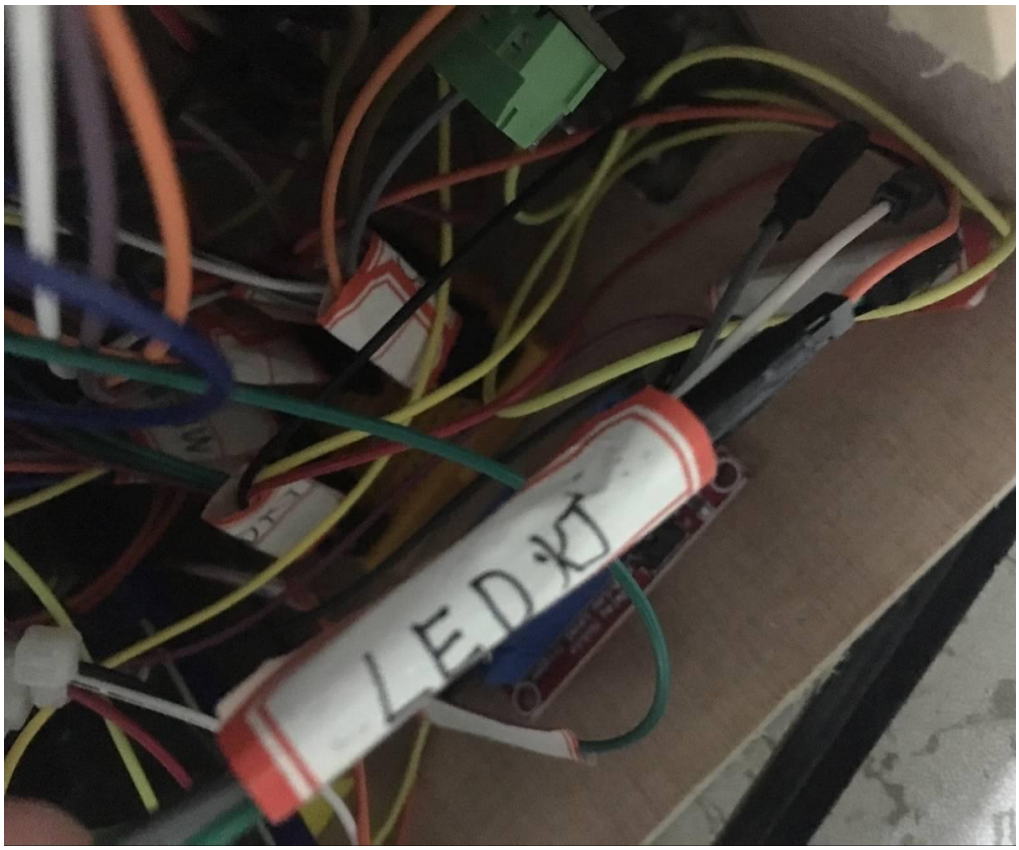


Figure 21 The label of LED

After about an hour, we finished the arrangement of wires. Then we tested again, still, the robotic arm couldn't move as expected, so we used tapes to fasten the connections between the dupont lines. Then, we finally succeeded, the robotic arm can move by controlling PC. To make sure the product could operate correctly, we used the glue gun to glue the connections and the breadboard.

After fitting in the FPGA and Mbed, connecting the wires of photoelectric sensors, distance sensor and color sensor, we met a problem that the voltage transformers cannot fit in the space of the box. But the door of the box still had space. So we put the transformers on the door.

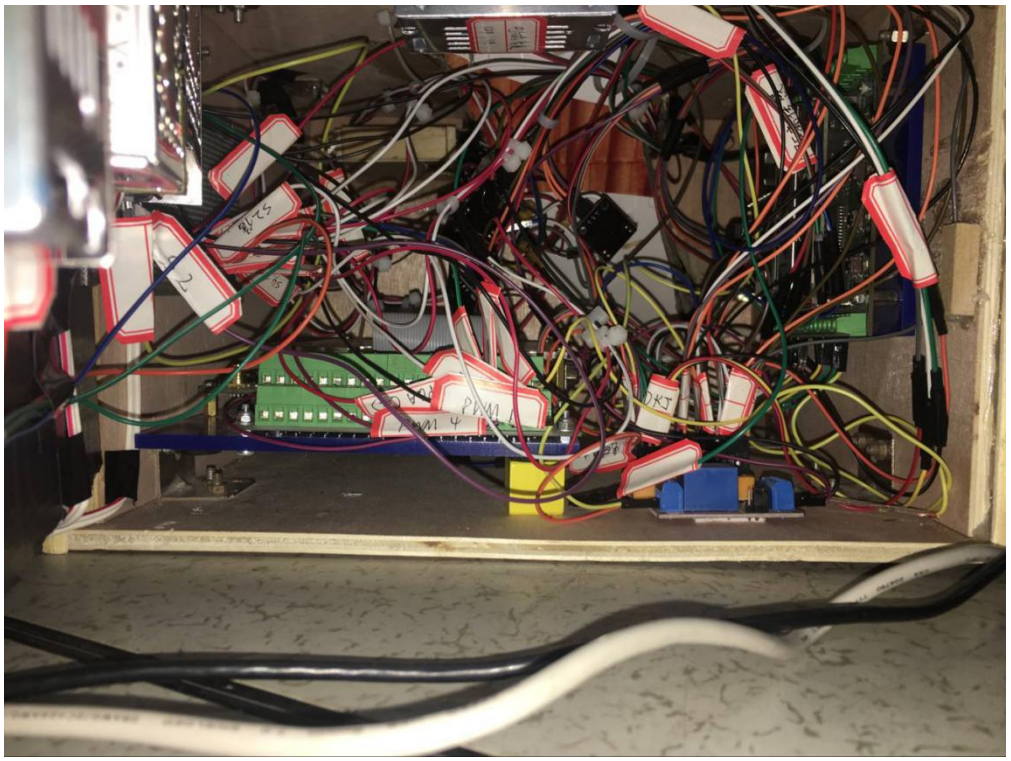


Figure 22 The arrangement of wires and devices

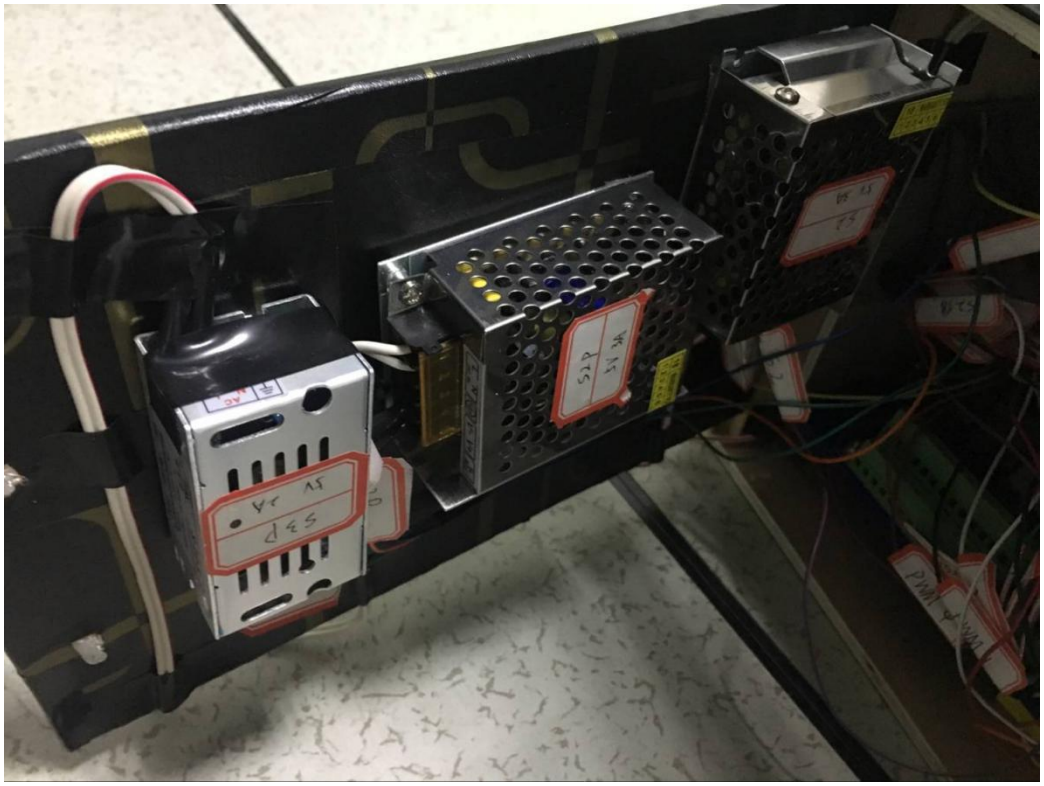


Figure 23 Voltage transformer on the box' s door

2.4 Operation Order

1. When there is a customer coming close enough, the distance sensor will work and if the card reader system sense there is a card insert, the game will begin.

2 .If the customer loses, the robotic arm will wave itself. If the customer wins, the robotic arm will magnetic attract corresponding color good by using color sensor and deliver it through the hole on the top of the box.

3. If the cells on the box have no goods, then we can open the door in the frame's back and put one good in the cell. Close the door and the robotic arm will check its color and grab it into corresponding cell.

3. Digital System Design

3.1 Introduction

In our project, we choose FPGA of Altera Corporation, which is an American manufacturer of programmable logic devices(PLDs), reconfigurable complex digital circuits [1]. What's more, FPGA is one of their main production, so there services are reliable.

What is an FPGA?
It is an acronym for field programmable gate array. It is a semiconductor IC where a large majority of the electrical functionality inside the device can be changed; changed by the design engineer, changed during the PCB assembly process, or even changed after the equipment has been shipped to customers out in the "field". [2]

The device we used is Cyclone II EP2C20F484C7N.

3.2 Functions of FPGA

FPGA controls all motors in our machine, including two 20kg digital servos, two 20kg analogue servos and a 3kg analogue servo motor (Six servos in total).

Servos are need to be adjust to a proper angle under FPGA's control and Mbed (Another developed board will be referred at next chapter) decided which angle should be. In this case, once FPGA received the instruction from Mbed, it will adjust specific servo motor to the right angle.

In maintain mode, FPGA can control each servo motor to let robot arm move to any point, based on the signal sent by Mbed.

3.3 Code structure

3.3.1 Overview

There are mainly three modules which are "servo", "rxtx" and "utra_servo".

1. **Module "servo"** is to set the basic parameter to control six servo motors (servo1, servo2, servo2p, servo3, servo3p, servo4)

2. **Module "rxtx"** is to receive signal from Mbed and send signal to Mbed (Although we didn't use the function that send signal to Mbed, but we reserve this function for future extension).

3. **Module "utra_servo"** has the highest hierarchy compare with "servo" and "rxtx". It combines module "servo" and "rxtx" which realize signal sent from Mbed control servos.

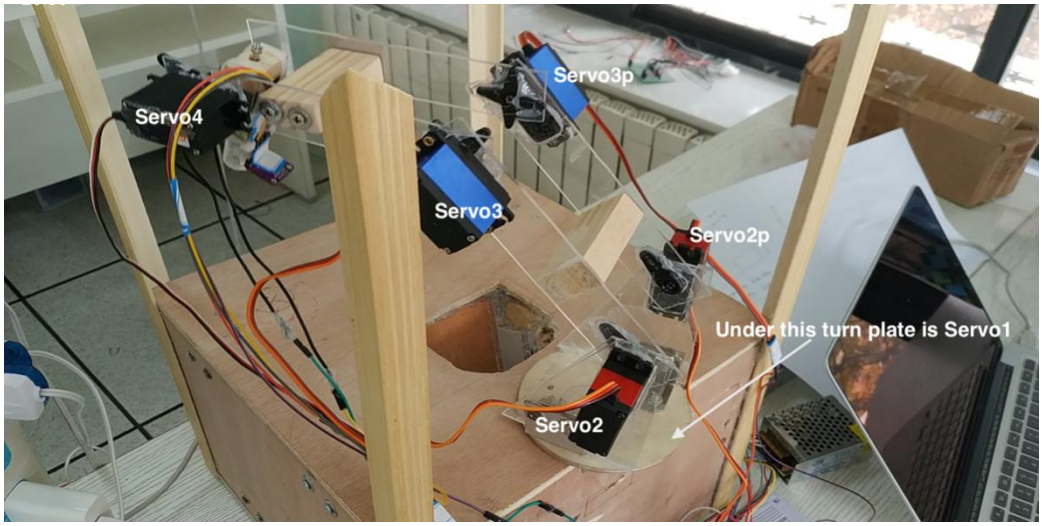


Figure 24 Servos' location

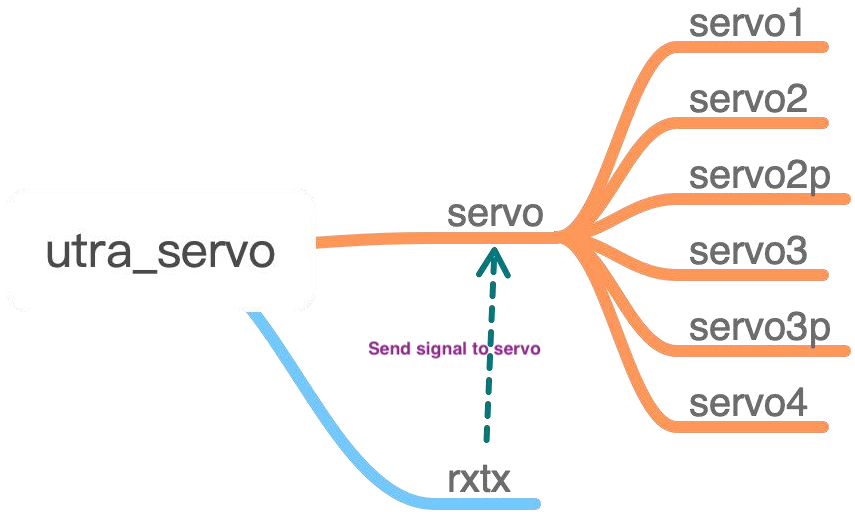


Figure 25 FPGA Code Structure

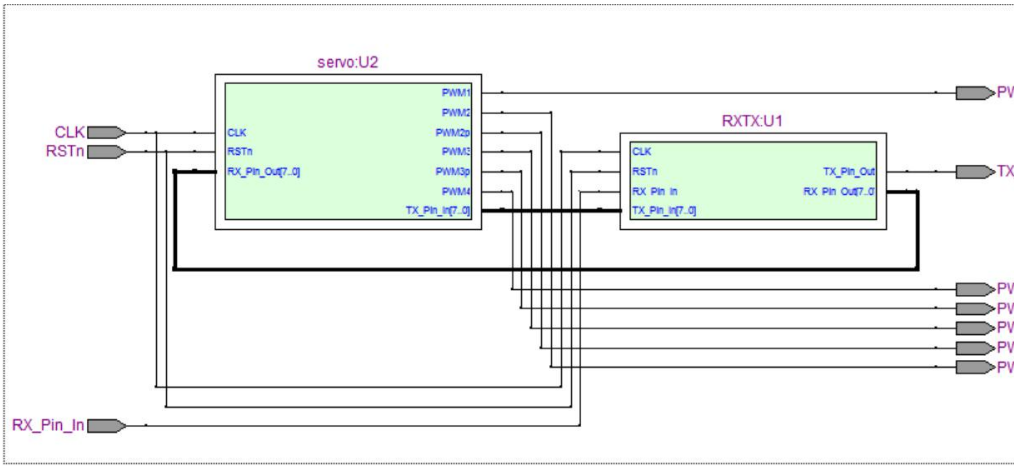


Figure 26 Block Diagram

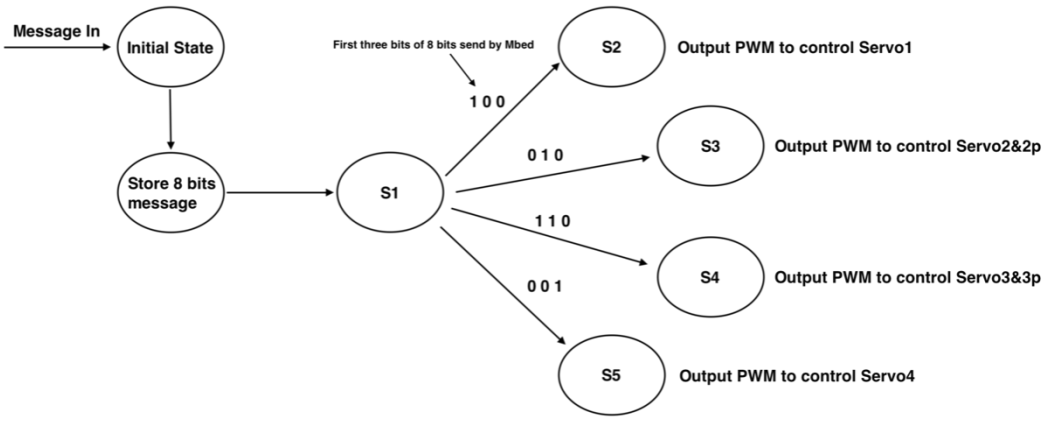


Figure 27 FSM Chart

3.3.2 Module "utra_servo"

The main function of this module is to link "servo" and "rxtx", so there is no actual content in this module.

```
1.  module utra_servo
2.  (
3.   CLK,   //Clock signal 50Hz
4.   RSTn,  //Reset signal
5.   RX_Pin_In, //Signal received from Mbed
6.   TX_Pin_Out,    //Signal sent by FPGA to Mbed
7.   PWM1,  // Signal control servo1
```

```
  PWM2,  // Signal control servo2
  PWM3,  // Signal control servo3
  PWM4,  // Signal control servo4
  PWM2p, // Signal control servo2p
  PWM3p  // Signal control servo3p
  );

input CLK;
input RSTn;
input RX_Pin_In;

output TX_Pin_Out;
output PWM1;
output PWM2;
output PWM3;
output PWM4;
output PWM5;
output PWM2p;
output PWM3p;

wire [7:0]RX_Pin_Out;
wire [7:0]TX_Pin_In;

RXTX U1 //rxtx module
(
 .CLK(CLK),
 .RSTn(RSTn),
 .RX_Pin_In(RX_Pin_In),
 .TX_Pin_In(TX_Pin_In),
 .RX_Pin_Out(RX_Pin_Out),
 .TX_Pin_Out(TX_Pin_Out)
 );

servo U2 //servo module
(
 .CLK(CLK),
 .RSTn(RSTn),
 .RX_Pin_Out(RX_Pin_Out),
 .PWM1(PWM1),
 .PWM2(PWM2),
 .PWM3(PWM3),
 .PWM4(PWM4),
 .PWM5(PWM5),
 .PWM2p(PWM2p),
```

```
52.  .PWM3p(PWM3p),
53.  .TX_Pin_In(TX_Pin_In)
54.  );
55.
56. endmodule
```

Figure 28 screenshot of code

3.3.3 Module “servo”

It contains six servo modules in “servo” module. They are “servo1”, “servo2”, “servo2p”, “servo3”, “servo3p” and “servo4”. The main part of each code almost same, the only different is the signal received. The first three bits of signal FPGA received will decide which servo motor should move. The chart below will show you in a intuitional way. And other six bits will decide which angle of servo motor supposed to be.

The First three Bits received	Servo1	Servo2&2p	Servo3&3p	Servo4
1 0 0	Move	--	--	--
0 1 0	--	Move	--	--
1 1 0	--	--	Move	--
0 0 1	--	--	--	Move

Chart 3.1

Here is a standard code used in “servo1”, “servo2” and so on.

```
1.  module servo2
2.  (
3.   CLK,
4.   RSTn,
5.   RX_Pin_Out,
6.   PWM2
7.   );
8.
9.  input CLK;  //Clock signal
10. input RSTn; //Reset
11. input [7:0]RX_Pin_Out; //Signal received from Mbed
12.
13. output PWM2;    //Output signal to servo motor
```

```
14.
15. parameter T33MS = 20'd166667; //3.3MS
16. parameter T1MS = 20'd50_000;    //1MS
17. parameter T2MS = 20'd100_000;   //2MS
18. parameter T005MS = 20'd2500;    //0.05MS
19.
20. reg [19:0]count1;   //counter
21.
22. always @(posedge CLK or negedge RSTn) //Count to 3.3ms
23. begin
24. if(!RSTn)
25. count1 <= 20'd0;
26. else if(count1 == T33MS)
27. count1 <= 20'd0;
28. else
29. count1 <= count1+1'b1;
30. end
31.
32. reg [19:0]dutycycle_init;
33.
34. always @(posedge CLK or negedge RSTn)   //Select one angle for servo2
35. begin
36. if(!RSTn)
37. begin
38. dutycycle_init <= T1MS+20*T005MS;
39. end
40. else if(RX_Pin_Out[7:5] == 3'b010)  //Judge whether the first three bits  o
    f signal is 010
41.     begin
42.     case(RX_Pin_Out)
43.     8'h0x41:
44.     begin dutycycle_init <= T1MS+20*T005MS; end //0
45.     8'h0x42:
46.     begin dutycycle_init <= T1MS+19*T005MS; end //1
47.     8'h0x43:
48.     begin dutycycle_init <= T1MS+18*T005MS; end //2
49.     8'h0x44:
50.     begin dutycycle_init <= T1MS+17*T005MS; end //3
51.     8'h0x45:
52.     begin dutycycle_init <= T1MS+16*T005MS; end //4
53.     8'h0x46:
54.     begin dutycycle_init <= T1MS+15*T005MS; end //5
```

```
    8'h0x47:
    begin dutycycle_init <= T1MS+14*T005MS; end //6
    8'h0x48:
    begin dutycycle_init <= T1MS+13*T005MS; end //7
    8'h0x49:
    begin dutycycle_init <= T1MS+12*T005MS; end //8
    8'h0x4A:
    begin dutycycle_init <= T1MS+11*T005MS; end //9
    8'h0x4B:
    begin dutycycle_init <= T1MS+10*T005MS; end //10
    8'h0x4C:
    begin dutycycle_init <= T1MS+9*T005MS; end //11
    8'h0x4D:
    begin dutycycle_init <= T1MS+8*T005MS; end //12
    8'h0x4E:
    begin dutycycle_init <= T1MS+7*T005MS; end //13
    8'h0x4F:
    begin dutycycle_init <= T1MS+6*T005MS; end //14
    8'h0x50:
    begin dutycycle_init <= T1MS+5*T005MS; end //15
    8'h0x51:
    begin dutycycle_init <= T1MS+4*T005MS; end //16
    8'h0x52:
    begin dutycycle_init <= T1MS+3*T005MS; end //17
    8'h0x53:
    begin dutycycle_init <= T1MS+2*T005MS; end //18
    8'h0x54:
    begin dutycycle_init <= T1MS+1*T005MS; end //19
    8'h0x55:
    begin dutycycle_init <= T1MS+0*T005MS; end //20
    endcase
    end
else begin dutycycle_init <= dutycycle_init; end //If the signal is not for
 servo2, it keeps static

end

assign PWM2 = (count1<dutycycle_init)?1:0;  //Output the dutycycle to contro
l servo2

endmodule
```

```
30.
31. reg [19:0]dutycycle_init;
32.
33. always @(posedge CLK or negedge RSTn) //Select one angle for servo2
34. begin
35.
36. if(!RSTn)   //Reset
37. begin
38. dutycycle_init <= T1MS+20*T005MS;
39. end
40.
41. else if(RX_Pin_Out[7:5] == 3'b010)
42. begin
43. case(RX_Pin_Out)
44. 8'h0x41:
45. begin dutycycle_init <= T1MS+20*T005MS; end
46. /***Here omit 19 cases, each of these cases coorponding to a anlge of servo2
    ***/
47. 8'h0x55:
48. begin dutycycle_init <= T1MS+0*T005MS; end
49. endcase
50. end
51.
52. else begin dutycycle_init <= dutycycle_init; end //If the message is not for
     servo2, the output not change
53.
54. end
55.
56. assign PWM2 = (count1<dutycycle_init)?1:0; //Output the dutycycle to contrl
    servo2
57.
58. endmodule
```

Figure 29 screenshot of code

There are something need to pay attention. The frequency of digital servo is 300Hz, not 50Hz. And servo2 in our system is a digital servo, so the period is 3.3ms not 20ms as usual.

3.3.4 Module "rxtx"

In this project, we use asynchronous serial communication. It can save lots of pins and enhance communication efficiency.

The asynchronous serial communication is not that complicated. It can send or receive a signal in eleven bits at once.

Bit	Function
0	Start bit
1~7	Data bits
9	Check bit
10	Stop bit

Chart 3.2

The default baud rate of Mbed is 9600 bps. So, we also need to set this up in our "rxtx" module.

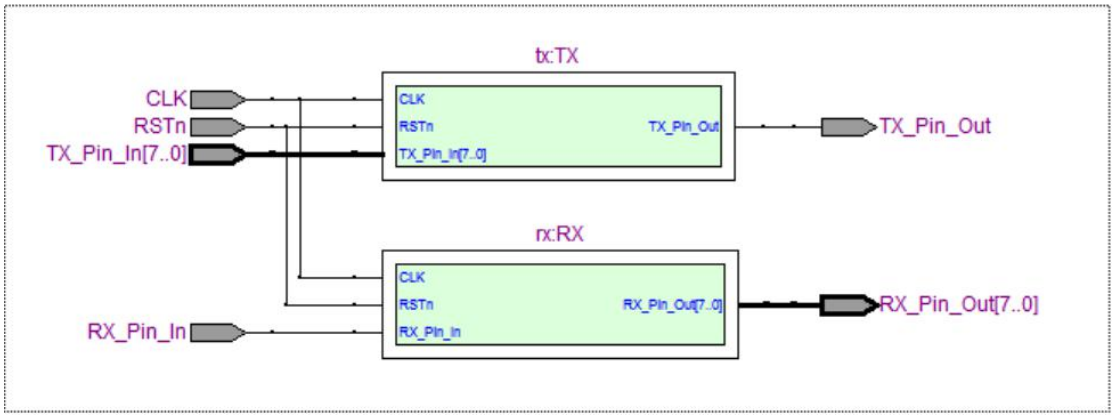


Figure 30 Block Chart For "rxtx" Module

Figure 3.3 clearly show this module. Pin "RX_Pin_Out" and "Tx_Pin_In" connect with FPGA , "RX_Pin_In" and "TX_Pin_Out" connect with Mbed.

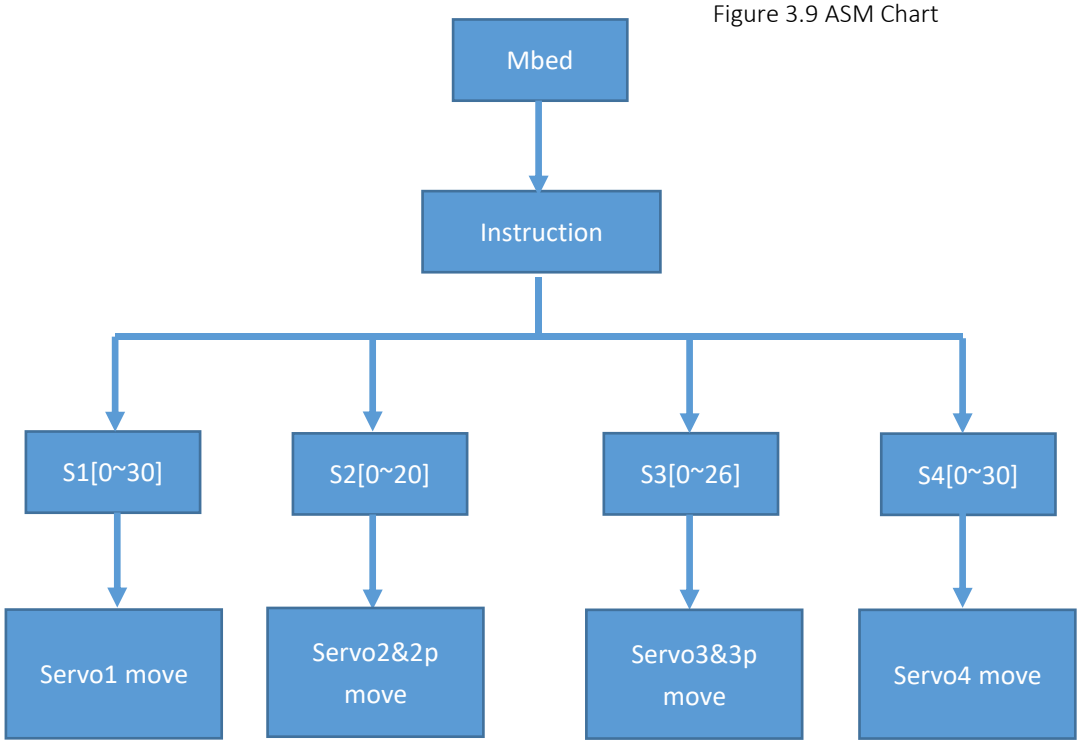
3.3.5 Pin Planning

Node Name	Direction	Location	I/O Bank	VREF Group	I/O Standard	Reserved
CLK	Input	PIN_L1	2	B2_N1	3.3-V LVTTL (default)	
PWM1	Output	PIN_B13	4	B4_N1	3.3-V LVTTL (default)	
PWM2	Output	PIN_B14	4	B4_N1	3.3-V LVTTL (default)	
PWM2p	Output	PIN_A15	4	B4_N1	3.3-V LVTTL (default)	
PWM3	Output	PIN_B15	4	B4_N1	3.3-V LVTTL (default)	
PWM3p	Output	PIN_A16	4	B4_N1	3.3-V LVTTL (default)	
PWM4	Output	PIN_B16	4	B4_N1	3.3-V LVTTL (default)	
RSTn	Input	PIN_R22	6	B6_N0	3.3-V LVTTL (default)	
RX_Pin_In	Input	PIN_A13	4	B4_N1	3.3-V LVTTL (default)	
TX_Pin_Out	Output	PIN_A14	4	B4_N1	3.3-V LVTTL (default)	

Figure 31 Pin Planning of FPGA

3.4 ASM Chart

Figure 3.9 ASM Chart



Each hexadecimal means the signal sent by Mbed, and it also corresponding to a right angle of a servo.

```
char s1[31] = {0x81, 0x82, 0x83, 0x84, // Control servo1
    0x85, 0x86, 0x87, 0x88,
    0x89, 0x8A, 0x8B, 0x8C,
    0x8D, 0x8E, 0x8F, 0x90,
    0x91, 0x92, 0x93, 0x94,
    0x95, 0x96, 0x97, 0x98,
    0x99, 0x9A, 0x9B, 0x9C,
    0x9D, 0x9E, 0x9F};
char s2[21] = {0x41, 0x42, 0x43, 0x44, // Control servo2 and servo2p at the same time
    0x45, 0x46, 0x47, 0x48,
    0x49, 0x4A, 0x4B, 0x4C,
    0x4D, 0x4E, 0x4F, 0x50,
    0x51, 0x52, 0x53, 0x54,
    0x55};
char s3[27] = {0xC1, 0xC2, 0xC3, 0xC4, // Control servo3 and servo3p at the same time
    0xC5, 0xC6, 0xC7, 0xC8,
    0xC9, 0xCA, 0xCB, 0xCC,
    0xCD, 0xCE, 0xCF, 0xD0,
```

```
    0xD1, 0xD2, 0xD3, 0xD4,
    0xD5, 0xD6, 0xD7, 0xD8,
    0xD9, 0xDA, 0xDB};
char s4[31] = {0x21, 0x22, 0x23, 0x24, // Control servo4
    0x25, 0x26, 0x27, 0x22,
    0x29, 0x2A, 0x2B, 0x2C,
    0x2D, 0x2E, 0x2F, 0x30,
    0x31, 0x32, 0x33, 0x34,
    0x35, 0x36, 0x37, 0x38,
    0x33, 0x3A, 0x3B, 0x3C,
    0x3D, 0x3E, 0x3F};
```

Figure 32 screenshot of code

4. Software Design

4.1 Mbed

4.1.1 Introduction

Mbed is a platform and operating system for internet-connected devices based on 32-bit ARM Cortex-M microcontrollers. Such devices are also known as Internet of Things devices. The project is collaboratively developed by Arm and its technology partners. [3]

Applications: Applications for the Mbed platform can be developed using the Mbed Online IDE, a free online code editor and compiler. Only a web browser needs to be installed on the local PC, since a project is compiled on the cloud, i.e. on a remote server, using the ARMCC C/C++ compiler. The Mbed IDE provides private workspaces with ability to import, export, and share code with distributed Mercurial version control, and it can be used also for code documentation generation. Applications can be developed also with other development environments such as Keil μVision, IAR Embedded Workbench, and Eclipse with GCC ARM Embedded tools.

Mbed OS: Mbed OS provides the Mbed C/C++ software platform and tools for creating microcontroller firmware that runs on IoT devices. It consists of the core libraries that provide the microcontroller peripheral drivers, networking, RTOS and runtime environment, build tools and test and debug scripts.

The type specification we used is LPC1768. More information about it can visit Mbed official website. [4]

4.1.2 Functions of Mbed

Mbed is a bridge between PC and FPGA, it also control numbers of sensors to keep whole system operating well.

Basic functions:

1. Receive data send by PC and execute corresponding operations.
2. Send data to PC to let PC know current state of the system.
3. Receive the data sent by distance sensor to judge whether customer is leave or not and also judge whether customer is too close to the machine.
4. Receive the data sent by colour sensor, to Judge whether there has goods.
5. Send use ID received from Photo Electric Gate to PC
6. Control electromagnet to "pick up" or "loose" goods by using relay.
7. Send data to FPGA to control servo motors to realise movement of robot arm.

Our system has two mode, one is **operational mode** and another is **maintain mode**.
Operational mode is for customer to take part in this game and maintain mode in our system has two main functions **stock mode** and **detect mode**.

Stock mode is convenient for administrator to stock if the goods were empty.

Detect mode is for administrator to move each servo motor to detect whether there has servo motor was broken and receive distance sensor and colour sensor's data to judge whether these sensors are working well.

4.1.3 Code structure

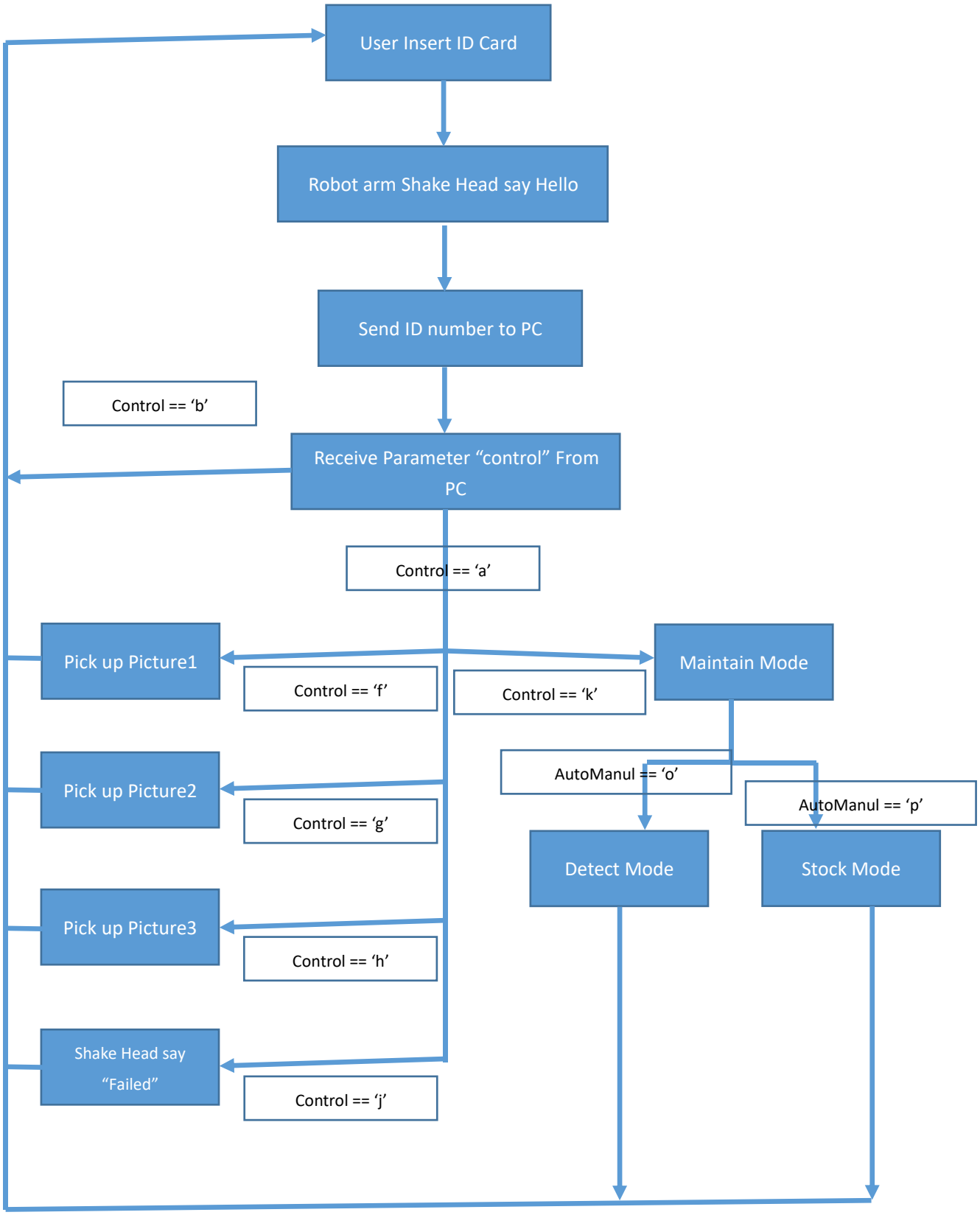


Figure 33 Code Structure for Mbed

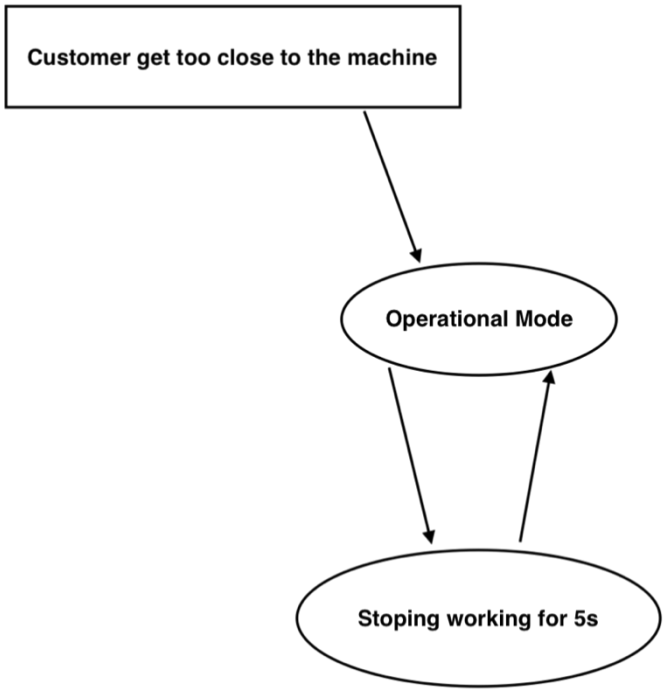


Figure 34 Interrupt situation 1

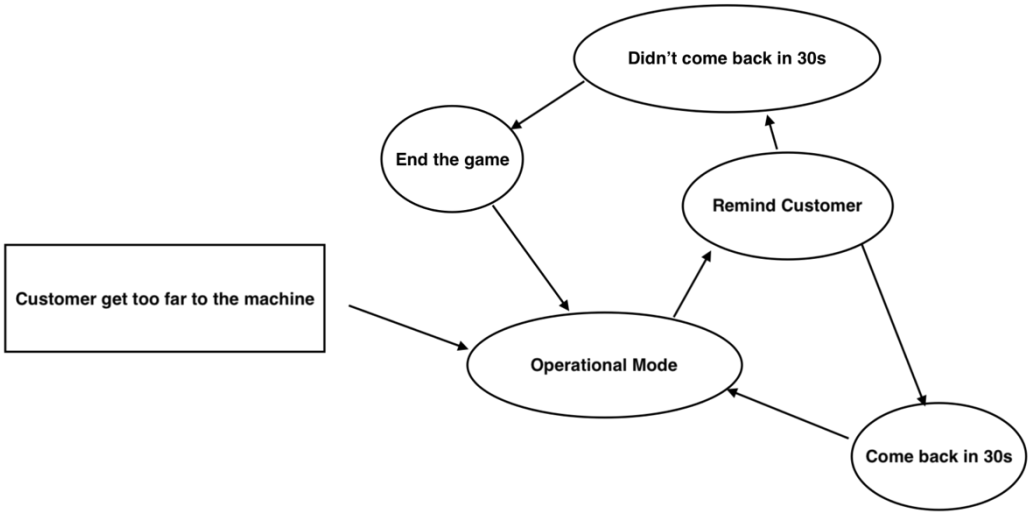


Figure 35 Interrupt situation 2

Pseudocode:

```
int main() {
    while(1) {

        //judge the user ID through infrared ray sensor
        shakehead();
         control = pc.getc();// to receive a char, to decide whether this is a legal user

        if(control == 'a') {
             control = pc.getc();    //ask pc to send char 'f' 'g' 'h' 'i' 'j'
            if(control == 'f') {    //Pick up picture1
                picture1();
            }
            else if(control == 'g') {       //Pick up picture2
                picture2();
            }
            else if(control == 'h') {       //Pick up picture3
                picture3();
            }
            else if(control == 'j') {       //Pick up picture4
                picture4();
            }
            else if(control == 'k') {
                maintain();//Maintain mode
            }
            else if(control == 'c') {
                stock();
            }
            else if(control == 'j') {failed();}     //do nothing
        }
        else if(control == 'b') {;}//Do nothing
    }

}

void maintain(void) {
    while(1) {
        AutoManual = pc.getc();
        if(AutoManual == 'o') {
            StockMode
        }
```

```
41.         else if(AutoManual == 'p') {
42.             DetectMode
43.         }
44.     }
45. }
```

Figure 36 screenshot of code

All functions contained in Mbed

void distancesensor();

a) This function will keep calling during the whole game. When customer is disappear, it would call function **customerdisappear()**. When customer is getting too close to the machine, it will call function **distanceprotect()**.

void distancesensorMaintain()

b) This function will provide distance information in **Detect Mode.**

void customerdisappear()

c) This function will tell PC that the customer is disappear and remind customer to get close to the machine. If customer doesn't show up in 30s, it will reset the game by machine itself.

void distanceprotect()

d) When this function been called, the all system will stop for 5s (Including robot arm in moving), and warn customer not get too close to the machine to avoid damage.

void colorsensor()

e) This function will wake up colour sensor and detect colour. It mainly work when robot arm need to detect whether there has goods, if there is no goods, colour sensor would detect white, however, if there has goods, it the colour corresponding to the goods must be detected.

void picture1()

f) Pick up the first kind of goods, it contain the picture of the first result.

void picture2()

g) Pick up the second kind of goods, it contain the picture of the first result.

void picture3()

h) Pick up the third kind of goods, it contain the picture of the first result.

void bufferS2(int x)

i) This function was used to slow down the movement of servo2 and servo2p, make

its movement more smooth.

void bufferS3(int x)

j) This function was used to slow down the movement of servo3 and servo3p, make its movement more smooth.

void pickup_away(int x)

k) This function executed when the good has been picked up. This function will deliver the good to the hole of exit.

void reset()

l) This function will make robot arm go to the initial position

void stock()

m) This function will let robot arm to stock goods.

void maintain()

n) Get into the maintain mode

void shakehead()

o) Let robot shake head to say hello

void failed()

p) Let robot arm shake head to represent failed.

void redlight()

q) Let LED shine red light

void greenlight()

r) Let LED shine green light

void bluelight()

s) Let LED shine blue light

void whitelight()

t) Let LED shine white light

4.2 PC

4.2.1 Introduction

The program running in the PC provides the interface of user and machine.The interface of our company needs to identify user identity and turn user's operation into software or hardware action.

The operation mode running in the PC can be divided into two modes, maintain mode and user mode. In the maintain mode, operators can detect the work state of every part and automatic replenishment of goods. And for the user mode, user can follow the instruction to experience the whole game and gain related present.

Our PC work is based on Visual Studio 2017 .NET framework. Our program satisfies the following requirements:

Operate mode:

1. Switch language between English and Chinese.
2. Using voice to provide more convenient hints, and display information on the screen.
3. User information can be easily add or modify in the database.
4. A help button tells the user how to finish the game
5. A button to add item automatically.
6. The user can leave when the game is finished, the program will return back to main page. Hence for every user the page they see is always the first one
7. The system is able to detect the distance of user and provide necessary prompt to ask user step forward or move further. Once the user leaves too long i n the middle of the game, the system will also return to the start page.

Maintain mode:

1. One button operation to identify problems. The robot arm will pick up items with a single request. Then the operator will observe the position of problem.
2. Using manual maintain mode, very part of the machine can be debugged. And based on the operation mode of each part, we can repair or change them.
3. Different kind of sensors can be tested and the value will display on the screen and the operator can fix them.
4. Provide a window to test the port communication. And if the problem occurs in PC program we can use the window to make sure that all parts in the hard ware work well

4.2.2 Structure

1. main structure

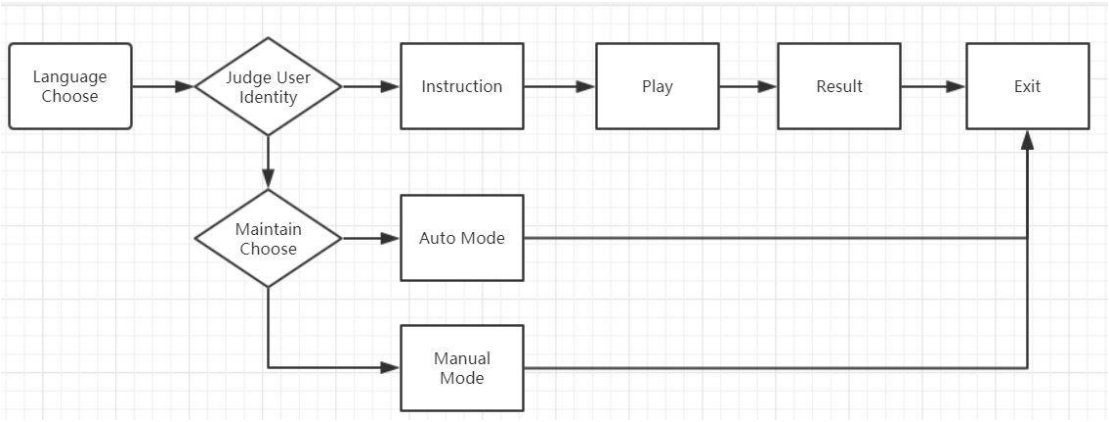


Figure 37 Structure for PC - overview

2. identity check

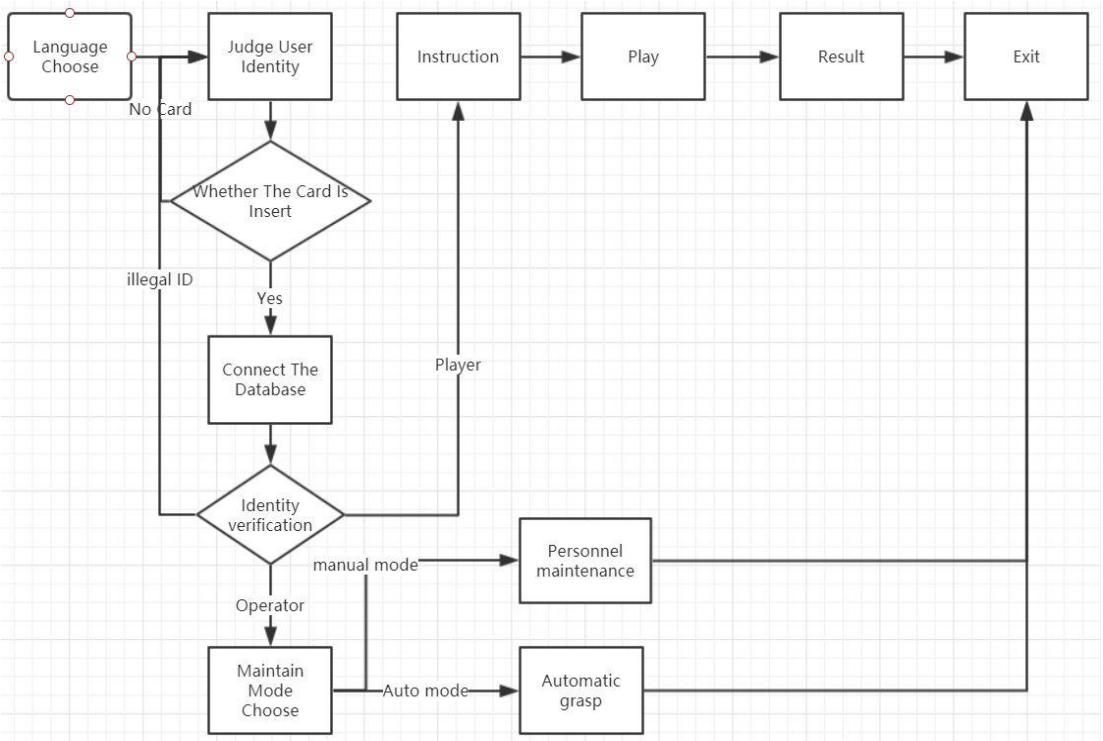


Figure 38 Structure Diagram for PC - identity check

3. Game structure

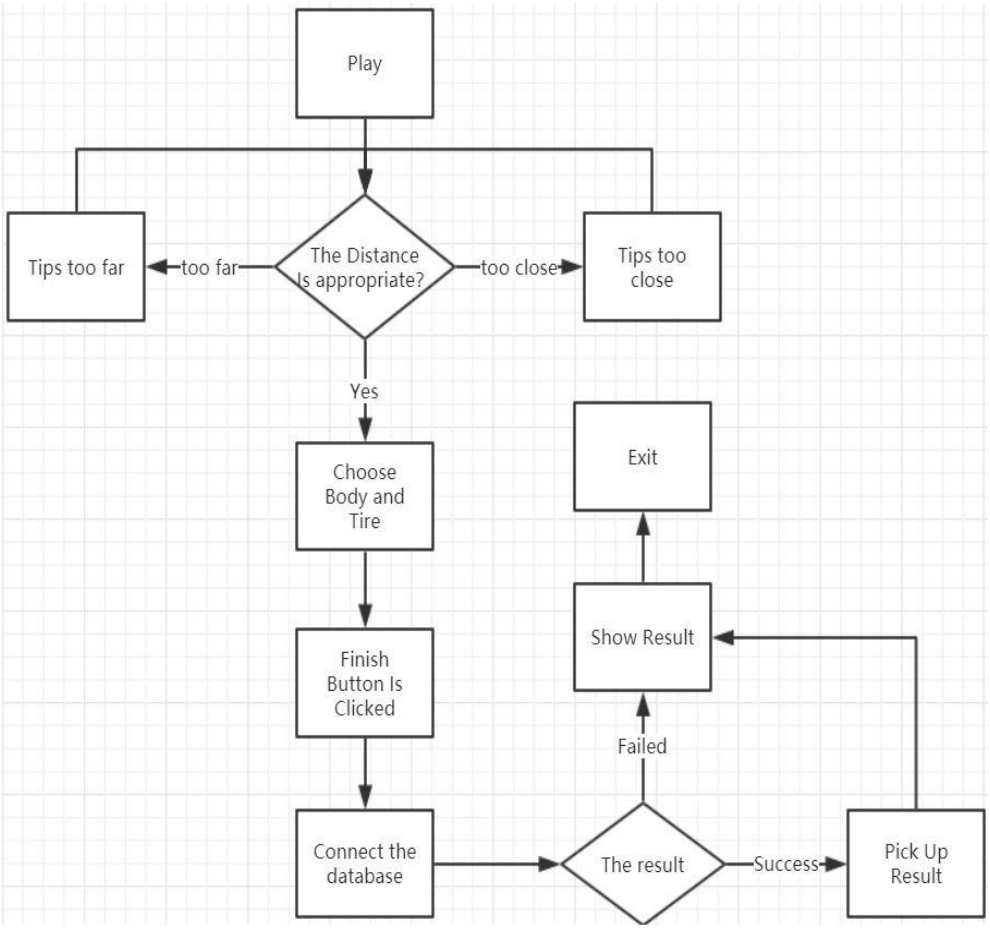


Figure 39 Structure Diagram for PC - Game

4.2.3 Functions

Here we just list some of the functions for more details please go through the whole program.

1. Language choose

At the welcome page, users are asked to choose a language to start the game. Once the language is chosen, the following page will present related information based on the language you first choose.

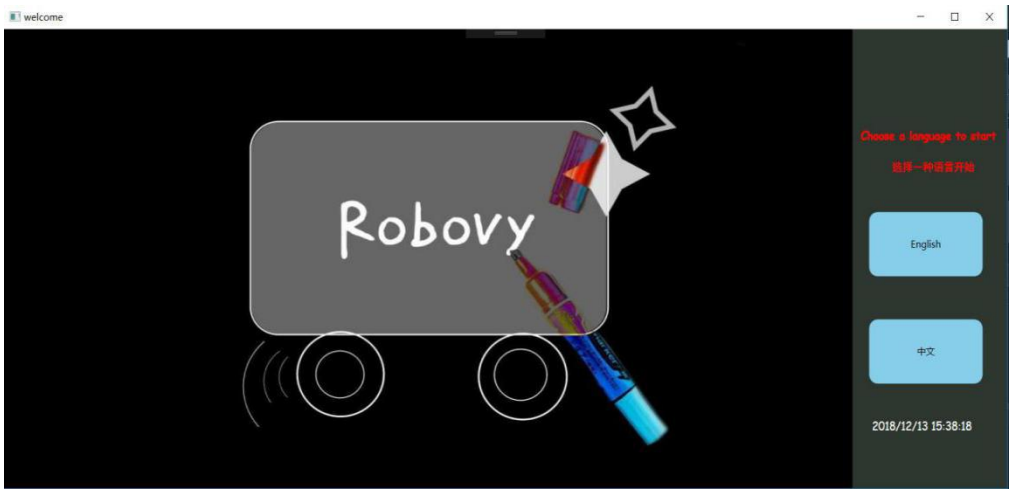


Figure 40 Welcome Page for PC

2. Voice prompt function

At the beginning of each page, we will have voice prompt users' rules of using this page. If the user is far away or too close to the machine, the machine will also have voice prompts.

```
1.  public static SpeechSynthesizer Synth = new SpeechSynthesizer();//read some text by computer
2.  MediaPlayer player = new MediaPlayer();  //play the video made by teammate
3.  Synth.Speak("Too Far Come Close");  //when the user is standing too close, computer will give a tip
4.  player.Open(new  Uri("C:/Users/source/repos/Version2/Version2/Resources/match.mp3",  UriKind.Relativ
    eOrAbsolute)); //the path of video
5.  player.Volume = (Double)0.99;  //the volume of the speaker
6.  player.Play();//start to read
```

Figure 41 screenshot of code

3. Database function

The database used by the project is SQL Server 2012 version. We need database to store information including user identity and the final result. Modify and add information can be easily achieved by altering the information in the database. And the code in the program can remain unchanged.

```
1.  public bool look_up(string ID)
2.  {
3.  string str = @"Data Source=DESKTOP-52V8CBO;Initial catalog=data1220;integrated Security=True";
        // we offer the information of database and give the security rank for login in
4.  SqlConnection conn = new SqlConnection(str);
5.  conn.Open(); //open the communication channel
6.  string queryString = "SELECT 用 户 名 FROM dbo.Students where ID 号
    码 = " + ID;                    // request for the information
7.  SqlCommand command = conn.CreateCommand();
```

```
command.CommandText = queryString;  //give the database our request
SqlDataReader reader = command.ExecuteReader();
result = null;   //the result database will return
while (reader.Read())
//convert the information we get to string in order to deal with the following steps
{
result += reader.GetString(0);
 }
  conn.Close();   //close the connection when the work is done
 Check_out(result.Trim());  //check the identity of the user
   return true;
}
```

Figure 42 screenshot of code

用户名	ID号码		
李涵	0001	no	1011
尤元岳	0010	no	1100
王垚凯	0011	no	1001
崔航奇	0100	no	1010
马恩泽	0101	no	1101
王一鸣	0110	no	1110
夏泽禹	0111	yes	1111
万晓奇	1000	no	0000

Figure 43 Database of user identity

Countdown function

During the game, if user leave for a long time, the hardware will send PC a letter represent the loss of user and we quit. In the final result page, we give user a limitation that there is only 5s to read their result(if they failed).

```
DispatcherTimer Timer = new DispatcherTimer();
Timer.Tick += new EventHandler(disTimer_Tick);  //the countdown function will not affect main progress
Timer.Interval = new TimeSpan(0, 0, 0, 1);  //the interval of each count down is 1s
Timer.Start();  //start timing
void disTimer_Tick(object sender, EventArgs e)
    {
        if (count == 0)  //if the counting is over we will close the current page
        {
            MainWindow f1 = new MainWindow();
            f1.Show();
            CurrentPort.Close();
            this.Close();
            count--;
```

```
        }
        else
        {
            count--;
            label2.Content = "there is " + count + "s left to leave this page";
        }
    }
```

Figure 44 screenshot of code

4. Serial port communication function

We need all kinds of sensor data to trigger the program, and the program needs to control the progress of the hardware by transmitting data.When the interface is loading, we need to connect Mbeb to complete the next task.

```
public static SerialPort CurrentPort = new SerialPort();  //declare a serial port
CurrentPort.PortName = "COM7";          //offer the information of port
CurrentPort.BaudRate = 9600;
CurrentPort.DataBits = 8;
```

Figure 45 screenshot of code

We need to send or receive messages through the serial port. At this point, we need to establish a delegate to realize the return of data.

```
public delegate void HandleInterfaceUpdataDelegate(string text);
private HandleInterfaceUpdataDelegate interfaceUpdataHandle;
Message_to_send = "a";          //the message we want to send
Serial();                       //call other function to achieve data send
private void Serial()
{
  //here we add a thread, when there is a data received, a function will start automatically
 CurrentPort.DataReceived += new SerialDataReceivedEventHandler(Sp_DataReceived);
 if (!CurrentPort.IsOpen)  //here we detect whether the port is open
 {
 CurrentPort.Open();
 }
 SendBytesData(CurrentPort);   //operate the send function
 }
```

```
15.  public static void SendBytesData(SerialPort Sp)
16.   {
17.    //we set that the information send and receive should all decoded by ASCII code
18.    byte[] bytesSend = Encoding.ASCII.GetBytes(Message_to_send);
19.    //write the data one by one to the port
20.    Sp.Write(bytesSend, 0, bytesSend.Length);
21.    }
22.    //this function is activated when there is a message comes in
23.  private void Sp_DataReceived(object sender, System.IO.Ports.SerialDataReceivedEventArgs e)
24.  {
25.    SerialPort serialPort = (SerialPort)(sender);
26.    //Delay for a while to prevent clutter of cached data caused by hardware sending rate not keepin
   g up with cached data
27.    System.Threading.Thread.Sleep(100);
28.    //Record first to avoid some reason, human reason, long time between operations, cache inconsist
   ency
29.     int n = serialPort.BytesToRead;
30.     //Declare a temporary array to store current serial data
31.      byte[] buf = new byte[n];
32.      serialPort.Read(buf, 0, n);//Read buffered data
33.      //To access UI resources, you need to synchronize UI using invoke
34.      interfaceUpdataHandle = new HandleInterfaceUpdataDelegate(UpdateTextBox);
35.      //Instantiating delegate objects
36.       Dispatcher.Invoke(interfaceUpdataHandle, new string[] { Encoding.ASCII.GetString(buf) });
37.      }
38.  private void UpdateTextBox(string text)
39.       {
40.       textBox1.Text += text.Trim();   //update the information we received
   }
```

Figure 46 screenshot of code

4.2.4 GUI Layout

The background is very simple and we want to simplify the operate procedure. Hence all buttons and boxes are very obvious.
All pages include buttons, textbox, labels, images, listboxs, radiobuttons, and messagebox.

Here we will introduce three main interfaces including login page, information page and manual maintain page.

1. login page

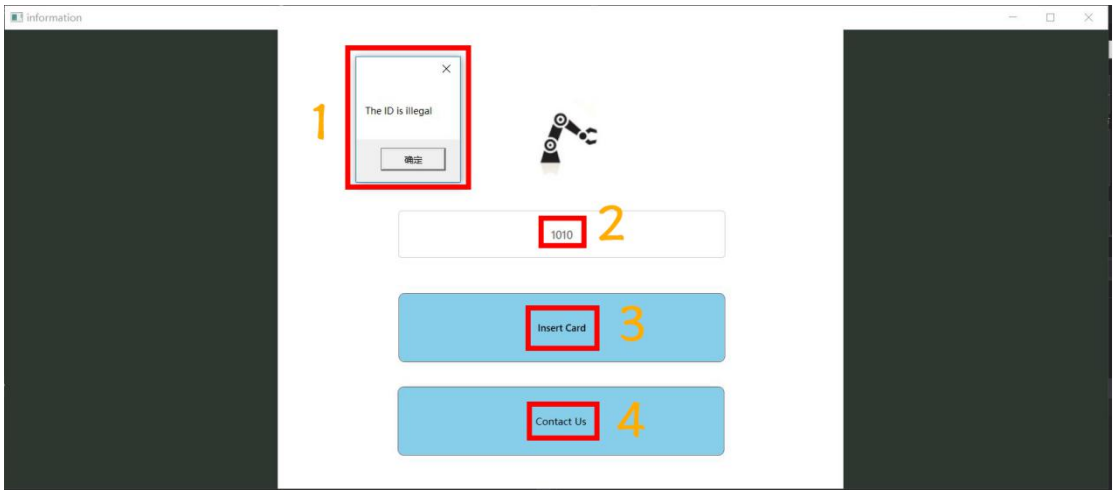


Figure 47 Screenshot of Login Page

Messagebox1: if the ID card number is illegal, there will a message appear telling the information and also there is a voice tip here to instruct the user to insert again.

Textbox2: the textbox will show the ID we have detected if the ID is illegal, if the ID is reserved before, we will automatically enter that page.

Button3: when pressing the button, mbed will detect the card information inserted by user, compare the returned value with the data in the database, and then enter the corresponding interface.

Button4: When the button is pressed, the system opens the company web page for the user.

2. Game page

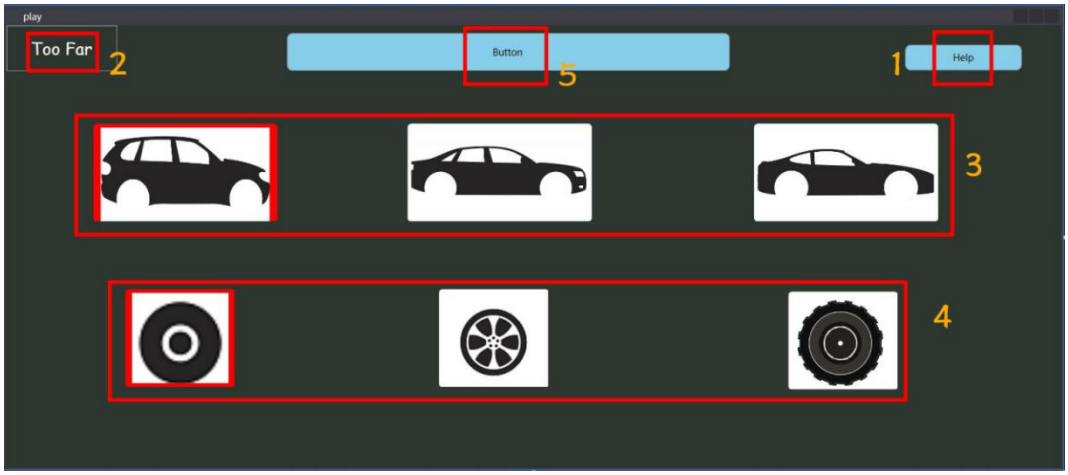


Figure 48 Screenshot of Game Page

Button1: if the user do not know how to choose the items, they can click this button and then the tip will show up.

Textbox1: The content of which indicates the state of user distance. Whenever user distance changes, the information in Textbox changes. We also use voice to prompt

the user's current distance.

Listbox2: There are three radiobutton included in the listbox, at the beginning the first one is chosen and we can make sure that only one car body can be chose for one game.

Listbox3: There are three radiobutton included in the listbox, at the beginning the first one is chosen and we can make sure that only one tire can be chose for one game.

Button4: After picking up, user can click confirm button to updata their choice. However the enabled of button is false when the distance is not in the legal scope. Hence user can not finish their game with an inappropriate distance.

3.Manual maintenance

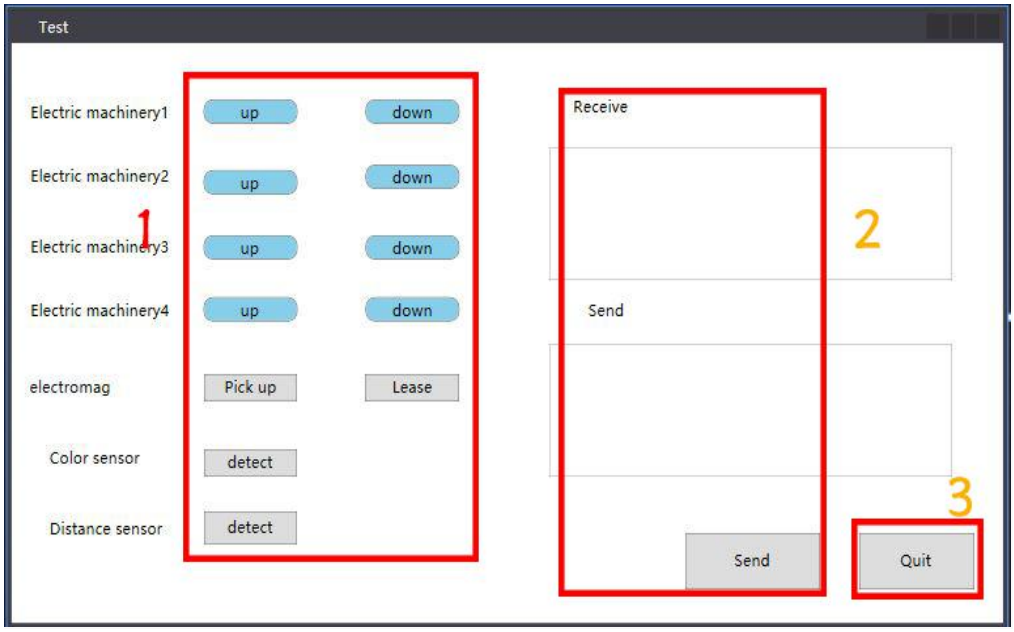


Figure 49 Screenshot of Maintenance page

Button 1: The buttons list here can directly control most of the devices in our program

Area2: It includes two textboxs, two labels and a button. One of the textbox is used to present the information received from Mbed and we can use the Send area to test the communication between Mbed and PC.

Button3: After the maintenance, we should click Quit to go back to first page.

4.2.5 Overview

Strength

1. The whole system is complete and all functions are covered.

2. The respond time is quit short. Once the button is clicked, the page will react immediately. And the whole program will not take up much memory.
3. Every step will be instructed by voice prompt, so the user will know what to do next.
4. Provide two type of maintain mode, through different kind of mode we can find different problems.

Weakness

1. There is no moving graph or video included in the program
2. Button has no effect and the background is quit similar for every page.
3. During the information check and game time, there are plenty of information exchange and they may conflict each other.

4.3 Communication

4.3.1 Mbed

Mbed has given the functions for asynchronous serial communication. Mbed total have four serial port, three of them through pins and one of them through USB cable. Since two of serial port also work for I2C, so, only pin 13 and pin 14 can connect with FPGA and use USB cable to connect with PC. Chart 4.1 shows the specific serial port API in Mbed.

Functions	Application
Serial	Establish a serial port and connect to specific pins
baud	Set up baud rate of serial port
format	Set up the format of transformation
putc	Write a character
getc	Read a character
printf	Write format characters
scanf	Read format characters
readable	Decide whether there has character to read
writeable	Decide whether there has character to write
attach	Attach a function, when interrupt happens, call this function

Chart 4.1

So, first we need to make a declaration at beginning: "Serial pc(USBTX, USBRX)" and "Serial FPGA(p13,p14)".
And use "pc.putc(), pc.printf, FPGA.putc(), FPGA.printf()" to send message to PC and FPGA. Using "pc.getc(), pc.scanf()" to receive message from PC.

4.3.2 Protocol

4.3.2.1 PC to Mbed

Chart 4.2

	PC Send	Mbed Send	Meaning
information	g		Robotic arm nods to indicate the arrival of the user
	a		enter normal mode
	b		enter maintain mode
play		h	the user is too close
		n	Distance after backwards is good
		e	the user leaves too long, Quit to original
		c	Distance after move forward is good
		d	the user is too far
	g		graph 1
	h		gragh 2
	f		graph 3
	j		Robotic arm Shaking Head Displays Game Failure
Stock	k		current mode is Maintain mode
	o		current mode is Stock mode
	q		Reload the first item
	v		Go back to original page
Detect	q,a		Control motor 1 up or down
	w,s		Control motor 2 up or down
	e,d		Control motor 3 up or down
	r,f		Control motor 4 up or down
	y,u		electromagnet drop or down
	h		color sensor
	j		distance sensor
	k		Quit

4.3.2.2 Mbed to PC

Operational Mode

1. Send "%c%c%c%c"
   - Tell the IC code that card reader detected
2. Send 'h' to PC

- Tell PC customer is getting to close to machine

3. Send 'n' to PC
   - Tell PC customer is not too close to machine anymore
4. Send 'c' to PC
   - Tell PC that customer was left
5. Send 'e' to PC
   - Tell PC that after 30s customer still not come back, we can end the game
6. Send 'd' to PC
   - Tell PC that customer has came back in 30s, we can continue the game
7. Send 'm' to PC
   - All instructions has been executed, game can be ended

Maintain Mode

1. Send "Red\n", "Green\n", "Blue\n" or "White\n" to PC
   - Tell PC the colour of colour sensor detected
2. Send "%d\n"
   - Tell PC the distance of distance sensor detected

4.3.2.3 Mbed to FPGA

Mbed use a serial port to communicate with FPGA to control total six servos to realise robot arms movement. Here is the instruction chart for Mbed to send.

Position	Servo1	Servo2&2p	Servo3&3p	Servo4
Position1	0x81	0x41	0xC1	0x21
Position2	0x82	0x42	0xC2	0x22
Position3	0x83	0x43	0xC3	0x23
Position4	0x84	0x44	0xC4	0x24
Position5	0x85	0x45	0xC5	0x25
Position6	0x86	0x46	0xC6	0x26
Position7	0x87	0x47	0xC7	0x27
Position8	0x88	0x48	0xC8	0x28
Position9	0x89	0x49	0xC9	0x29
Position10	0x8A	0x4A	0xCA	0x2A
Position11	0x8B	0x4B	0xCB	0x2B
Position12	0x8C	0x4C	0xCC	0x2C
Position13	0x8D	0x4D	0xCD	0x2D
Position14	0x8E	0x4E	0xCE	0x2E
Position15	0x8F	0x4F	0xCF	0x2F
Position16	0x90	0x50	0xD0	0x30
Position17	0x91	0x51	0xD1	0x31
Position18	0x92	0x52	0xD2	0x32
Position19	0x93	0x53	0xD3	0x33

Position20	0x94	0x54	0xD4	0x34
Position21	0x95	0x55	0xD5	0x35
Position22	0x96		0xD6	0x36
Position23	0x97		0xD7	0x37
Position24	0x98		0xD8	0x38
Position25	0x99		0xD9	0x39
Position26	0x9A		0xDA	0x3A
Position27	0x9B		0xDB	0x3B
Position28	0x9C			0x3C
Position29	0x9D			0x3D
Position30	0x9E			0x3E
Position31	0x9F			0x3F

Chart 4.3 instruction list

5. Sensor System

5.1 Overview Diagram and System Layout

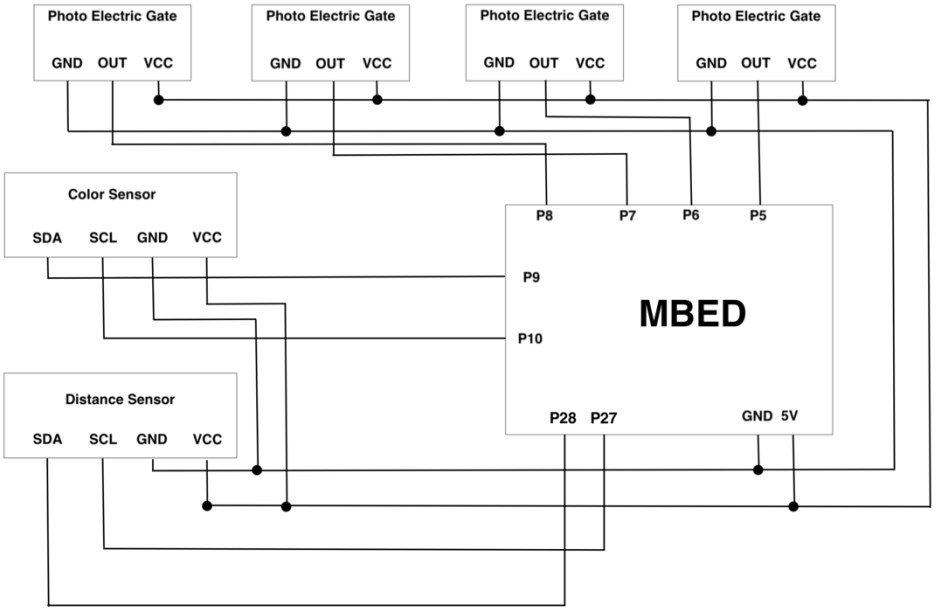


Figure 50 Overview of Mbed Structure

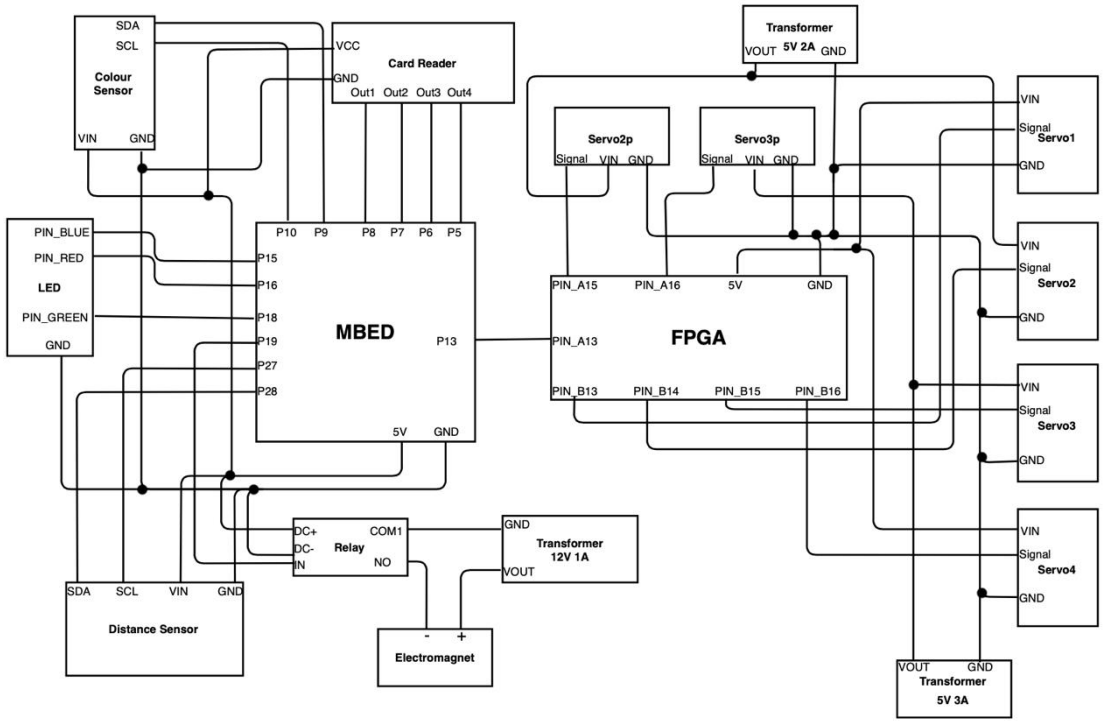


Figure 51 Whole System Layout

5.2 Card Reader

5.2.1 Introduction

The sensor we used is Photo Electric Gate, produced by Risym company in China. Figure 5.1 clearly show what it looks like.

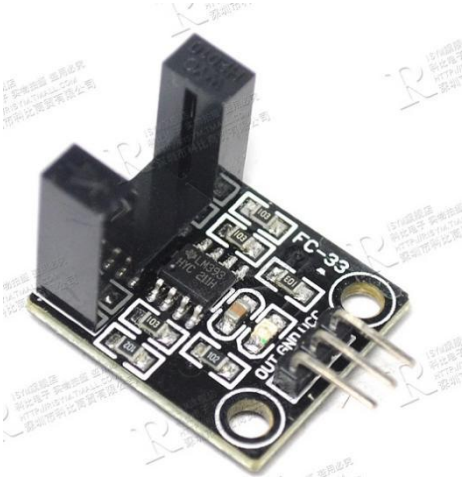


Figure 52 PEG

It has three pins, VCC is connect with positive pole of Mbed, it can connect with 3.3V~5V power. GND should connect with negative pole of Mbed. OUT is the output signal send by itself to Mbed.

The working principle is shown in Figure 5.2, if there is no card, receiver can receive infrared ray, and pin "OUT" would send '0' to Mbed. However, when card appeared, receiver could not receive infrared ray and then, pin "OUT" would send '1' to Mbed.

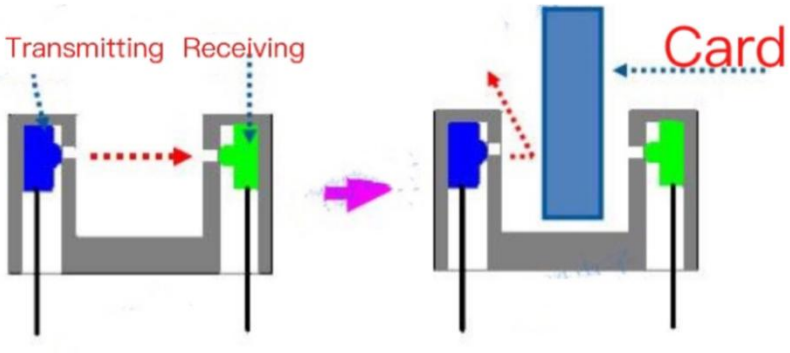


Figure 53 Schematic Diagram of PEG

5.2.2 Test and Data Recording

It was very sensitive in every environment in daily life. It hasn't appeared error before, so, we just use it directly and unnecessary to record data.

5.2.3 Code

```
/**Infrared Ray sensor**/
DigitalIn ir1(p5);
DigitalIn ir2(p6);
DigitalIn ir3(p7);
DigitalIn ir4(p8);

char id[4];//User ID

if(ir1 == 1) {
    id[0]='1';
}
else
id[0]='0';
if(ir2 == 1) {
    id[1]='1';
}
else
id[1]='0';
if(ir3 == 1) {
    id[2]='1';
}
else
id[2]='0';
if(ir4 == 1) {
    id[3]='1';
}
else
id[3]='0';

pc.printf("%c%c%c%c\n", id[0],id[1],id[2],id[3]); //Send the ID message to PC
```

Figure 54 screenshot of code

5.3 Color Sensor

5.3.1 Introduction

The color sensor we used is TCS34725, which has RGB and Clear light sensing element. An IR blocking filter, integrated on-chip and localized to the color sensing photodiodes, minimized the IR spectral component of the incoming light and allows color measurements to be made accurately. [5]

Figure 55 Colour Sensor

It support 3.3V and 5V input, so we can connect them directly to Mbed. In our system, we only need to connect four pins of TCS34725 to Mbed.

- VIN >> 5V
- GND >> GND
- SDA >> PIN 9
- SCL >> PIN 10

Mbed complier also provide open source libraries. It contained TCS34725's library. So, it much easier to use TCS34725 colour sensor after import **#include "TCS3472_I2C.h".**

5.3.2 Testing and Data Recording

Colour sensor is tend to be affect by light intensity in a giant degree. So we need to improve error tolerant rate by using a better algorithm. We establish a three-dimensional coordinate. The origin data can get from test, and then, every time colour sensor get data, they will do the calculations and compare which colour is much close to this data.

Colour / RGB Value	Red	Green	Blue
Red	682	43	32
Green	278	284	191
Blue	419	520	497
Environment Light	57	43	32

In the future, we will design a black box covering the colour sensor to reduce the influence by environment

5.3.3 Code

```
1.  //Initialize the color sensor
2.  rgb_sensor.enablePowerAndRGBC();
3.  rgb_sensor.setIntegrationTime( 200 );
4.  rgb_sensor.setRGBCGain(1);
5.
6.  void colorsensor(void) {
7.      int R,B,G,P,W;
8.      int red=0;
9.      int green=0;
10.     int blue=0;
11.     rgb_sensor.getAllColors( rgb_readings );
12.     red = rgb_readings[1];
13.     green = rgb_readings[2];
14.     blue = rgb_readings[3];
15.     W = (red-57)*(red-57)+(green-43)*(green-43)+(blue-32)*(blue-32);
16.     R = (red-682)*(red-682)+(green-184)*(green-184)+(blue-166)*(blue-166);
17.     G = (red-287)*(red-287)+(green-284)*(green-284)+(blue-191)*(blue-191);
18.     B = (red-419)*(red-419)+(green-520)*(green-520)+(blue-497)*(blue-497);
19.     if(R<B&&R<G&&R<P&&R<W) {
20.         colorflag = 1;//red
21.         redlight(); // LED will be red
22.     }
23.
24.     else if(G<R&&G<B&&G<P&&G<W) {
25.         colorflag = 2;//green
26.         greenlight(); // LED will be green
27.     }
28.     else if(B<R&&B<G&&B<P&&B<W) {
29.         colorflag = 3;//blue
```

```
30.         bluelight();  // LED will be blue
31.     }
32.     else if(W<R&&W<B&&W<G&&W<P) {
33.         colorflag = 5;//white
34.         whitelight();  // LED will be white
35.     }
36.
37.     return;

}
```

Figure 56 screenshot of code

5.4 Distance Sensor

5.4.1 Introduction

The VL6180X is the latest product based on ST's patented $FlightSense^{TM}$ technology. This is a ground-breaking technology allowing absolute distance to be measured independent of target reflectance. Instead of estimating the distance by measuring the amount of light reflected back from the object (Which is significantly influenced by colour and surface), the VL6180 precisely measures the time the light takes to travel to the nearest object and reflect back to the sensor (Time-of-Flight)

Combining an IR emitter, a range sensor and an ambient light sensor in a three-in-one ready-to-use reflowable package, the VL6180X is easy to integrate and saves the end-product maker long and costly optical and mechanical design optimizations. [6]

Mbed compeller also contained VL6180X library. It is called **#include <VL6180x.h>**.

It just like TCS34725, also used I2C protocol. And also connect four pins to Mbed.

- VIN >> 5V
- GND >> GND
- SDA >> PIN 28

- SCL >> PIN 27

5.4.2 Testing and Data Recording

Distance sensor is very accurate and through test, the detect range of it is from 13mm to 255mm.

5.4.3 Code

```
1.  /**distance sensor configure**/
2.  #define VL6180X_ADDRESS 0x29
3.  VL6180xIdentification identification;
4.  VL6180x sensor(p28, p27, VL6180X_ADDRESS<<1);
5.
6.
7.  void distancesensorMaintain(void) {
8.      /**distance sensor configure**/
9.      uint8_t retaddr;
10.     wait_ms(100); // delay .1s
11.     sensor.getIdentification(&identification);
12.      sensor.VL6180xDefautSettings(); //Load default settings to get started.

13.     wait_ms(1000); // delay 1s
14.     retaddr=sensor.changeAddress(0x27,0x29);
15.
16.     pc.printf("Distance measured (mm) = ");
17.     distance = sensor.getDistance(); // Read diatance
18.     pc.printf("%d\n", distance);
19. }
```

Figure 57 screenshot of code

6. Product Market Analysis and Marketing Strategy

6.1 General Statement

The main purpose of this part of the report is to analyze various factors, dynamics and trends of market supply and the changes of market demand.

The concrete process is: collecting the relevant information and data, using the appropriate method to explore the potential market in order to anchor the type of consumers to the **product varieties**, **specifications**, **quality**, **performance**, **reasonable price** and **requirements**. Meanwhile, because this kind of product(entertainment robot) in the market now is not popular, so we don't need to consider the **competitive environment** up to now. But you will see the market outlook, understanding and the purchasing power of robovyserver's similar commodity(some entertainment robots on the market now), commodity supply, demand balance, the company's production and management decision-making (balance or supply greater than demand, or on the contrary) so that we can adjust the market correctly and balance the future production and marketing.

6.2 Prospective Market Plan

Huge market opportunity. (Only 4% of the total market share is occupied by entertainment robot.)
Driven by strategies such as "made in China 2025", the domestic industrial robot market continues to grow rapidly. With the accelerated breakthroughs in key technologies such as the Internet of things, big data and human-computer interaction, service robots are increasingly widely applied, and have been extended to various fields such as entertainment, education, catering and medical treatment. Robovy can be concluded in this type.
According to the data, professional service robots mainly focus on the application of national defense and security, accounting for about 43%. **Education/entertainment robots** are still in the promotion and popularization stage, **accounting for 4%** of the total market share now due to the relatively high requirements on human-computer interaction, speech recognition and other artificial intelligence technologies and immature product development.

6.2.1 Target Consumer

Wide range of Target user.
Our interactive robot requires users to assemble a cool car before communicating with you,

which indicates that consumers need to be able to distinguish at least one part from another to complete the game, get colored eggs and get a good user experience. Therefore, according to the characteristics of the product, the age range of our audience is very **wide**:

Target user:

- **1. Teenagers between 7 and 22 years old.** Teenagers at this stage have been exposed to robots in cartoons since they were young. They love robots very much and have the ability to successfully complete games.
- **2. people aging from 22 to 40** . Although consumers at this stage usually work under great pressure, our products are launched in theme parks. Hence, they must be very willing to contact with new products and technologies at that time. Men would be interested in the car itself, while women would prefer the section of getting 'easter eggs'.

6.2.2 Anticipating Product Features

- **Friendly.**

  We promise that Robovy server will be friendly and good-tempered even if you hurt him. Of course we don not want you do something in that way, but we didn't add any function related to emotions to him actually.

- **Guiding.**

  The Robovy server will interact with the user. We assure that some concrete and necessary instructions will be given by robot automatically.

- **Heart-healthy and Secure-safe.**

  The cover of the robot will be so hard and good-quality that any motions and movements of the robot arm will not hurt the consumer. Besides, the game we published will be heart-healthy, any information and concepts of violence, blue and anti-social will be prohibited strictly and definitely.

- **Updated.**

  The Robovy server will be updated and preserved at regular intervals based on the administrator model we designed. And the gift and the elements of game will be changed or update at fixed time.

6.2.3 Profit Model

Firstly, on the first stage of marketing Robovy's product in the theme part, the key point is testing the availability of the product instead of the profit model. All of the services such as playing with robovy server, getting the easter eggs and etc are free of charge.
After gaining enough statistics about UE (user experience) and US (users' satisfaction), we plan to take 5 yuan per time if you want to retry the game and talk with robovy server.

6.3 Marketing Strategy

In short-term, we will mainly focus on the accumulation of brand's reputation and the method of marketing. Such as improving the quality and advantage of product, increase the investment on advertisement, increase the number of salesman, hold on some exhibitions and so on.

- **6.6.1 poster&media**

Figure 58 Poster of ROBOVY Company

We designed a poster to showcase our company and products. The upper-left corner is our logo including our company name "Robovy", which is the combination of **Robot** and **Groovy**.
Robot is the main areas that we research and development, and **Groovy** means our team is absolutely groovy.

On the right of the poster is our game name Talent CARcraft, people can have a preliminary understanding about our product by reading this poster.

6.6.2 Exhibition Stand

On November 30, 2018, we made an exhibition for our products and company in classroom 101, building E. We have prepared a complete set of product brochures, posters, bulletin boards and professional interpreters for this commercial activity. During the process of exhibition, the members of professional evaluation team directly interacted with the robot,felt and used our products and services intuitively ,evaluated the user experience at the same time. After finishing, we demonstrate the specific operation of the maintenance mode of the product in the technical part, and explain the composition and design concept of the manipulator in detail; besides, in the business section, we explained the company's culture and the advantages of the products, and boldly preset the future development of the company's products.

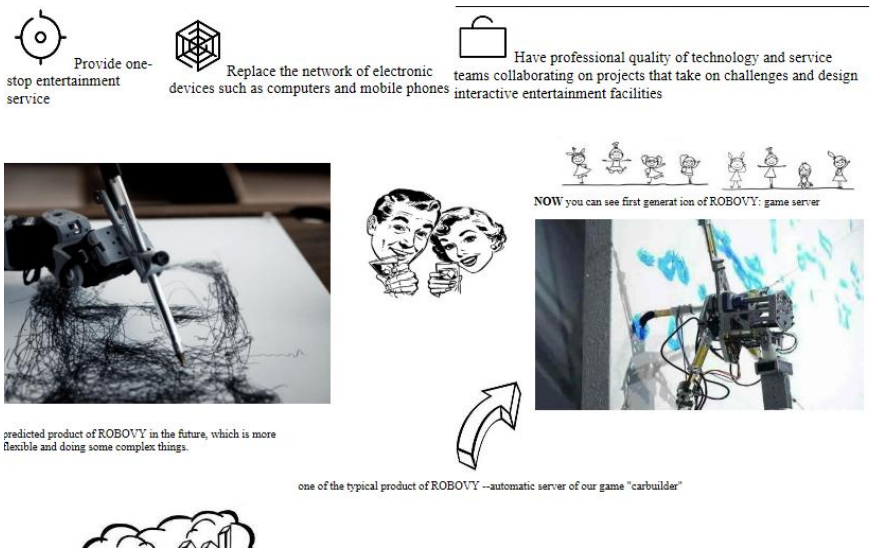
Figure 59 Exhibition Stand of ROBOVY Company on Nov 30th,2018

In long-term, we will be able to marketing our brand based on the good reputation we achieved before. Meanwhile we will widen the scale of our Website, a domain of www.robovy.com will be reserved for us.

6.6.3 Web

Our website right now:

You can find out the company profile of robovy easily on the first page, it concludes some fundamental information about Robovy company, some blueprints of our prospect product. You can even find the marketing analysis on it.



Some information about company culture and advantages will be fetched if user visits the page.
Some products can be also spotted.

Figure 60 Screenshot of ROBOVY company's web

Figure 61 Screenshot of ROBOVY company's web

You can find the company profile on the first page on the web.

Figure 62 Screenshot of ROBOVY company' s web

You can also get the contact of our company
by looking through the web page:

6.4 Biographies of team members

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Han Li is a junior student of xi 'an university of electronic science and technology. He got a high score in the C language course before, and he is kind to others. In the project, he was the manager and chief software designer, who designed and implemented the software part of the product. At the same time, in the process of product manufacturing, he was almost fully involved in the procedure of debugging, design and problem solving.

Kaicheng Zhang, the chief hardware designer of our company, who is modest and calm. He is very patient in solving complex problems such as wiring, repeatedly debugging and designing logical structure. He has comprehensive technology and outstanding ability. In the project, he designed and implemented the hardware part (mbed and fpga) of the product. At the same time, in the process of product manufacturing, he tested and modified the code of mbed module for thousands of times, and finally succeeded in solving all hardware technical problems before bidding, so that the mechanical arm could run successfully and accurately.

Yibing Liu is the workshop engineer in our team, with strong hands-on ability, flexible thinking, leading the design and manufacturing of the basic structure of the product. In the early stage of the project, he was mainly responsible for CAD drawing. Besides, he participated in the production of the three versions of robot arm demos we expected in the process of product manufacturing.

Tian Tan is the workshop engineer and hardware developer in our team, he participated in designing and manufacturing the basic structure of the product and was very familiar with the development of fpga board. In the first step of the project, he was mainly responsible for setting up fpga. In addition, he also participated in the production of the three versions of robot arm demos.

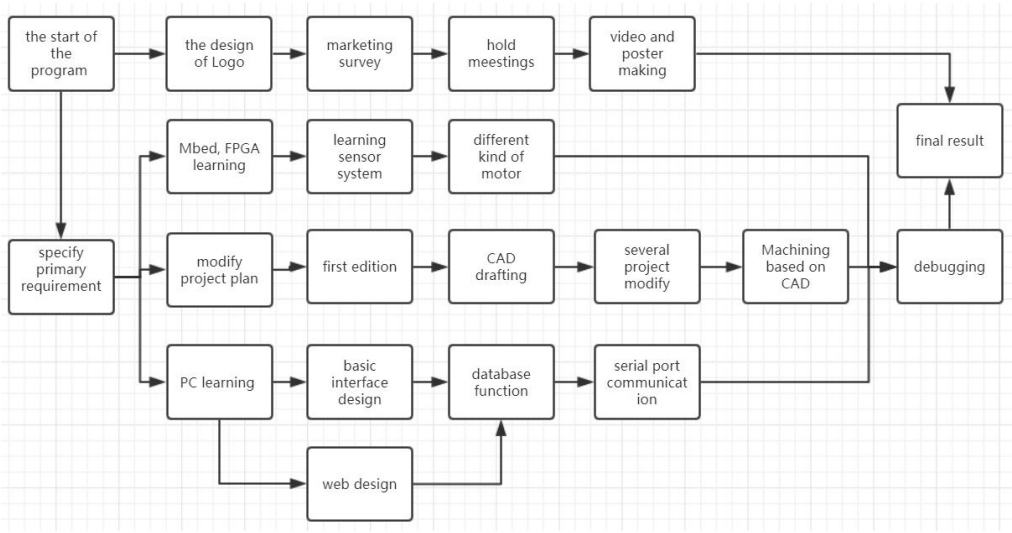
Dongli Deng is the secretary and chief public relations officer in our company. In the early stage of the project, she designed the poster and LOGO, and recorded the content and key points of each meeting.In the later stage of the project, she produced exquisite video and product manual.In addition, she produced the project Gantt chart. She handles and edits a large part of the pictures of our company.

Zheyuan Zheng is the Chief web designer of our company, who is familiar with HTML language and PS technology. In the early stage of the project, he was responsible for editing and designing the official website and assisting the chief software engineer to develop the database. With the change of project plan and direction, he began to participate in the layout of field exhibitions and the design of product appearance.

7. Project Management

7.1 First Plan of Project

7.1.1 Flow Diagram of Project



In order to improve the effective and efficient teamwork, we reached a consensus that all the members must know the importance of their responsibility. So the project manager assigned the assignments and missions in the first meeting. Meanwhile, all the members were supposed to make the plan every week, and secretory would draw a diagram of project plan. And the leader would check out the current schedule at periodic intervals. The figure of Gantt chart is displayed below:

7.1.2 Time Table (Gantt Chart) of Project Plan

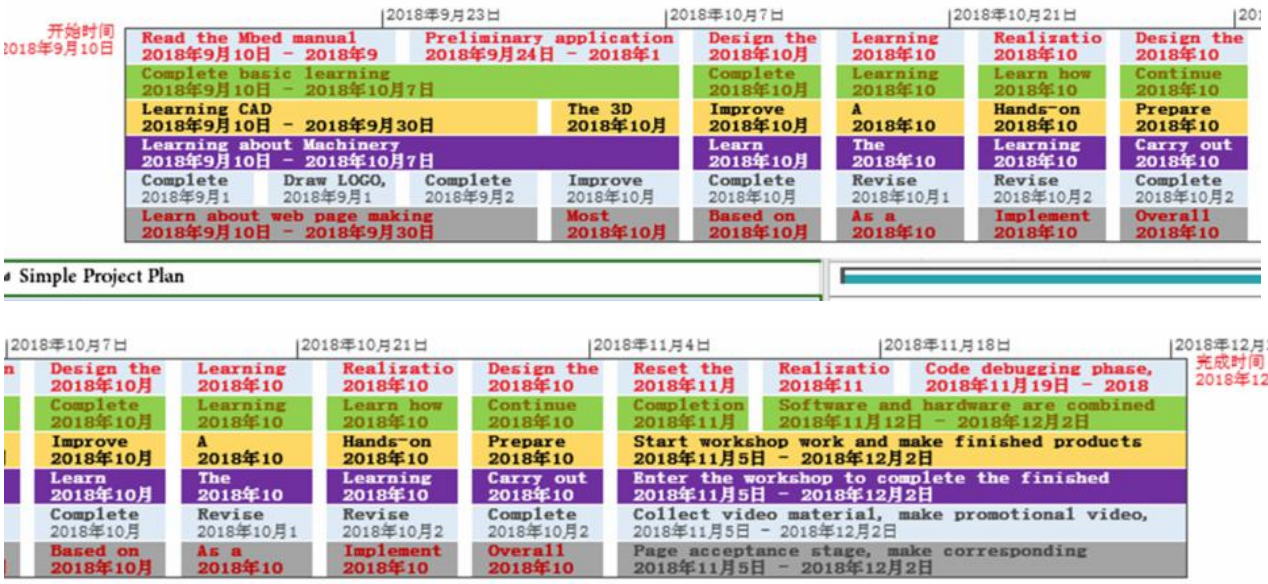


Figure 63 Screenshot of Tracking chart of Individual Project Schedule

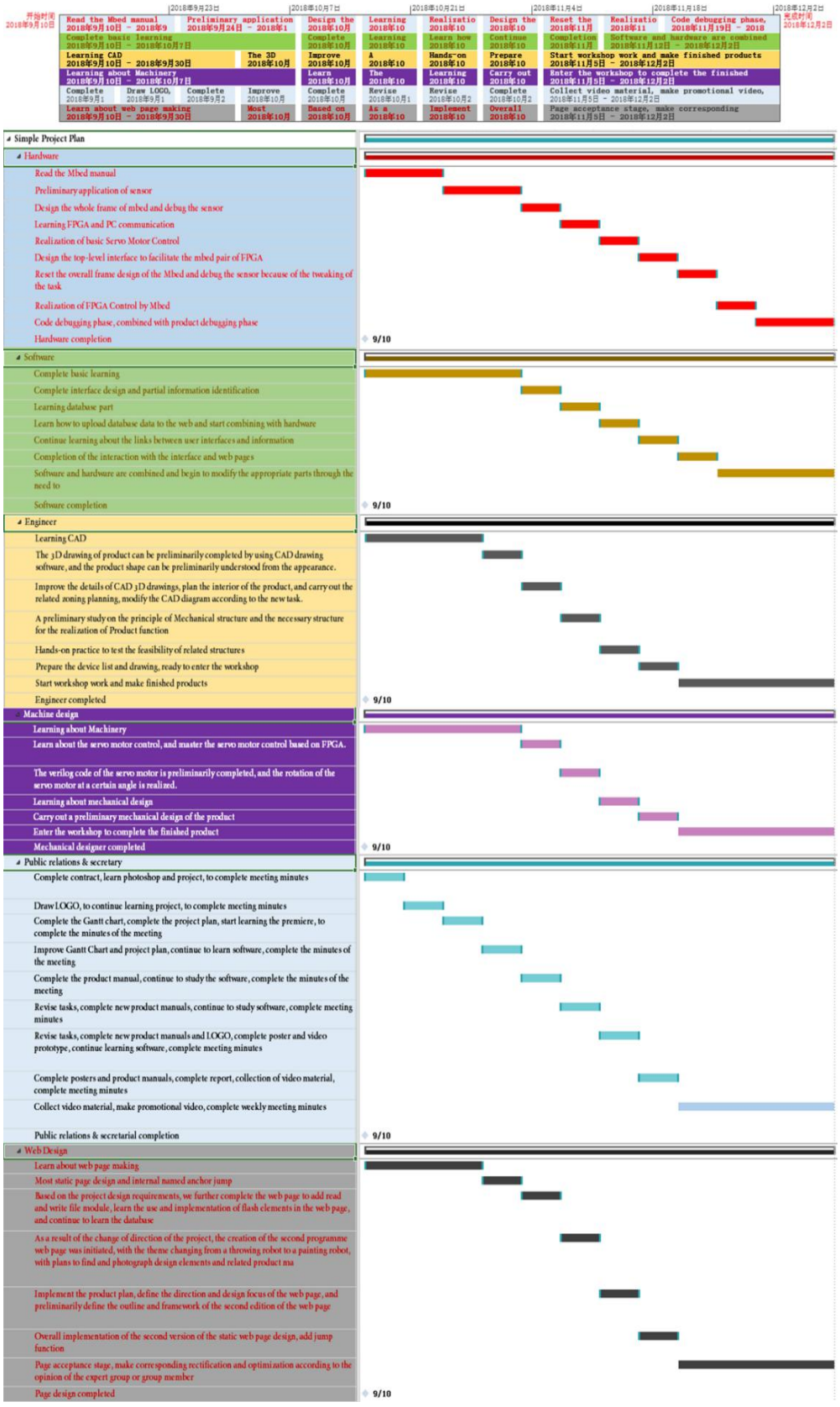


Figure 64 Screenshot of Tracking Diagram of Individual Project Schedule

7.2 Evolution of Project

In the process of designing our products, we constantly put forward new solutions, improve or even completely renovate the old ones. After several twists and turns, we spend a lot of time trying to provide customers with the best use experience.

1. In the original scenario, we designed a shooting machine that uses a mechanical arm to throw the ball. Users can control the mechanical arm to pick up the ball, put it into different baskets and get different points, and then exchange the points for the corresponding prizes. However, because the automation parts of this scheme are too few and it does not meet the requirements of the project, it was abandoned.

2. In the second scheme, we designed a game to feed the robot. The ball is randomly arranged on the conveyor belt. The player presses the button at the right time, grabs the balls that rolls under the mechanical arm and feeds them to the robot. If the ball is red, it stands for food, and the blue ones represents stone. If players successfully feed three times in game time, they will be judged to be successful, otherwise the they fails. However, the project did not meet the requirements and was abandoned.

3. In the third scheme, we designed an automatic brush machine. The user completes the car assembly game at the PC. If the game is judged to be successful, the mechanical arm will draw the cars assembled by the user as a reward. However, the scheme is difficult to achieve and has a large error. So after discussion, we unanimously decided to delete the brush section and instead use the mechanical arm to grab the prepared prize as a reward. After a number of improvements and repeated debugging, we finally get our final products.

7.3 Team Member and Task Assignment (change)

At the first meeting, we democratically decided the project manager, then the manager assigned tasks as fairly and reasonably as possible, according to each person's abilities and characteristics.

(EARLY)

NAME	POSITION & TASK
HAN LI	Managing Director Chief Software Engineering Workshop Engineer
KAICHENG ZHANG	Chief Mechanical Designer Chief Digital Systems Engineer Electronics and Wiring Engineer Workshop Engineer
YIBING LIU	Workshop Engineer Electronics and Wiring Engineer Mechanical Designer
DONGLI DENG	Chief Company Secretary Public Relations Organizer Software Engineering
TIAN TAN	Workshop Engineer Mechanical Designer Digital Systems Engineer
ZHEYUAN ZHENG	Software Engineering Chief Web Designer Company Secretary

However, there was a extreme difference between ideal hypothesis and reality. During the process of cooperation and manufacture, we found that the missions and workloads were absolutely more difficult and complex than we thought.

Hence the actual works we did **on the late stage** were more than the plan as follow:

(LATE)

NAME	WORK & TASK
HAN LI	Planning Project Software Design Joint Debugging Organizing Feedback Meeting PC Maintenance Mode
KAICHENG ZHANG	Joint Debugging Sensor System Coding & testing & MBED Coding Electronics and Wiring Engineer Product Manufacture
YIBING LIU	Planting Mechanical Drawing (CAD) Product Manufacture Mechanical Design
DONGLI DENG	Poster&LOGO Design Promotional Video Design Document Compiling
TIAN TAN	Digital System Design Mechanical Design Product Manufacture
ZHEYUAN ZHENG	Web Design Product Appearance & Exhibition Designer Document Compiling

7.4 Risk management & Countermeasure

Risk management is a inevitable and significant section of our project, it made rules for us before coming across some problems. According to the contract we compiled, we can deal with the problem more easily and validly. Meanwhile, it is also a best way for team members to remind of them that they should finish their missions on time to assure the overall schedule. We display the page of risk management in the appendix later.

7.5 Meetings

In order to report personal task progress in real time, make timely rectification for project changes, and improve the efficiency and quality of project implementation, we will hold a meeting every Thursday. In case of emergency or insurmountable difficulties, we will organize additional meetings.

7.6 Experience & Lessons

- About the code of design department, after the design and writing code, be sure to keep code, be sure to backup (which can be sent to a project in the QQ group or stored in the notepad file), and avoid wasting unnecessary time.
- Some pictures or design elements must be original, can reference some famous brand, because otherwise it will copyright fee increase the initial investment of project.
- In the later stage of product design and use, we must experience it by ourselves, otherwise we would ignore some problems. Fortunately, we finally found the problem and adjusted accordingly.
- The use of transformers and other additional components must avoid overload, otherwise the components will be bad, causing delays and waste of time.
- In the assumption stage, the difficulty of project implementation should be as simple as possible, because in the actual operation and manufacturing process, there are often many difficulties that could not be imagined before, resulting in slow progress of the project or adjustment of project direction.The implementation of the drawing robot we proposed in the early stage was too difficult. Fortunately, the expert group pointed out the problem to us, and we changed the project plan in time.

- Learning process and project change process can be synchronized.

- The project needs to set aside a lot of debugging time, wiring ahead of time before final debugging to prevent disconnection during debugging.

- The interaction between devices needs to be considered in advance. If the temperat ure is too high or the magnetic field disturbs

- Read more reference book and related knowledge before actual execution

8. Appendix

8.1 Meeting minutes

Meeting Minutes			
Group Name:	Robovy	**Group Number:**	1
Week:	1		
Time:	16:00-16:45, 6th September 2018		
Place:	Dormitory building #04		
Present:	Li Han Zhang Kaicheng Liu Yibing Tan Tian Zheng Zheyuan Deng Dongli		
Apologies:	None		
Agenda:	• Team initiation • Selection of team name • Assignment of roles		
Review of previous actions:	None		
Main business:	• Team introduction and setup began • Assignment of roles and next meeting time approved		
Action	• The name of group to be decided by vote. • Assignment of roles to be ensured by all members.		

Meeting Minutes			
Group Name:	Robovy	**Group Number:**	1
Week:	4		
Time:	19:00-20:15, 28th September 2018		
Place:	Dormitory building #04		
Present:	Li Han Zhang Kaicheng Liu Yibing Tan Tian Zheng Zheyuan Deng Dongli		
Apologies:	None		

Agenda:	• Details of project • Learning process • Discussion about business planning
Review of previous actions:	• Improve details of project • Make study plan • Finish risk response plan and register
Main business:	• Improve details of project • Make study plan • Improve details of business planning
Action	• Details of project to be improved by all members. All members finished game rules and operating process of the project together. We also discussed about reward mechanism. Then we discussed about data base because we need to collect users' information so that we can send prizes to them. At first, we planed to let users register before the game start so that we can collect data to send prizes. However, it was too troublesome to users. Thus, we decided to use electronic ticket of amusement parks as starting keys. We can get users' information from data base of parks. If the Robovys are put in restaurants or malls, users can prove their status by their shopping information. We perfected the product manual, added company introduce and the format of the manual has been standardized. We added some functions to the user interface such as skipping the novice guide options, and we have a little test with it. We decided to put a little wooden hub on the pressure pickups so that it will not be missed by balls because of its too-little size. • Business planning to be improved by each of members. • Learning process to be reported by each of members. ME/ WE: In the past week, Tan had learnt verilog modeling knowledge and a little about sequency from the pdf file given by the tutor. Liu finished the basic study of CAD drawing and completed the preliminary 3D draw for our product. SE: The design of the interface is complete, and this week is about writing the code set for serial communication and starting to learn the database. WD: Most static page design and jump among anchor points task . Already borrowed database related bibliography next week plans to read database basics and book project cases to complete preliminary study Preliminary conception of database structure according to the rules of the game. PR/ Sec: Already finished learning about Project and Premiere, finished product manuals. DE: 1. Test pressure sensor and make it work well. 2. Combine all sensors in whole system 3. Debug the system and solve potential errors 4. Download to mebed board and test code

Meeting Minutes			
Group Name:	Robovy	**Group Number:**	1
Week:	7		
Time:	19:00-20:15, 17th October 2018		
Place:	Meeting Room of Library		
Present:	Li Han Zhang Kaicheng Liu Yibing Tan Tian Zheng Zheyuan Deng Dongli		
Apologies:	None		
Agenda:	• New design of team logo • New project • Learning process		
Review of previous actions:	• Details of project to be improved by all members. All members finished game rules and operating process of the project together. We also discussed about reward mechanism. Then we discussed about data base because we need to collect users' information so that we can send prizes to them. At first, we planed to let users register before the game start so that we can collect data to send prizes. However, it was too troublesome to users. Thus, we decided to use electronic ticket of amusement parks as starting keys. We can get users' information from data base of parks. If the Robovys are put in restaurants or malls, users can prove their status by their shopping information. We perfected the product manual, added company introduce and the format of the manual has been standardized. We added some functions to the user interface such as skipping the novice guide options, and we have a little test with it. We decided to put a little wooden hub on the pressure pickups so that it will not be missed by balls because of its too-little size. • Business planning to be improved by each of members. • Learning process to be reported by each of members.		
Main business:	• Decide on new projects • Report on learning progress • New design of team logo to be decided		
Action	• New project need to be decided. According to the request of Party A, we have to start a new project. • Learning process to be reported by each of members. At the same time, all members need to make new learning plan. • New design of team logo to be decided because of new project.		

Meeting Minutes			
Group Name:	Robovy	**Group Number:**	1
Week:	8		
Time:	19:00-20:15, 24th October 2018		
Place:	Meeting Room of Library		
Present:	Li Han Zhang Kaicheng Liu Yibing Tan Tian Zheng Zheyuan Deng Dongli		
Apologies:	None		
Agenda:	• New design of team logo • New project plan • Learning process and plan		
Review of previous actions:	• New project need to be decided. • According to the request of Party A, we have to start a new project. • Learning process to be reported by each of members. At the same time, all members need to make new learning plan. • New design of team logo to be decided because of new project.		
Main business:	• Redetermination on new projects • Report on learning progress • New design of team logo has been decided		
Action	• New project need to be decided. We decided a new project. We realized that the new project is too difficult because there will be at least three difficult points. Thus, we need to make it as simple as we can. We simplified the PC game such as replacing automobile parts with simple graphics, reducing number of car parts, simplifying the standard of judgment. We can also reduce difficulty of drawing through this. • Learning process to be reported by each of members. At the same time, all members have made new learning plans. We have finished assignment of connected database, and PC Mbed FPGA link communication. Device summary and device list have been finished. • New design of team logo to be decided because of new project.		

Meeting Minutes			
Group Name:	Robovy	**Group Number:**	1
Week:	9		
Time:	19:00-20:15, 1st November 2018		
Place:	Dormitory building #04		
Present:	Li Han Zhang Kaicheng Liu Yibing Tan Tian Zheng Zheyuan Deng Dongli		
Apologies:	None		
Agenda:	• Improving details of project, including how to show results and detect the number of paintings. • Learning process including how to make beautify outlook and implement our machine installation. • Plan for next week • Purchase the items which is unreal to produce by ourselves • Make radio of our company and give brief introduction of our product		
Review of previous actions:	The web designer has finished main functions and corresponding links (WD). The communication between PC, MBED, FPGA and database has been achieved. (DE, SE). The mechanical drawing has been modified according to the decisions we made in the last meeting (ME). All the sizes according to the machine is confirmed, we can start installing it when the laboratory is opened to us(ME).		
Main business:	• Details of project to be changed • The logo of our company and product manual have been modified. • Plan for next week		
Action	• Details of project to be changed. Simplify the hardware section, remove the automatic brush, and instead grab the prize with a robotic arm to ensure that the project is not too difficult to complete. • Learning process to be reported by each of members. ME/ WE: In the last week, Liu Yibing has finished the final version of the project d esign. And according to the design, he has bought the materials and small devices we need. Tan: The laboratory safety knowledge has been learned and tested to meet the standard, and a preliminary understanding of the mechanical structure has been obtained. It can enter the workshop and manufacture the parts of the product. SE:		

	The main functions of procedure is finished and the connection between program and database is done either. By far, the hardware can communic ate with database through program which achieves the login and result di splay functions. currently the procedure needed to be decorated using WP F, so the chief software engineer is studying it and making effort to achie ve it. WD: Install database software and borrow a book from SQLserver project based on vs studio. Perfect the page frame and page, and adjust the material or picture to the feedback from the teacher on the 30th. Next week plan to learn the web database development, as soon as possible to complete the construction of the site data, if possible to participate in the workshop. PR/ Sec: Already finished learning about Flash and be able to make small anime by it. Poster has been finished. Start to make video. DE: Mbed and FPGA 1. Write program to make 3 servos work together. 2. Write program for mbed to control servos with FPGA 3. Write all code for game and adjust distance sensor sensitive a) It is hard to find reason why distance sensor can't work well, after many times failure, I found that the frequency of sensor detecting was too high. After lowing the frequency and adjust the logic of code, it worked well.

Meeting Minutes			
Group Name:	Robovy	**Group Number:**	1
Week:	10		
Time:	19:00-20:15, 8st November 2018		
Place:	Dormitory building #04		
Present:	Li Han Zhang Kaicheng Liu Yibing Tan Tian Zheng Zheyuan Deng Dongli		
Apologies:	None		
Agenda:	• Plan for next week • Purchase the items which is unreal to produce by ourselves		
Review of previous actions:	Continue to refine the page framework and the page changes according to the theme. (WD) Has optimized the code of mbed and FPGA and wait to debug on the		

	machine. Perfect interface design. (DE, SE) The cutting line has been drown on the board and the device have been bought. (ME) Had a certain understanding of the use of processing instruments, which can safely carry out the processing and manufacturing work, and completed the combination of the various parts. (ME)
Main business:	• Plan for next week • Make sure we have all the devices we need
Action	• Learning process to be reported by each of members. ME/ WE: In the last week, Liu Yibing drew the cutting line on the board and bought the device. Tan had a certain understanding of the use of processing instruments, which can safely carry out the processing and manufacturing work, and completed the combination of the various parts. SE: Perfect interface design, prepare to dock with workshop. WD: Continue to refine the page framework and the page changes according to the theme (from the focus of the painting robot to the content of the design is no longer drawn by the mechanical pen) replaced some page elements. PR/ Sec: Continue to make video. Video tools have been prepared. DE: Mbed and FPGA 1. Optimize the code of mbed and FPGA 2. Wait to debug on the machine

Meeting Minutes			
Group Name:	Robovy	**Group Number:**	1
Week:	12		
Time:	14:00-18:15, 22nd November 2018		
Place:	Dormitory building #04		
Present:	Li Han Zhang Kaicheng Liu Yibing Tan Tian Zheng Zheyuan Deng Dongli		
Apologies:	None		
Agenda:	• Plan for next week		

	• Prepare for the final report • Acceptance preparation
Review of previous actions:	Improve the web page, improve the presentation section of the final technical report, and help improve workshop work. (WD) Debug new servos.Begin to do some test on the machine and recording original data. Finished all the functions and beautified the form. Now we are adjusting the procedure according to the hardware. (DE, SE) The manufacture of the manipulator and the initial machining of the shell have been completed. (ME) Complete assembly and processing of shell and manipulator. (ME)
Main business:	• Plan for next week • Start to determining the format of the report • Acceptance preparation
Action	• Prepare the material needed for the video and improve the function of the product • Learning process to be reported by each of members. ME/ WE: Liu： The manufacture of the manipulator and the initial machining of the shell have been completed. Tan: Complete assembly and processing of shell and manipulator. SE: This weekwe finished all the functions and beautified the form. Now we are adjusting the procedure according to the hardware. WD: This week improve the web page, improve the presentation section of the final technical report, and help improve workshop work. Find materials, purchase materials and prepare final packaging and design for the product. Plan for next week: for the last week, try to strengthen communication within the group and support the heavy and complex team mates. PR/ Sec: Advance video progress and support other team members. Modify the car drawings as required. DE: FPGA and Mbed: 1. Debug new servos. 2. Begin to do some test on the machine and recording original data.

8.2 Risk Management

Project Name: System project	**Prepared by Team: NO.1**	**Date: 2018/9/20**
Course Code: B39VS	**Contact Name: Han Li; Kaicheng Zhang; Yibing Liu; Dongli Deng; Tian Tan; Zheyuan Zheng**	**Customer/End User group:**
Year of study/Discipline: 3	**Project Manager: Han Li**	**Project Sponsor:Han Li**

WBS Number	Risk Event	Risk Type	Probability	Impact	Risk Response	Risk Owner
	Some problems of hardware	Technical risks	Roughly 5%	The motion or command detected or transmitted by sensors can not work normally without the hardware supports. Meanwhile, all of the components prepared by relative members will not be able to combine with. The schedule of system project will stall for an uncertain period of time.	Project manager send the members taking charge of the hardware to contact with suppliers and reflect and analyse the problem in order to figure out the plan B.(if it is recoverable rapidly, then we will deliver the item to the factory. We also need to realize that what we mentioned before was always inapplicable. Then we need to buy a brand new one rapidly to keep pace with the schedule.) At the same time, marking this thing as an emergency and check out whether the board was broken by members. This one will take the dominating responsibility in the future. But we should face the challenge together.	All of the members
	Loss of code	Technical risks	About 10%	It will exerts enormous effects on the schedule of modules which get involved in code and programs. Such as part of hardware (FPGA ; mbed ;protocols), software(C#;SQL server;web designing) etc.	Firstly finding out how much code we have lost, if the missing data is so much that impossible for members in charge to complete on time, all the people who have programming technology will give the assistance to a certain extent. And the concrete	programmers

					mission will be allocated by project manager in terms of the amount of work of all members. In order to avoid this type of problem, all of us will intend to send a reproduction of code to the shared files in QQ group.	
	Shortage of raw materials	External risks	80%	If we were lack of materials, it will cause the problem that the delay of machanical component accomplishing.	In this case, we will make every effort to find an alternative instead of making the plan stagnate.	machinists
	The laboratory, or the conference rooms are occupied	External risks	90%	On the day of the tasks will be cancel if there is no place for our group to do experiments. Such as punching machine, electrical drilling and some equipment will not be provided and applied in this case.	We plan to ask for having the priority and right to use garret room of building G. we will book it in advance if necessary. If all things above are not available we can hold online meeting to deliver the most vital information.	All of the members
	Disagreement	Organizational risks	95%	If the plan or opinion cannot be consistent, it will give rise in the decrease of members' efficiency and motivation. Meanwhile, if we adapt some strategies without attention and analyses, the product will probably not the optimization.	Team members express their opinions in the conference of each week organized by project manager, and then the members votes. The consequence will be got in this case, however, there might be 4 members who have the rights to vote, so a balance probably occurs （2 negative Vs. 2 positive）. if it is not resolved, we will find professionals to judge.	All members
	Individual procrastination	Organizational risks	20%	Individual team members who can't complete the task on time will exert great impacts on the phase of schedule. If we don't focus on this kind of things , team members will be more unlikely to finish their tasks	People who work in the same group will give the assistance to targeted members. Meanwhile, there is a punishment rule that we made before. It is said that a reduction in your final score will appear if you put off the submission of your task for a long time. At the same time the	Probably all members

					secondary of the same project will take over unfinished job	
	uneven distribution of tasks	Project management risks	60%	It will also exerts enormous impacts on the schedule of modules. The best distribution is a matter of realistic difficulty instead of the number of tasks. For instance, some technical tasks such as hardware designing (FPGA ; mbed ; protocols), software(C#;SQL server;web designing) need more time.	We are prone to send imbalanced tasks of different part of project because of the unfamiliar with some technical issues at the beginning. If the uneven distribution happens, the most important thing is ensuring the punctuality, so we would organize a emergency conference when the manager discover the fact in order to let members communicate with each others adequately.	All members
	Too ambitious goal	Project management risks	70%	It will form and create a great deal with barriers and obstacles on the way of finishing project. There is not enough time for us to finish the system. Besides, it will lose members’ heart, this is no deny bad for group efficiency and confidence.	We organize the group meeting weekly to avoid it. Of course, if it happens, we need to weaken our goals and make it more appropriate. Meanwhile, there is also a professional group of experts who will make a objective assessment for our plan and expected system.	Project sponsor
	Acute disease of members	Health and safety risks	2%	Acute disease of our group members means the absence of him/her. So it will break up the previous plan we made. It can be regarded as the problem of individual procrastination which will exerts enormous impacts on the schedule of the project. And other members will be distracted to some extent.	Firstly, we need to make sure the work environment will be clean and comfortable so that some illness can be avoid to triggered by it. And project manager will also schedule the tasks appropriate as possible as he can. Secondly,if the unlucky thing happens, we will adjust the responsibility rapidly, the patient’s mission will be allocated to other members fairly.	All members
	Occupational injury	Health and safety risks	5%	The general framework is made by wood and some metal components, which means we need to cut off the materials inevitably. And these processes are linked with occupational	To deal with, it is similar to the former, we will adjust the responsibility rapidly, the patient’s mission will be allocated to other members fairly if the situation is not good.	

				injuries, which not only will be harmful for members' life and physical health, but have great impact on the rate of process.		
	Increment of function	Technical risks	30%	Owing to the simpleness in function, we need to add more senors or code and this will increase workload on everyone dramatically.	If the improvement is agreed by all members, the task will be allocated to every member.	All the members
	Unexpected problems during combination of different work	Project management risks	30%	The union of different job takes more time than expected and discourage team members	Members relating to combination will certainly pay more attention to it. And other members will help him finish the allocated jobs in order to conserve more time for him and rewards will be given to all team members.	Soft and hardware and software engineers
	Poor quality of materials	External risks	10%	Because most materials are bought online, the quality can not be guaranteed leading to the loss of time and sometimes money	In this situation, we will make plan and purchase items beforehand. If the materials is not suitable, we will instantly find it from neighboring market.	Workshop engineer

8.3 About this Document

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