Color Tracking

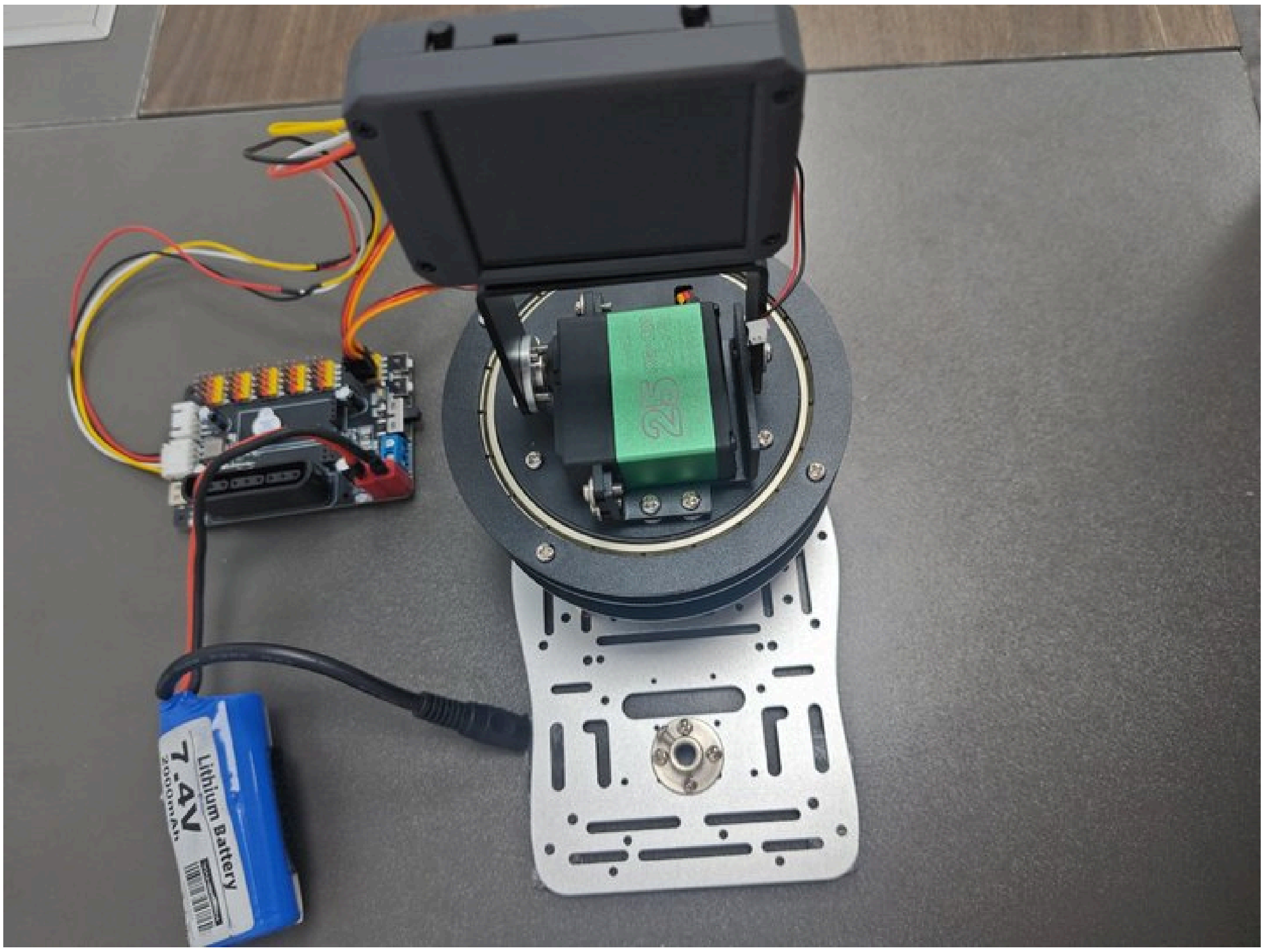
1. Introduction

Please read the information in the 24-way Servo Driver Board and STM32 Getting Started Tutorial first to understand how to burn programs and the basics of getting started with 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

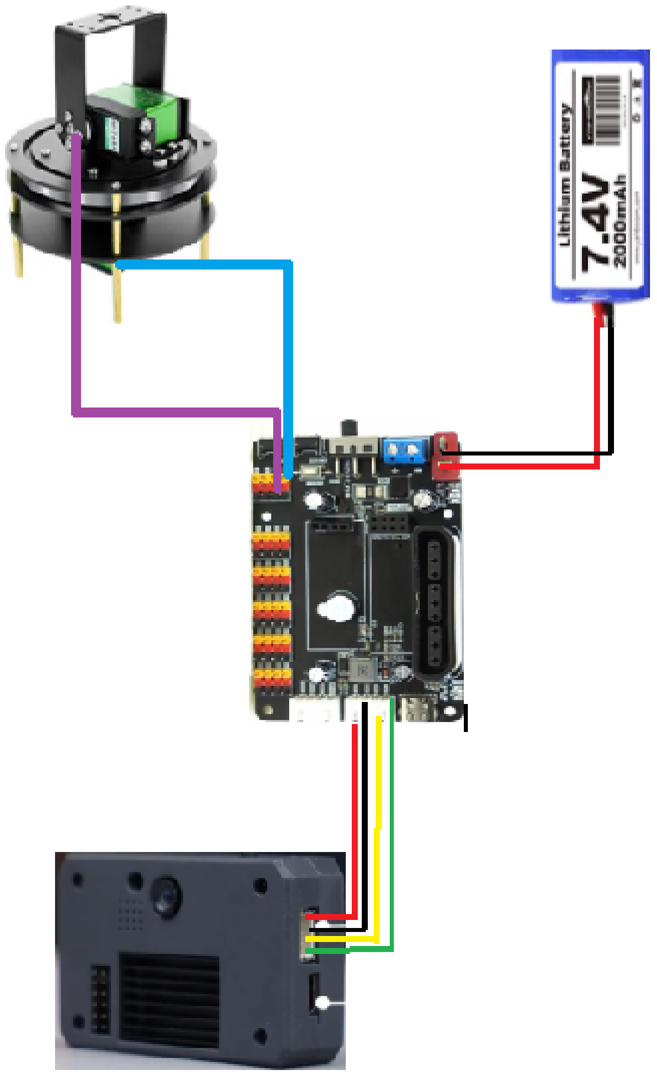


The placement is as shown in the figure. You can choose our aluminum base frame as the base plate to fix the k230 and the gimbal, or you can choose a fixed base plate. The chassis can be glued to prevent the gimbal from moving too much and causing deviation. The k230 is fixed on the two-dimensional gimbal. 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 code analysis

- **Complete code**

```
import time, os, sys
from media.sensor import *
from media.display import *
from media.media import *

from libs.YbProtocol import YbProtocol
from ybUtils.YbUart import YbUart
# uart = None
uart = YbUart(baudrate=115200)
pto = YbProtocol()

last_cx = 300 # Initial point x coordinate
last_cy = 220 # Initial point y coordinate
# Display parameters / Display parameters
DISPLAY_WIDTH = 640 # LCD display width / LCD display width
DISPLAY_HEIGHT = 480 # LCD display height / LCD display height

# LAB color space thresholds / LAB color space thresholds
# (L Min, L Max, A Min, A Max, B Min, B Max)
THRESHOLDS = [
(0, 66, 7, 127, 3, 127), # Red threshold / Red threshold
(42, 100, -128, -17, 6, 66), # Green threshold / Green threshold
(43, 99, -43, -4, -56, -7), # Blue threshold / Blue threshold
(37, 100, -128, 127, -128, -27) # Color of YAHBOOM Logo
]

def get_closest_rgb(lab_threshold):
"""Calculate closest RGB color based on LAB threshold"""
# Get the center point value of LAB space
l_center = (lab_threshold[0] + lab_threshold[1]) // 2
a_center = (lab_threshold[2] + lab_threshold[3]) // 2
b_center = (lab_threshold[4] + lab_threshold[5]) // 2
return image.lab_to_rgb((l_center,a_center,b_center))

def init_sensor():
"""Initialize camera sensor"""
sensor = Sensor()
sensor.reset()
sensor.set_framesize(width=DISPLAY_WIDTH, height=DISPLAY_HEIGHT)
sensor.set_pixformat(Sensor.RGB565)
return sensor

def init_display():
"""Initialize display"""
Display.init(Display.ST7701, to_ide=True)
MediaManager.init()

def process_blobs(img, blobs, color):
```

```
global last_cx
global last_cy
"""Process detected color blobs"""
for blob in blobs:
img.draw_rectangle(blob[0:4], color=color, thickness=4)
img.draw_cross(blob[5], blob[6], color=color, thickness=2)
cx = blob[0]
cy = blob[1]
last_cx = cx#Update coordinates
last_cy = cy#Update coordinates
return cx,cy,1
return last_cx, last_cy, 0


def draw_fps(img, fps):
"""Draw FPS information / Draw FPS information"""
img.draw_string_advanced(0, 0, 30, f'FPS: {fps:.3f}', color=(255, 255, 255))


def conversion_postion(x,y):
if x > 510:
x_h = 255 x_l = 255
x_z = x-255-255
elif 510>=x>=255:
x_h = 255
x_l = x-255
x_z = 0
else:
x_h = x
x_l = 0
x_z = 0
if y > 510:
y_h = 255
y_l = 255
y_z = y-255-255
elif 510>=y>=255:
y_h = 255
y_l = y-255
y_z = 0
else:
y_h = y
y_l = 0
y_z = 0
return x_h,x_l,x_z,y_h,y_l,y_z

def main():
try:
# Initialize devices
sensor = init_sensor()
init_display()
sensor.run()
clock = time.clock()
# Select color index to detect (0: red, 1: green, 2: blue)
```

```
color_index = 1 # You can modify this value to select different colors
threshold = THRESHOLDS[color_index]
detect_color = get_closest_rgb(threshold)
while True:
clock.tick()
img = sensor.snapshot()
# Detect specified color
blobs = img.find_blobs([threshold], area_threshold=5000, merge=True)
if blobs:
x,y,ok= process_blobs(img, blobs, detect_color)
cx_h,cx_l,cx_z,cy_h,cy_l,cy_z = conversion_postion(x,y)
uart.write(bytearray([0x55,0xaa,0x00,int(cx_h),int(cx_l),int(cx_z),0xfa]))
uart.write(bytearray([0x55,0xaa,0xff,int(cy_h),int(cy_l),int(cy_z),0xfa]))
fps = clock.fps()
draw_fps(img, fps)

print(fps)

Display.show_image(img)

except KeyboardInterrupt as e:
print("User interrupted / User interrupted: ", e)
except Exception as e:
print(f"An error occurred / Error occurred: {e}")
finally:
if 'sensor' in locals() and isinstance(sensor, Sensor):
sensor.stop()
Display.deinit()
MediaManager.deinit()

if __name__ == "__main__":
main()
```

- **Split coordinate function**

```
def conversion_postion(x,y):
if x > 510:
x_h = 255
x_l = 255
x_z = x-255-255
elif 510>=x>=255:
x_h = 255
x_l = x-255
x_z = 0
else:
x_h = x
x_l = 0
x_z = 0
if y > 510:
y_h = 255
```

```
y_l = 255
y_z = y-255-255
elif 510>=y>=255:
y_h = 255
y_l = y-255
y_z = 0
else: y_h = y
y_l = 0
y_z = 0
return x_h,x_l,x_z,y_h,y_l,y_z
```

Because stm32 only transmits 8-bit binary numbers, the maximum transmission data is 255, and our K230 uses 640x480, so its coordinates need to be divided and 640 is split into 3 frames of data for transmission.

- ## Code structure

Basic settings:

- Set the display screen to 640×480 resolution
- Define the detection thresholds for red, green and blue using the LAB color space
- DRAW_COLORS and COLOR_LABELS arrays are used to draw markers and display color labels

Main improvements:

- Detect three colors at the same time
- Add color label text annotations to detected objects
- Simplify the color processing logic

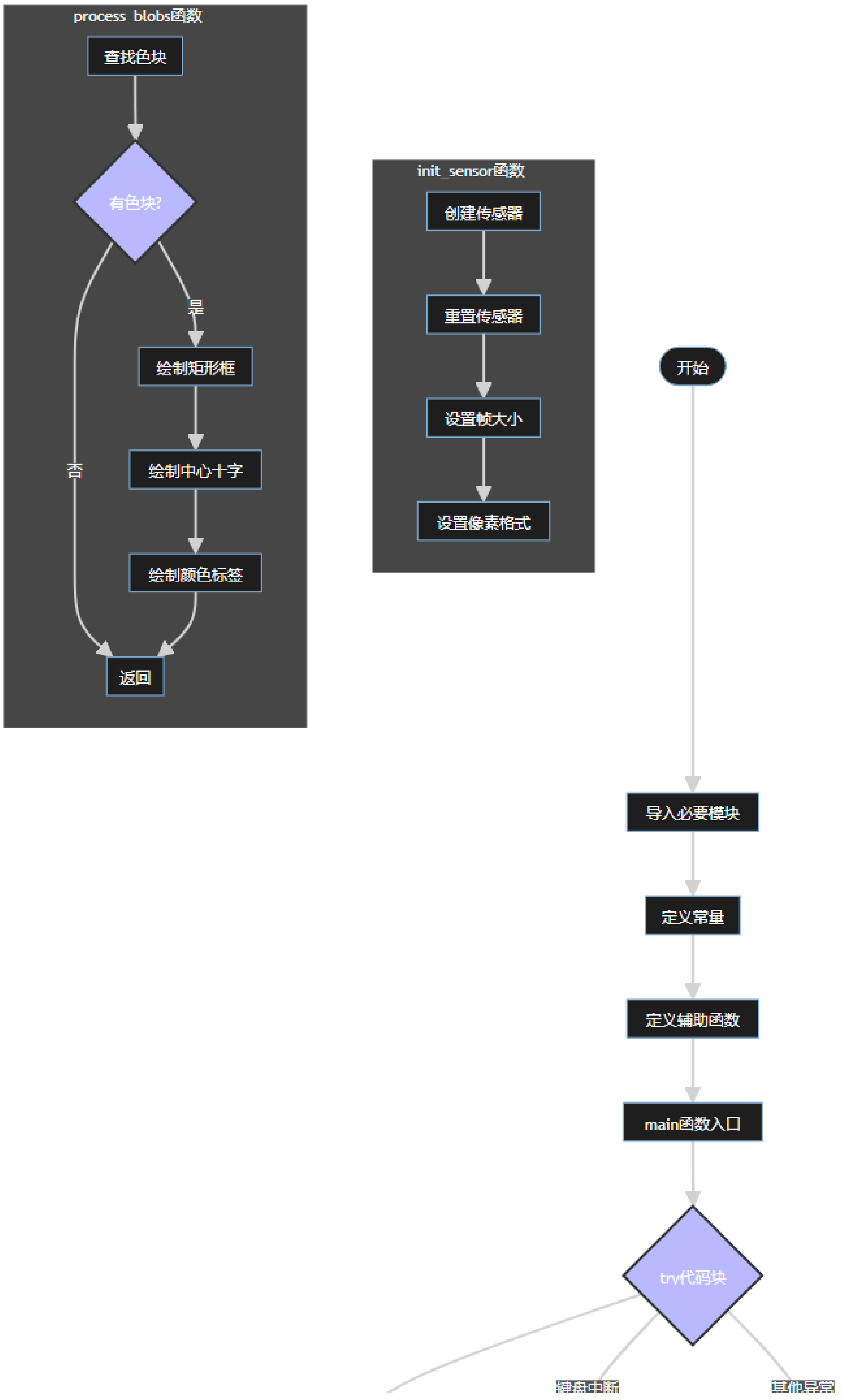
Workflow:

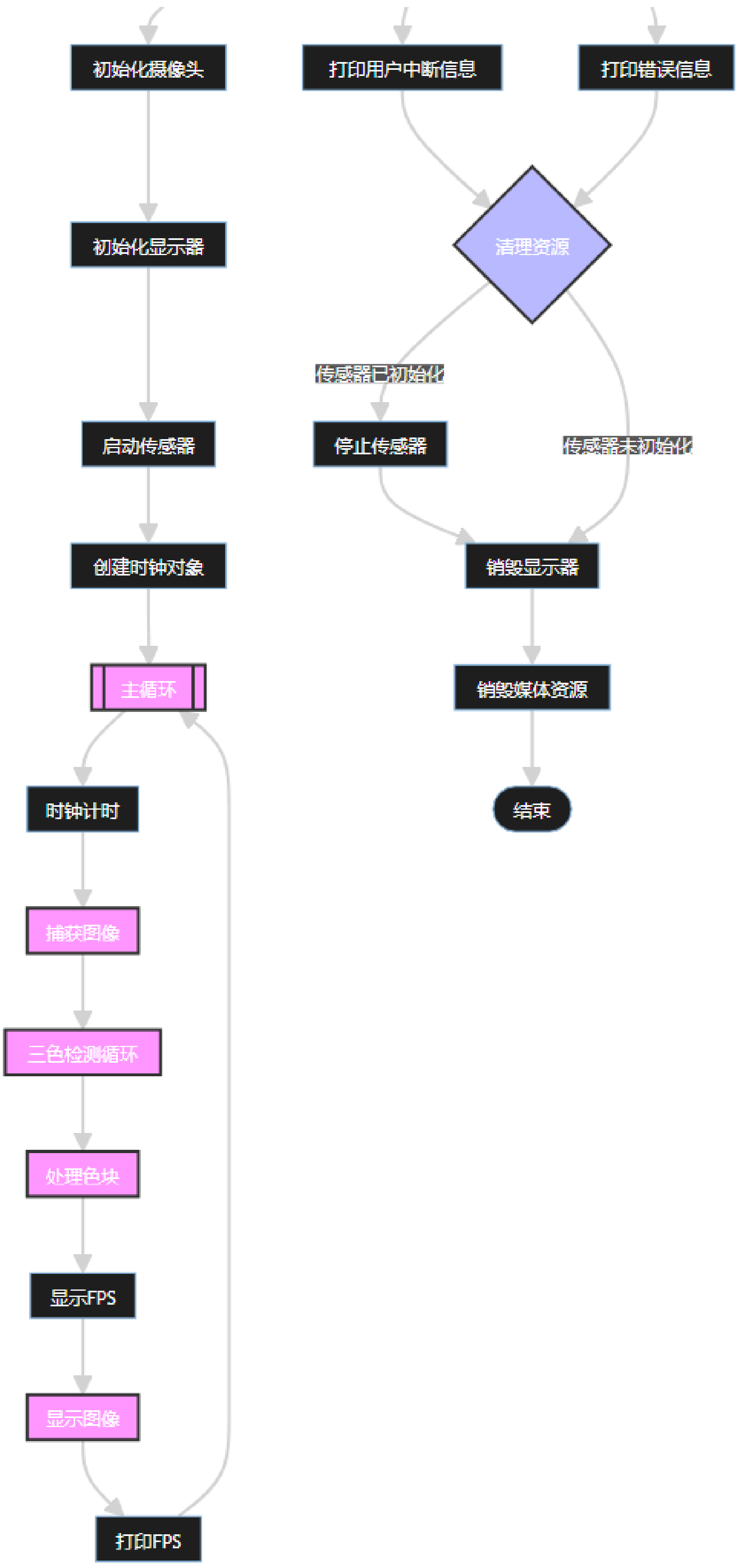
- Initialize the camera and display
- After entering the main loop:
    - Continuously capture images
    - Detect three colors in turn
    - Draw a rectangle, cross mark and color label for each detected object
    - Display frame rate information

Exception handling:

- Keep the complete exception handling mechanism
- Ensure that hardware resources are released correctly when the program ends

The detailed flow chart is as follows:


process_blobs函数
查找色块
有色块?
是
否
绘制矩形框
绘制中心十字
绘制颜色标签
返回
init_sensor函数
创建传感器
重置传感器
设置帧大小
设置像素格式
开始
导入必要模块
定义常量
定义辅助函数
main函数入口
try代码块
键盘中断
其他异常



6. stm32 key code analysis

- ## control.c

```
uint8_t get_point2_p() //Coordinate processing function
{
uint8_t lable, load_1, load_2 ,load_3 ,ret=0;
if(DataDecode1(&Uart3_RingBuff,&lable, &load_1, &load_2,&load_3) == 0){
if(lable == 0x00){
rec_step_p[0][0] = load_1 + load_2 + load_3 ;
// ret=1;

} else if(lable == 0xff){

rec_step_p[0][1] = load_1 + load_2 + load_3 ;
// ret=1;

}

return ret;
}
}
```

This code adds the 3 frames of data transmitted by k230 together. As mentioned earlier, the coordinate data of k230 is split into 3 frames and then sent separately. Here, the data is added together to form the correct coordinates and assign the coordinates to the two-dimensional array.

```
get_point2_p();

set_target(rec_step_p[0][0],rec_step_p[0][1]);
```

This code uses the coordinates as the pid target value based on the face coordinates obtained above, and then controls the movement of the servo.

- ## bsp_servo.c

```
ServTypdef Xserv = {
.pwm = 2000,
.MAXPWM = 2500,
.MINPWM = 500,
.MIDPWM = 1400
};

ServTypdef Yserv = {
.pwm = 1000,
.MAXPWM = 2300,
.MINPWM = 500,
.MIDPWM = 1000
};
```

This code sets the starting position of the servo, so it needs to be modified to fit the vertex of the gimbal movement. I set the initial position of the gimbal at the upper right corner, and then the gimbal can be adjusted proportionally through the coordinate changes of the k230. If you need to adjust the gimbal position and fine-tune the position, you need to adjust this position parameter.

```
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 transmitted by splitting each vertex into three groups of data, 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 description

The code sets the thresholds of three colors, and selects which color to recognize by modifying 0.1.2. When the selected color is recognized, k230 transmits the coordinates to the 2D gimbal, and then the 2D gimbal moves with the color to achieve the tracking effect.