Fruit sorting

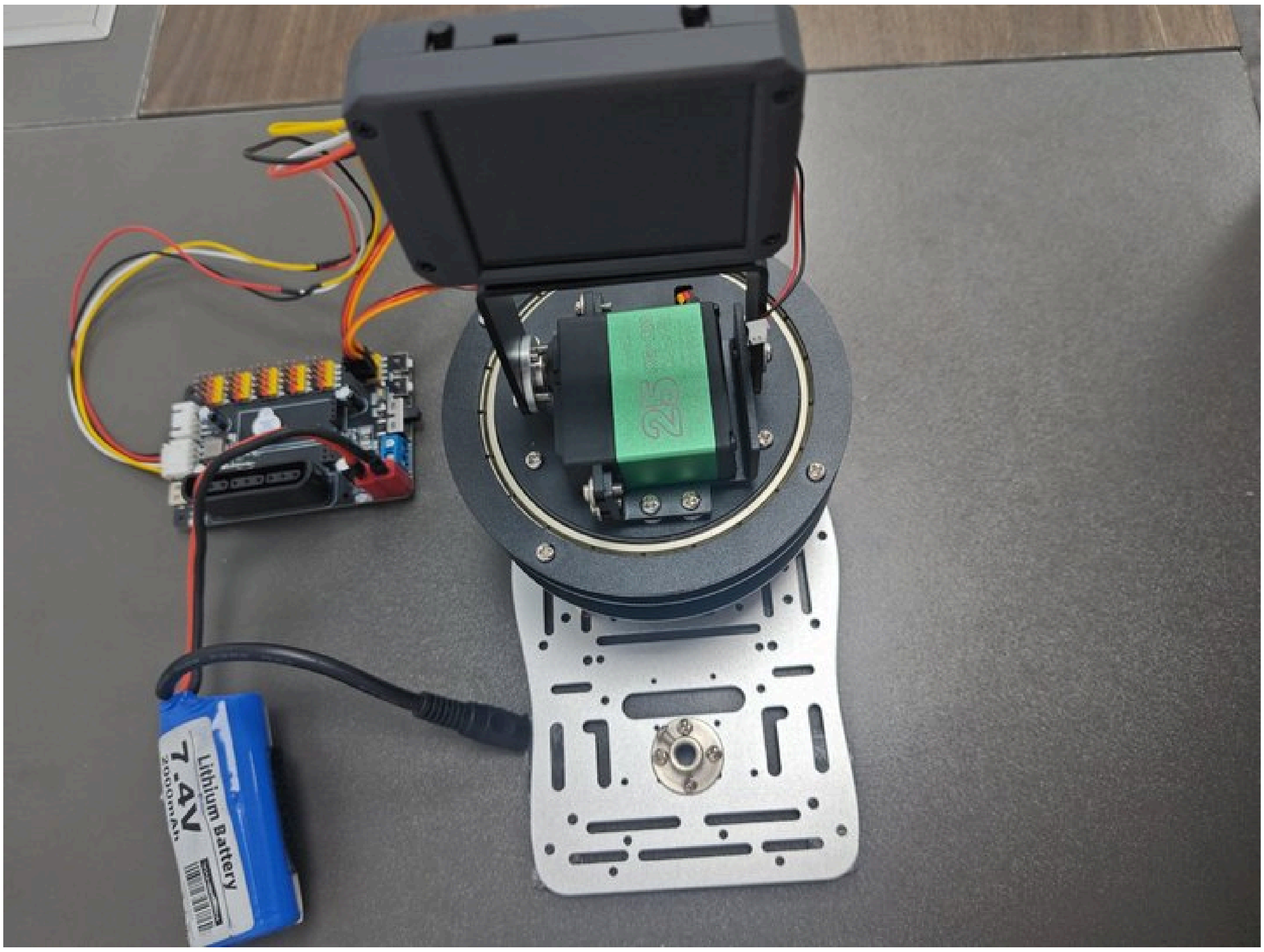
1. Introduction

Please read the information in the 24-way servo driver board and the STM32 introductory tutorial first to understand how to burn the program and the basics of STM32. This will make it easier to learn and burn the following programs.

2. Equipment list

- k230 x1
- 24-way servo driver board x1
- 7.4v battery x1 Buy
- Aluminum alloy plate x1 Buy

3. Placement

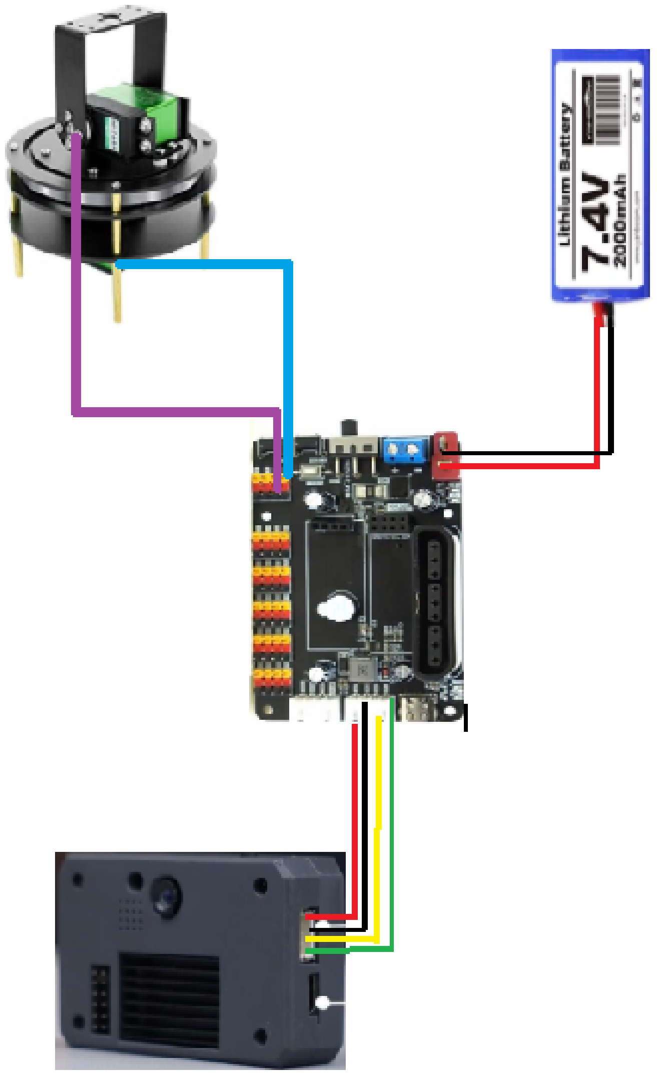


The placement is as shown in the figure. You can choose our aluminum base frame as the base plate to fix the k230 and the gimbal, or you can choose a fixed base plate. The chassis can be glued to prevent the gimbal from moving too much and causing deviation. The k230 is fixed on the two-dimensional gimbal. When using the battery, if the gimbal rotates too much, you can moderately reduce the pid parameter.

4. Experimental preparation

First, build the 2D gimbal according to the 2D gimbal installation tutorial

Hardware wiring:



2D gimbal	24-way servo driver board
X-axis servo	S1
Y-axis servo	S2

K230 vision module	24-way motor driver board
5V	5V
GND	GND
TX	RX3
RX	TX3

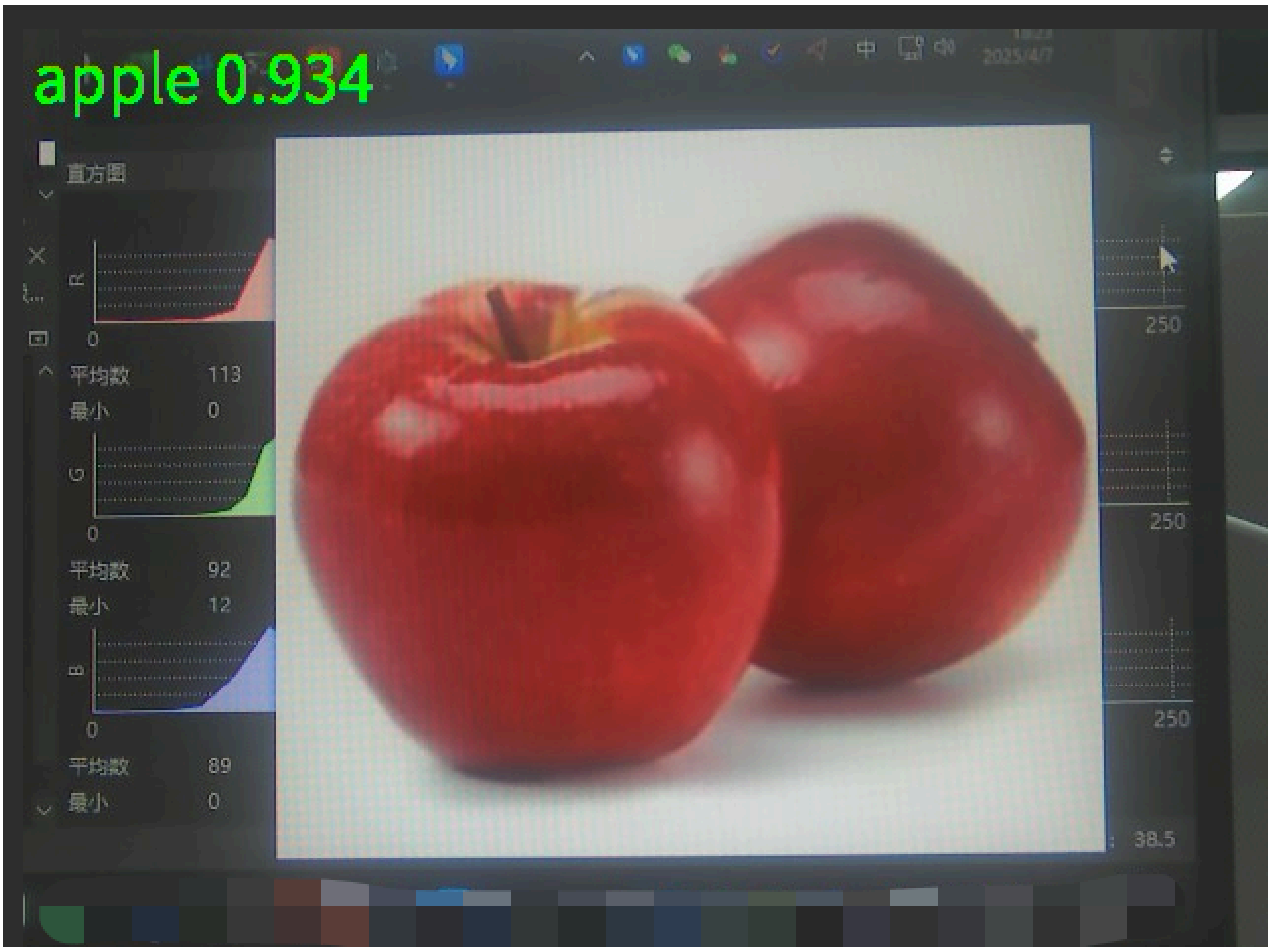
Note: When plugging in the servo cable, be sure to align the yellow cable with the yellow GPIO port of the 24-way servo driver board, and the brown cable with the black GPIO port of the 24-way servo driver board.

5. K230 key code analysis

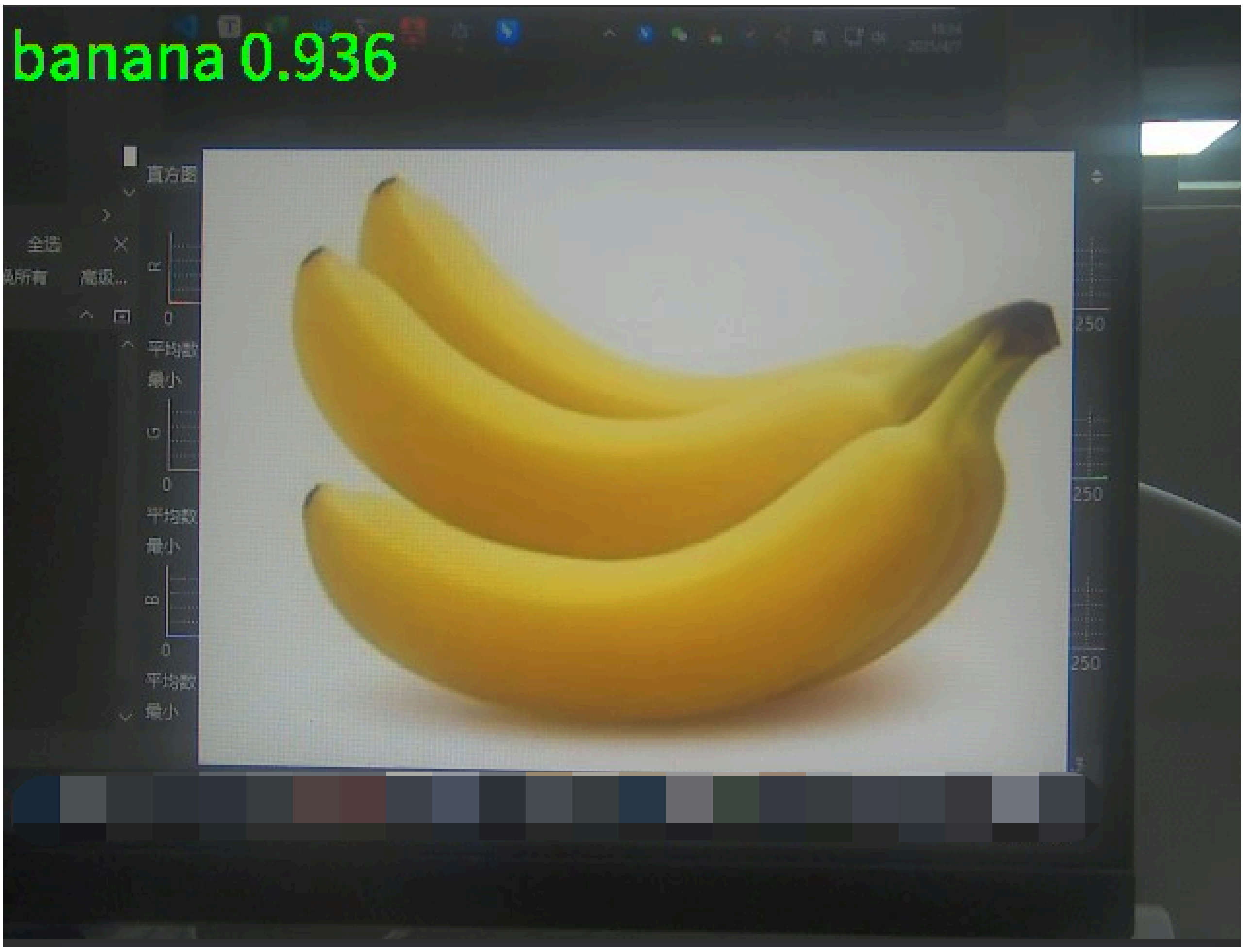
In this section, we will use the classification model based on yolov5 training to perform simple fruit classification

> Note: Training requires a GPU environment and has a certain degree of operational difficulty

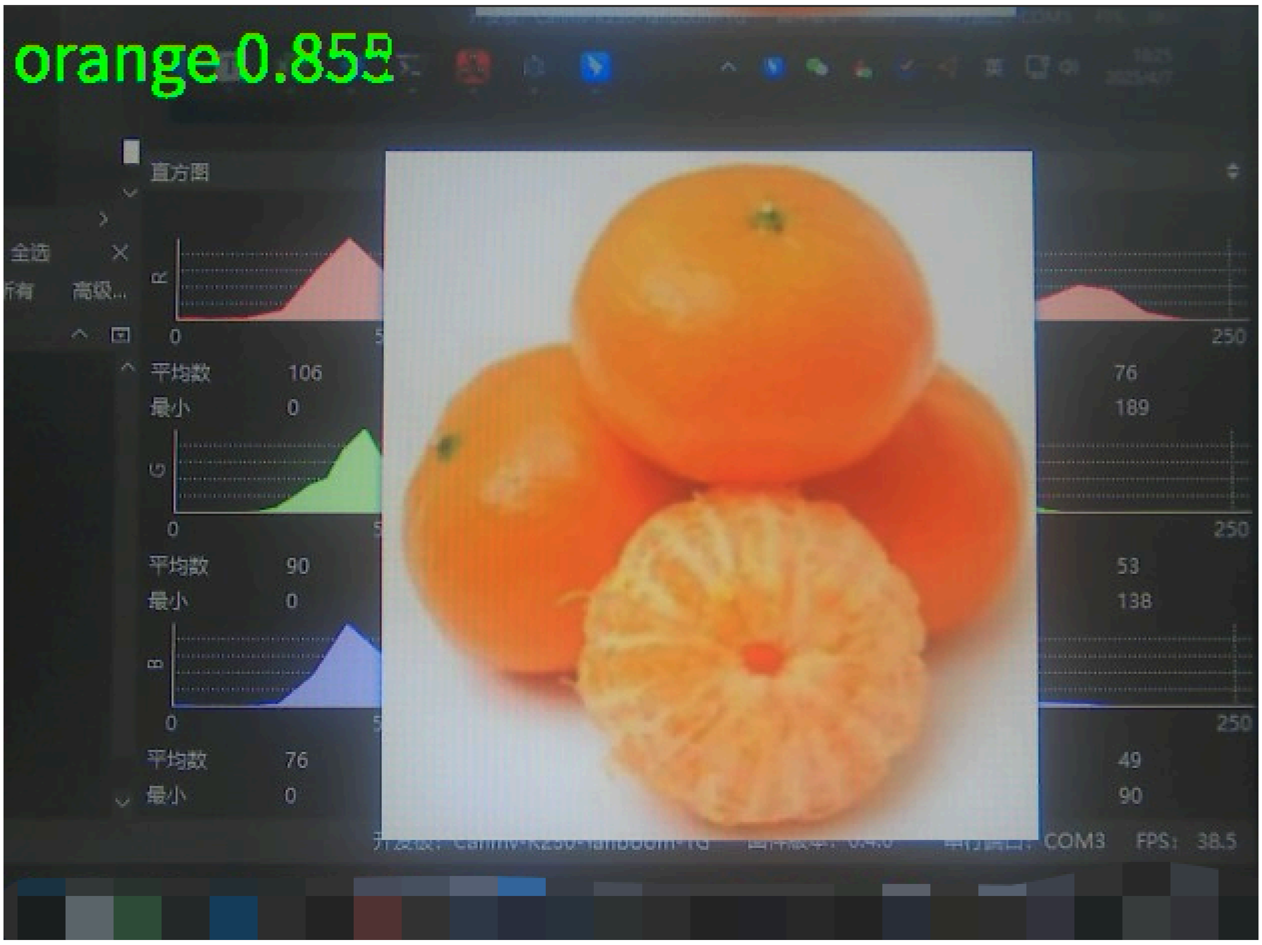
Identify apples



Identify bananas



Identify oranges



##

Main working principle:

1. Get real-time video stream from the camera
2. Preprocess each frame and adjust the size to adapt to the model input requirements
3. Send the processed image to the neural network for reasoning
4. Filter the classification results according to the confidence threshold
5. Draw the recognition results on the display interface
6. Loop to process the next frame

Import dependencies

```
from libs.PipeLine import PipeLine, ScopedTiming
from libs.YOLO import YOLOv5
import os,sys,gc
import ulab.numpy as np
import image
```

- `PipeLine`: Processing image pipeline
- `ScopedTiming`: Performance timing tool
- `YOLOv5`: Encapsulates the reasoning interface of the YOLO model
- `ulab.numpy`: NumPy compatible library under MicroPython, optimized for embedded devices

Configuration initialization

```
rgb888p_size=[1280,720] # Original image size
display_size=[640,480] # Display size
kmodel_path="/sdcard/kmodel/fruit_cls.kmodel" # Model path
labels = ["apple","banana","orange"] # Classification label
confidence_threshold = 0.7 # Confidence threshold
model_input_size=[224,224] # Model input size
```

Pipeline and model instantiation

```
pl=PipeLine(rgb888p_size=rgb888p_size,display_size=display_size,display_mode="lcd")
pl.create()
yolo=YOLOv5(task_type="classify",mode="video",kmodel_path=kmodel_path,labels=labels,
rgb888p_size=rgb888p_size,model_input_size=model_input_size,
display_size=display_size,conf_thresh=confidence_threshold,debug_mode=0)
yolo.config_preprocess()
```

Main loop

```
try:
while True:
os.exitpoint()
with ScopedTiming("total",1):
# Frame-by-frame reasoning
img=pl.get_frame() res=yolo.run(img)
flag=res[0]
if flag == -1:
uart.write(bytearray([0x55,0xaa,0x00,0xfa]))
if flag == 0:
uart.write(bytearray([0x55,0xaa,0xff,0xfa]))
yolo.draw_result(res,pl.osd_img)
pl.show_image()
gc.collect()
```

5. Exception handling and resource release

```
except Exception as e:
sys.print_exception(e)
finally:
yolo.deinit()
pl.destroy()
```

6. stm32 key code analysis

- **control.c**

```
uint8_t get_active()
{
uint8_t lable ,ret=0;
if(DataDecode2(&Uart3_RingBuff,&lable) == 0){
if(lable == 0x00){
rec_step_p[0][0] =1;
}

else if(lable ==0xff){
rec_step_p[0][1] =1;

}
}

return ret;
}
```

This code converts and receives the information transmitted by k230 for fruit identification, and then assigns it to the flag bit.

```
{
TIM_ITConfig(TIM1,TIM_IT_Update, ENABLE);
TIM_Cmd(TIM4, ENABLE);
USART_Cmd(USART3, ENABLE);
get_active();

if(mode_flag==0&&rec_step_p[0][0]==1){


USART_Cmd(USART3, DISABLE);
go_to_point(0, 0, 400, 0);

go_to_point(400, 0, 0, 0);
rec_step_p[0][0]=0;

mode_flag=1;

}

if(mode_flag==0&&rec_step_p[0][1]==1){
USART_Cmd(USART3, DISABLE);
go_to(0, 0, 400, 0); go_to(400, 0, 0, 0);

rec_step_p[0][1]=0;
mode_flag=1;
}

}
```

This code is used to obtain the fruit information, and then control the servo to move to one side and then return.

```
void go_to_point(uint16_t now_x, uint16_t now_y, uint16_t targ_x, uint16_t targ_y)
{
uint16_t i;
float step_num = 200;/* 1000 steps*/
float step_x, step_y; /* step value */
float going_x = now_x, going_y = now_y; /* Current target value*/

step_x = (targ_x - now_x) / step_num;
step_y = (targ_y - now_y) / step_num;

for(i = 0; i < step_num; i++)
{

kfp_x.source = step_x;
kfp_y.source = step_y;
kfp_x.out = KalmanFilter(&kfp_x, kfp_x.source);
kfp_y.out = KalmanFilter(&kfp_y, kfp_y.source);
going_x += kfp_x.out;
going_y += kfp_y.out;
set_target(going_x, going_y);
}
}
```

This code subdivides the coordinates of the two points obtained, thereby dividing the two points of the rectangle into many points, and then performing pid calculations between many points to make the servo movement more accurate.

```
void go_to(uint16_t now_x, uint16_t now_y, uint16_t targ_x, uint16_t targ_y)
{
uint16_t i;
float step_num = 100;/* 250²½ */
float step_x, step_y; /* ²½½øÖµ */
float going_x = now_x, going_y = now_y; /* µ±Ç°Ä¿ ±êÖµ*/

step_x = (targ_x - now_x) / step_num;
step_y = (targ_y - now_y) / step_num;

for(i = 0; i < step_num;i++){



kfp_x.source = step_x;
kfp_y.source = step_y;
kfp_x.out = KalmanFilter(&kfp_x, kfp_x.source);
kfp_y.out = KalmanFilter(&kfp_y, kfp_y.source);



going_x += kfp_x.out;
going_y += kfp_y.out;

set_target(-going_x, -going_y); }
}
```

This code is to subdivide the coordinates of the two points obtained, so as to divide the two points of the rectangle into many points, and then do pid calculations between many points to make the servo movement more accurate.

- ## bsp_servo.c

```
ServTypdef Xserv = {
.pwm = 1600,
.MAXPWM = 2400,
.MINPWM = 500,
.MIDPWM = 1400
};

ServTypdef Yserv = {
.pwm = 1600,
.MAXPWM = 2500,
.MINPWM = 300,
.MIDPWM = 1400
};
```

This code is to set the starting position of the servo, so it is necessary to modify this to fit the vertex of the gimbal movement. I set the initial position of the gimbal to the middle point, and change the starting position of the servo through this.

```
void servo_ctr(ServTypdef *servo, int PidInput)
{
uint16_t CompSet = servo->MIDPWM + PidInput;

if( CompSet > servo->MAXPWM ){
CompSet = servo->MAXPWM;
} else if ( CompSet < servo->MINPWM ){
CompSet = servo->MINPWM;
}
if(servo->pwm == CompSet){/*Avoid repeated changes in comparison value*/

return;
}

if( servo == &Xserv ){

GPIO_SetBits(Servo_J1_PORT, Servo_J1_PIN ); //Set the servo level high
delay_us(CompSet); //Delay pulse value in microseconds

GPIO_ResetBits(Servo_J1_PORT, Servo_J1_PIN ); //Set the servo level low
delay_ms(20 - CompSet/1000);
}
else if( servo == &Yserv ){

GPIO_SetBits(Servo_J2_PORT, Servo_J2_PIN ); //Set the servo level high
delay_us(CompSet); //Delay pulse value in microseconds

GPIO_ResetBits(Servo_J2_PORT, Servo_J2_PIN ); //Set the servo level low
delay_ms(20 - CompSet/1000);
}
}
```

This code outputs the pid to the pwm, connects the pid to the pwm, and limits the pwm. It is also the core code for the servo movement. It controls the rotation of the servo through the delay and the change of the pwm, and connects the servo movement with the pwm.

- ## pid.c

```
float pid_calculate(PID_TypeDef *PID, float CurrentValue)
{
PID->Err = PID->Target - CurrentValue;
PID->Integral += PID->Err;
if(PID->Integral > 7000){
```

```
PID->Integral = 7000;
}
if(PID->Integral < -7000){
PID->Integral = -7000;
} //Points limit
PID->PID_out = PID->Kp * PID->Err /*proportion*/
+ PID->Ki * PID->Integral /*Points*/
+ PID->Kd * (PID->Err - PID->LastErr); /*Derivative*/

PID->LastErr = PID->Err;
return PID->PID_out;
}
```

This code is the configuration of the position PID operation, including integral limiting. The position PID is calculated by the current deviation value (difference between target value and actual value), integral value (sum of past errors) and differential value (error change rate), and then the weighted addition of these three parts is used to obtain the PID output. If you want to fine-tune the code to achieve better results, you can fine-tune the PID parameters of the main function.

- ## bsp_usart.c

```
uint8_t DataDecode1(RingBuff_t *ringbuff, uint8_t *data1, uint8_t *data2, uint8_t
*data3,uint8_t *data4)
{
static uint8_t uart_dec_count;
static uint8_t uart_rec_data[6];
uint8_t ret = 1;

if(Read_RingBuff(ringbuff, &uart_rec_data[uart_dec_count]) == RINGBUFF_ERR){
return 1;

}
if((uart_dec_count == 0)&&(uart_rec_data[uart_dec_count] != 0x55)) { //Frame header 0x55
uart_rec_data[uart_dec_count] = 0; }
else if((uart_dec_count == 1)&&(uart_rec_data[uart_dec_count] != 0xaa)){ //Second frame 0xaa
uart_rec_data[uart_dec_count] = 0;
uart_rec_data[uart_dec_count-1] = 0;
uart_dec_count = 0;
}else if((uart_dec_count == 6)&&(uart_rec_data[uart_dec_count] != 0xfa)){ //Frame end 0xfa
uart_rec_data[uart_dec_count] = 0;
uart_rec_data[uart_dec_count-1] = 0;
uart_rec_data[uart_dec_count-2] = 0;
uart_rec_data[uart_dec_count-3] = 0; uart_rec_data[uart_dec_count-4] = 0;
uart_rec_data[uart_dec_count-5] = 0;
uart_dec_count = 0;
}
else{
if(uart_dec_count == 6)//Successfully received one frame of data
{
*data1 = uart_rec_data[2];
*data2 = uart_rec_data[3];
*data3 = uart_rec_data[4];
*data4 = uart_rec_data[5];
ret = 0;

}
uart_dec_count++;
if(uart_dec_count == 7)
{
uart_dec_count = 0;
}

}
return ret;

}
```

This code is for receiving k230 data. It receives data only when the frame header is 0x55, the second data is 0xaa, and the frame tail is 0xfa. It locates a frame of data through three data. Since the coordinates of the four vertices transmitted from k230 are split into three groups of data for each vertex, the transmitted data is very large. In order to ensure that the transmitted data is accurate, three data are used to confirm a frame of data.

7. Effect display

Fruit is recognized through the yolov5 training model. When k230 recognizes an apple, it transmits information to the two-dimensional gimbal to move left and then return. When it recognizes an orange, it transmits information to the two-dimensional gimbal to move right and then return. When you install a pole on the gimbal, the left and right movement can achieve the effect of sorting. After one recognition, press the reset key and continue the recognition movement.