K230 Gesture Control (Voice)

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This tutorial is a comprehensive experiment combining multiple peripherals. It's recommended to familiarize yourself with individual peripherals first before proceeding with this experiment.

I. Software-Hardware

- **KEIL5**
- **MSPM0G3507 Robot Development Board**

k230 Module: External

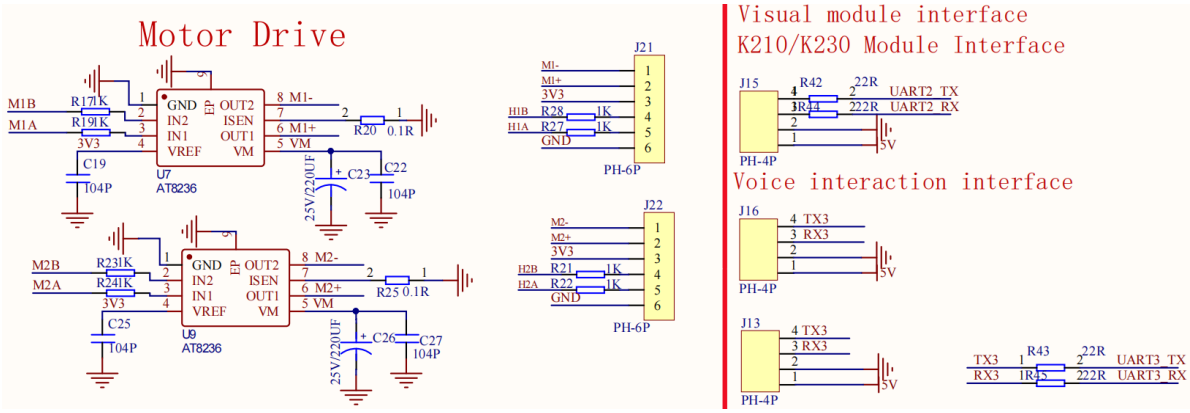
AI Voice Interaction Integration Module: External

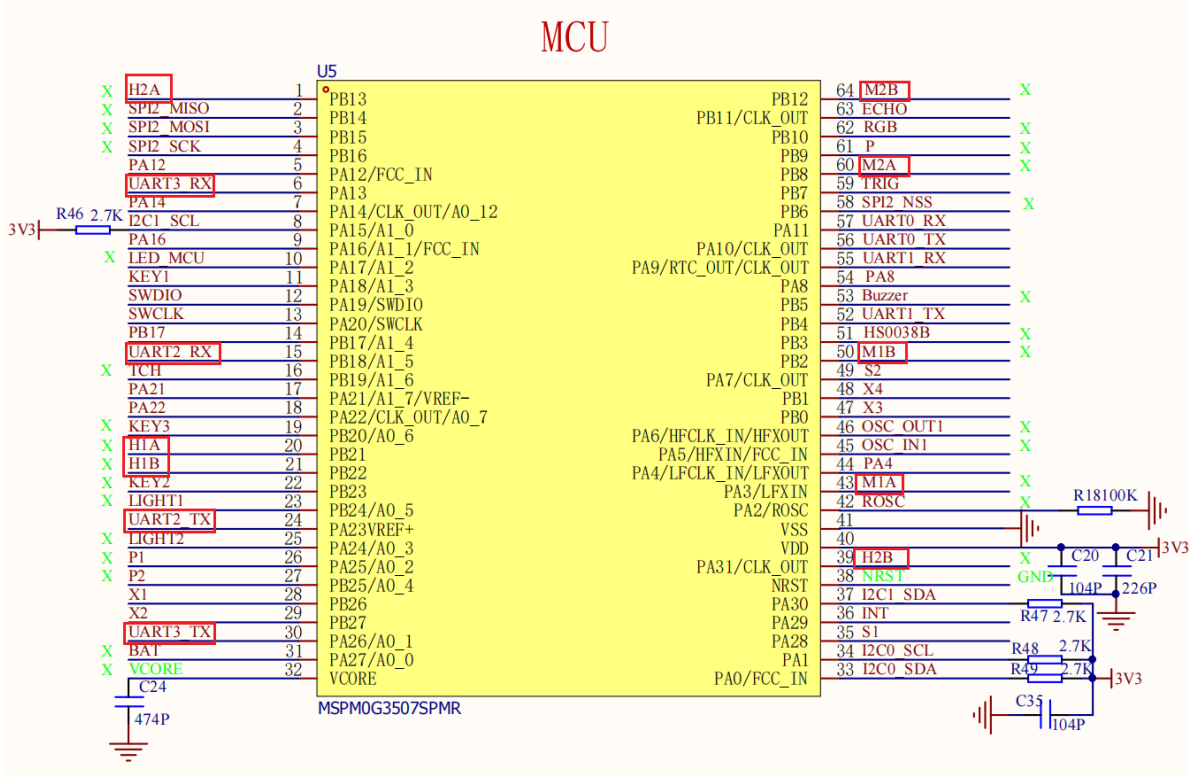
- **Type-C Data Cable or DAP-Link**

Download or simulate the program on the development board

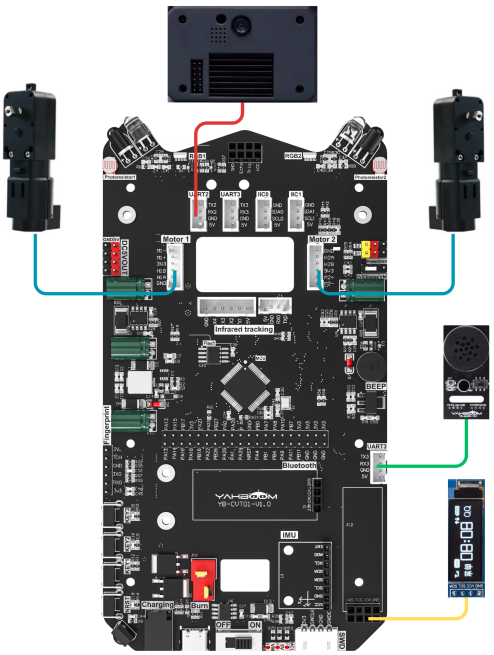
II. Brief Principles

1. Hardware Schematic Diagram





2. Physical Connection Diagram



Wire Connection Pins

Motor Wiring (Note: The wiring diagram below is for reference only. Our products come with a double-ended PH2.0 6-pin all-black cable with a foolproof design, so there's no need to worry about wiring issues.)

TT Encoder Motor	MSPM0G3507
M -	M1 -
M +	M1 +
VCC	3V3
Encoder B	H1B
Encoder A	H1A
GND	GND

TT encoder motor	MSPM0G3507
GND	GND
Encoder A	H2A
Encoder B	H2B
VCC	3V3
M +	M2 +
M -	M2 -

Voice module wiring (Note: The wiring diagram below is for reference only. Our products come with a dual-ended PH2.0 4-pin all-black voice module cable with a foolproof design; no wiring issues are necessary.)

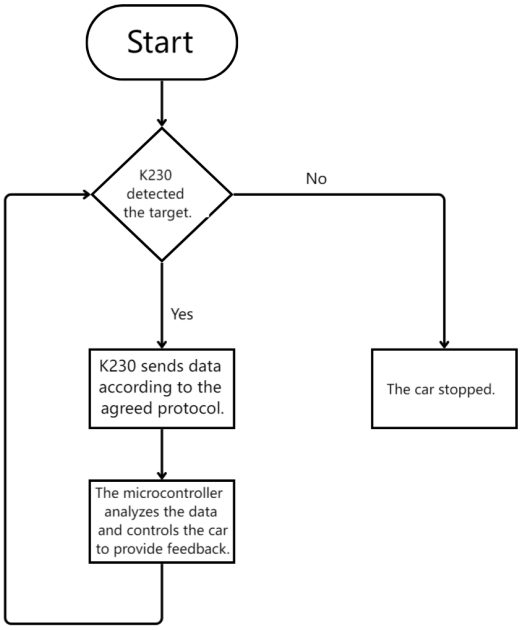
Intelligent voice interaction module	MSPM0G3507
RX1	TX3
TX1	RX3
GND	GND
5V	5V

K230 Wiring (Note: The wiring diagram below is for reference only. Our products come with a K230 double-ended PH2.0 4-pin all-black cable with a foolproof design; you don't need to worry about wiring issues.)

K230	MSPM0G3507
RX	TX2
TX	RX2
GND	GND
5V	5V

3. Control Principle

- **Program Flowchart**



Control Principle:

PID Control

PID control is a commonly used closed-loop control algorithm. It continuously adjusts the controller's output to minimize the error between the system's actual output and the desired output.

PID Parameters	Function	Purpose
P (Proportional)	Determines the response speed of the PID controller output	Speeds up system response
I (Integral)	Determines the PID controller's response to accumulated errors	Eliminates steady-state errors
D (Differential)	Determines the PID controller's response to the rate of change of error	Improves the system's steady-state performance

Module	Function
k230 Vision Module	Select the line you want to identify, then send the data to the microcontroller via serial port

Communication Protocol:

After the k230 identifies the color track, it will send a data frame via serial port, in the following format:

Experimental Routine	Start Character	Length	Separator	Routine Number	Separator	x	Separator	y	Separator	w	Separator	h	End Character
Color Recognition	$	XX	,	12	,	XXX	,	XXX	,	XXX	,	XXX	#

Microcontroller Section:

Receives data sent by the K230 via serial port and processes each byte of data. Extracts valid data from the data frame content and stores it in an array. Then, performs PID processing on the array data, and the microcontroller uses the processed data to drive the motor, thus moving it along the track.

III. Code Analysis

Main Function Analysis

> **Function: Pto_Loop**

Function Prototype	void Pto_Loop(void)
Function Description	The main function for running the program
Input Parameters	None
Output Parameters	None

Partial Function Analysis

- main.c

```
ColorMode color_mode = 1;  //1: Line patrol, 2: Tracking


int main(void)
{

    bsp_init();//Peripheral initialization required
    Control_RGB_ALL(OFF);//Turn off RGB
    delay_ms(100);
 OLED_ShowString(0,0,"pid_output:",8,1);//The PID output is used to control left
and right.
    OLED_ShowString(0,20,"pid_output1:",8,1);//The PID output is displayed to
control the front and rear.
    OLED_Refresh();


    while (1)
    {
            Pto_Loop();
            OLED_ShowSNum(75,0, pid_output, 3, 8, 1);
            OLED_ShowSNum(75,20,pid_output1,3,8,1);
            OLED_Refresh();

    }
}
```

BSP_init: Hardware initialization

pto__Loop: Continuously processes received messages from the K230.

- yb_protocol.c

```c
/**
 * @Brief: Data Analysis
 * @Note:
 * @Parm: The received data frame and its length are input.
 * @Retval:
 */
void Pto_Data_Parse(uint8_t *data_buf, uint8_t num)
{
    uint8_t pto_head = data_buf[0];
    uint8_t pto_tail = data_buf[num-1];

    //Verify the beginning and end
    if (!(pto_head == PTO_HEAD && pto_tail == PTO_TAIL))
    {

        return;
    }

    uint8_t data_index = 1;
    uint8_t field_index[PTO_BUF_LEN_MAX] = {0};
    int i = 0;
    int values[PTO_BUF_LEN_MAX] = {0};
    char msgs[][PTO_BUF_LEN_MAX] = {0};

    //split field
    for (i = 1; i < num-1; i++)
    {
        if (data_buf[i] == ',')
        {
            data_buf[i] = 0;
            field_index[data_index] = i;
            data_index++;
        }
    }

    //Parsing Length and Function ID
    for (i = 0; i < 2; i++)
    {
        values[i] = Pto_Char_To_Int((char*)data_buf+field_index[i]+1);
    }

    uint8_t pto_len = values[0];
    uint8_t pto_id = values[1];


 ParseCommonFields(pto_id,data_buf,pto_len,field_index,data_index,values,msgs);

}
```

This function parses the received data that conforms to the protocol, extracts the function ID number and the data information carried within the data, and executes the corresponding processing function. This project uses metadata parsing. The core idea is to separate the protocol format description (field position, type, etc.) from the parsing logic. The protocol format is defined

through data structures (such as structure arrays), and the parsing function automatically processes the data based on these descriptions.

The protocol can also parse data containing different data types. For implementation details, you can research it yourself; we won't go into too much detail here. This function is compatible with all K230 communication protocols in our store; you don't need to fully understand it to use it normally.

- bsp_PID_motor.c

```
// PID is calculated for a single channel.
float PID_Calc_One_Motor(uint8_t motor_id, float now_speed)
{
    if (motor_id >= MAX_MOTOR)
        return 0;

        return PID_Location_Calc(&pid_motor[motor_id], now_speed);


}

void Set_PID_Motor(float set_l ,float set_r,float turn_out)
{


        l_pid_out = PID_Calc_One_Motor(0, set_l);
        r_pid_out = PID_Calc_One_Motor(1, set_r);

        PWM_Control_Car(l_pid_out+turn_out , r_pid_out-turn_out );

}

// Positional PID Calculation Method

float PID_Location_Calc(PID_t *pid, float actual_val)
{
    /*Calculate the error between the target value and the actual value.*/

    pid->err = pid->target_val - actual_val;

    /* Limited closed-loop dead zone */

    if ((pid->err >= -40) && (pid->err <= 40))
    {
        pid->err = 0;
        pid->integral = 0;
    }

    /* Integral separation; remove the integral action when the deviation is
large.*/

    if (pid->err > -1500 && pid->err < 1500)
    {
        pid->integral += pid->err; // error accumulation 误差累积

        /*  Limit the range of points to prevent points saturation. */
```

```
        if (pid->integral > 4000)
            pid->integral = 4000;
        else if (pid->integral < -4000)
            pid->integral = -4000;
    }

    /*PID algorithm implementation*/
    pid->output_val = pid->Kp * pid->err +
                      pid->Ki * pid->integral +
                      pid->Kd * (pid->err - pid->err_last);


    /*Error propagation*/
    pid->err_last = pid->err;

    /*Returns the current actual value*/
    return pid->output_val;
}
```

Set_PID_Motor: Sets the target values for the two motors and the steering loop output value.

PID_Calc_One_Motor: Calculates the position loop PID value for one channel and returns the calculated value.

PID_Location_Calc: The position loop PID calculation formula and the complete position loop structure.

- bsp_K230_control.c

```
//Dynamic gesture recognition case
void hand_Rec(const char* msg)//The received data is analyzed, and then the
movement of the car is controlled.
{
    if(strcmp(msg,"UP")==0)
    {
            Write_Data(0x27);//Send to the voice module


        Set_PID_Motor(70,70,0);
        delay_ms(1000);

             Motor_Stop(1) ;
    }
    else if(strcmp(msg,"DOWN")==0)
    {

        Write_Data(0x28);

        Set_PID_Motor(-70,-70,0);
        delay_ms(1000);
             Motor_Stop(1) ;

    }
    else if (strcmp(msg, "RIGHT")==0)
    {
```

```
            Write_Data(0x2A);

        Set_PID_Motor(70,70,50);
        delay_ms(1000);
        delay_ms(1000);
             Motor_Stop(1) ;
    }
    else if (strcmp(msg, "LEFT")==0)
    {

            Write_Data(0x29);

        Set_PID_Motor(70,70,-50);
        delay_ms(1000);
        delay_ms(1000);
             Motor_Stop(1) ;
    }
    else {

             Motor_Stop(1) ;

    }
}
```

hand_Rec: The car will react based on the hand gestures (from top to bottom, bottom to top, left to right, and right to left) recognized by the K230.

IV. Voice Module Commands

命令词 (Command Word)	功能类型 (Function Type)	播报语句 (Broadcast Statement)	播报模式 (Broadcast Mode)	发送协议 (Send Protocol)	接收协议 (Receive Protocol)
WELCOME	欢迎语 (Welcome)	welcome	被 (Passive)	AA 55 01 00 FB	AA 55 01 00 FB
BYE	休息语 (Rest)	bye	主 (Active)	AA 55 02 6F FB	AA 55 02 00 FB
HI-YAHBOOM	唤醒词 (Wake Word)	I am here	主 (Active)	AA 55 03 00 FB	AA 55 03 00 FB
VOLUME-UP	增大音量 (Increase Vol)	Volume Up	主 (Active)	AA 55 04 00 FB	AA 55 04 00 FB
VOLUME-DOWN	减小音量 (Decrease Vol)	Volume down	主 (Active)	AA 55 05 00 FB	AA 55 05 00 FB
MAX-VOLUME	最大音量 (Max Volume)	Maximum volume	主 (Active)	AA 55 06 00 FB	AA 55 06 00 FB
MID-VOLUME	中等音量 (Medium Volume)	Medium volume	主 (Active)	AA 55 07 00 FB	AA 55 07 00 FB
MINI-VOLUME	最小音量 (Min Volume)	Minimum Volume	主 (Active)	AA 55 08 00 FB	AA 55 08 00 FB
START-REPORT	开播报 (Enable Broadcast)	Start broadcasting	主 (Active)	AA 55 09 00 FB	AA 55 09 00 FB
STOPT-REPORT	关播报 (Disable Broadcast)	Stop Broadcast	主 (Active)	AA 55 0A 00 FB	AA 55 0A 00 FB
UP	命令词 (Command)	The car moves forward upon recognizing the upward gesture	主 (Active)	AA 55 00 27 FB	AA 55 00 27 FB
DOWN	命令词 (Command)	The car reverses when the downward gesture is detected	主 (Active)	AA 55 00 28 FB	AA 55 00 28 FB
LEFT	命令词 (Command)	The car turns left upon recognizing a leftward gesture	主 (Active)	AA 55 00 29 FB	AA 55 00 29 FB

命令词 (Command Word)	功能类型 (Function Type)	播报语句 (Broadcast Statement)	播报模式 (Broadcast Mode)	发送协议 (Send Protocol)	接收协议 (Receive Protocol)
TO-THE-RIGHT	命令词 (Command)	The car turns right upon recognizing a right hand gesture	主 (Active)	AA 55 00 2A FB	AA 55 00 2A FB

V. Experimental Operation

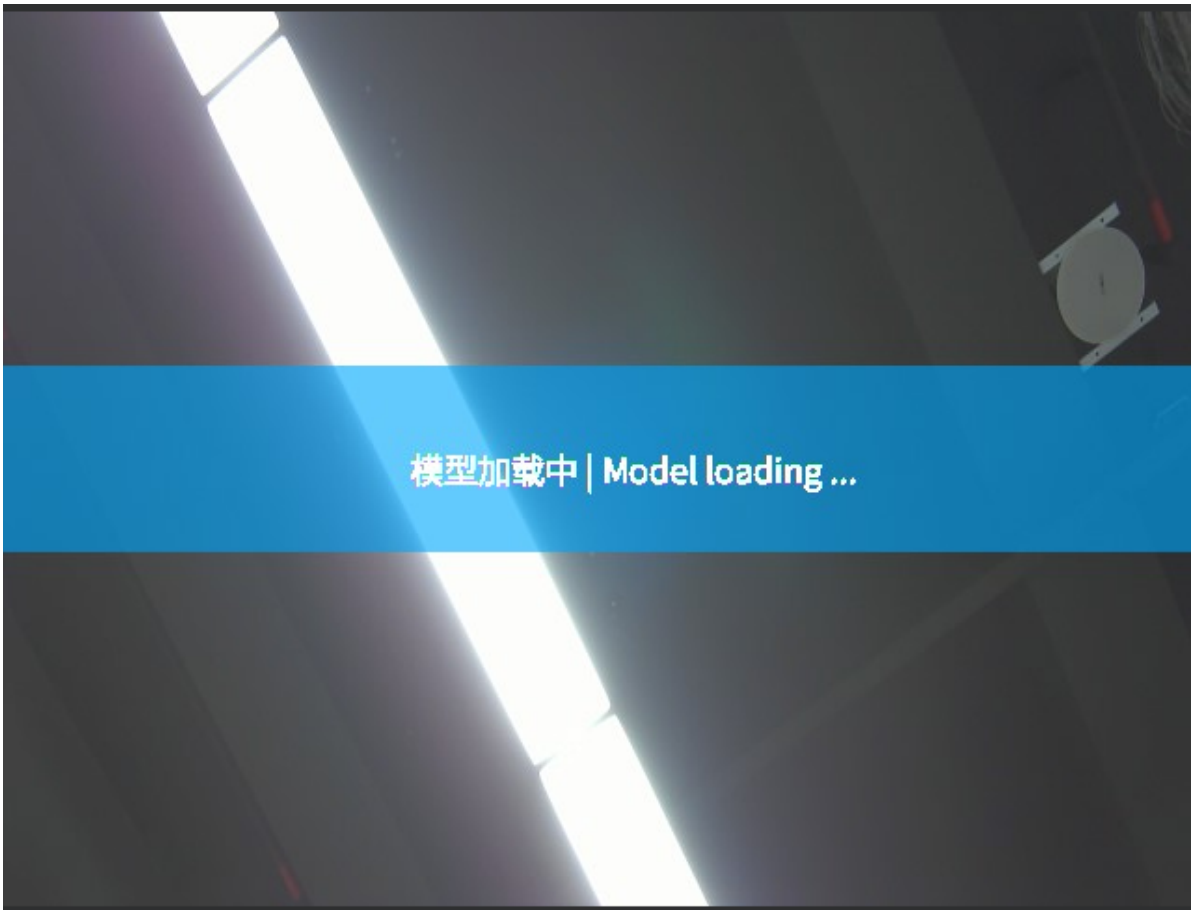
1. Connect the wires according to the hardware wiring instructions in the tutorial.
2. Place `dynamic_gesture.py` in the root directory of the K230's SD card and rename it to `main.py`. Then reset or power cycle the device. If you are unsure how to program the K230, please refer to the K230 quick start tutorial.
3. Place the car in an open area and position the K230 correctly for better gesture recognition.
4. After successful initialization, the K230 will begin recognizing dynamic gestures. Press the car's reset button and wait three seconds. When the K230 recognizes a handprint, an image of a hand will appear. Move the handprint from top to bottom, bottom to top, left to right, and right to left. The car will react according to the K230's recognition.

Note: The voice module requires firmware flashing in advance.

Voice Module Firmware Flashing

```
Simply burn the CI1302_EN_Single_V00916_UART1_115200_2M(MSPM0).bin file we provide to implement all the related cases of the intelligent voice interaction module for this car. For firmware burning, please refer to [Chapter 8: Extended application course (Sold separately) → 1.Voice interaction module communication]. If it has been burned before, it does not need to be burned again.
```

VI. Experimental Phenomena



After waiting for the routine to run and load the model, we place our hand in front of the camera and wait for the gesture icon to appear in the upper left corner. The appearance of this icon indicates that the K230 is ready to recognize the gesture, and then performs the corresponding gesture wave. The car will perform the corresponding action. For details, please see the following animation: **Note: When connected to our AI voice interaction integration module, there will be a voice broadcast when the gesture action is detected. Users who have not purchased the voice module do not need to worry. Even without connecting the voice module, the K230 can still achieve this case, but without the voice broadcast function.**