Design and Realization of Intelligent Vehicle Based on Embedded System

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Abstract: The paper takes the STM32F103ZET6 development board as the core to design a smart car with a PC-side real-time monitoring system and infrared wireless remote control. It is equipped with a small OLED display to monitor the running state of the necessary services in the car and the system network in real time through Wi-Fi monitoring video transmission and display, using infrared receiver and remote control to achieve NEC protocol communication, and control the wireless movement and the steering of a two-degree-of-freedom camera.

1. Introduction
With the development of technology, more and more enterprise production and application environments have begun to introduce automatic robots to replace traditional inefficient manual operations [1]. Among them, wheeled robots in popular research field with simple structure and strong capacity can perform automatic task execution or manual remote control. In the 20th century, all countries began to study the application of wheeled robots or smart cars for military industry, deep space exploration, factory monitoring and special terrain exploration.

The article is based on the STMF103ZET6 development board equipped with an OLED display to monitor the running state of the necessary services in the car system and the system network in real time, realize the transmission and display of the monitoring video through Wi-Fi, and use infrared remote control to realize the wireless control and two degrees of freedom camera head steering. The camera’s pan-tilt rotation can be controlled by manual remote control to take pictures. Through TCP communication, the image of the camera can be detected in real time after the PC Web is successfully connected more convenient and flexible than fixed.

2. System development environment
STM32F103ZET6 has an ARM 32-bit Cortex-M3 core, a maximum operating frequency of 72MHz, a maximum of 512K bytes of flash program memory, low power consumption, 3 12-bit analog-to-digital converters, 11 timers and 13 communication interfaces. It is composed of a micro-controller and Keil μVision5 IDE (integrated development environment) ready-made software, and it writes programs into flash at high speed through JLINK or ST LINK [2].
3. System hardware design

3.1 Power buck module
The system takes a 12V rechargeable lithium battery as the power supply for the L298N motor drive module. The power supply voltage is reduced to DC 5V through the MP1584EN fixed output step-down module to supply the STM32F103ZET6 development board and other sensor modules. The EN enable pin and Vin pin of the MP1584EN module are connected to the power supply in series, and the corresponding GND can be connected with 96% peak conversion [3].

3.2 DC motor drive module
L298N DC motor drive module, 12V input and GND pin can be connected to the 12V battery. By controlling L298N’s IN1, IN2, IN3, IN4 to different levels to achieve the motor’s forward and reverse rotation through the STM32F103ZET6 PWM output control, the speed regulating end A (B) of L298N can control the speed of the DC motor. The connection of the output terminals A and B of the L298N with the DC motor can realize simple control of the DC motor.

3.3 Two-degree-freedom pan-tilt
The two-degree-of-freedom pan-tilt consists of two Mg996r servos, which control the vertical and horizontal movement of the pan-tilt. The adjustment angle of the Mg996r servo is controlled by the input pulse width. It sets the PWM output working frequency of the timer TIM4 of the STM32F103ZET6 development board to 50Hz, and the working period T is as follows:

\[ T = \frac{10^3 \text{ freq}}{\text{ (m s) }} \]  

Formula (1)

According to formula (1), T=20ms, the calculation formula of pulse width PW and duty cycle D is as follows:

\[ D(\%) = \frac{PW}{T} \times 100 = \frac{PW}{10^3 \text{ freq}} \times 100 \]  

Formula (2)

The signal line of Mg996r is connected to the PWM output pin of the STM32F103ZET6 development board, and the value of the duty cycle in channel 1 of timer 4 is calculated by formula (2) to adjust the angle of the servo.
3.4 HY-SRF05 ultrasonic ranging sensor
The system takes three HY-SRF05 sensors, which are placed on the front, left and right of the trolley. The VCC and GND pins of the HY-SRF05 module are connected to the VCC and GND of the STM32F103ZET6 development board. The trigger signal input pin “TRIG” can be connected to any IO port of the STM32F103ZET6 development board. The 24-bit system tick timer system built in STM32 can be used for 10us timing. After receiving the “ECHO” from the HY-SRF05 sensor, the transmitted square wave signal is converted between high and low level at a frequency of 10us [4]. When STM32F103ZET6 and the IO port connected to the “ECHO” pin receive a high level, timer 4 is used to count the duration to obtain the high level time, and then the distance s is obtained by formula (3) as follows:

\[ S = \frac{(\text{High level time} \times \text{Speed of sound (340M/S)})}{2} \]  

Formula (3)

3.5 ATK-ESP8266 WiFi module
The functions of the ATK-ESP8266 Wi-Fi module include wireless audio and video transmission, high-speed acquisition and transmission, and fast transmission of large amounts of data. The STM32F103ZET6 development board in the system performs SPI communication with the ATK-ESP8266 module, and the VCC and GND of the ATK-ESP8266 module are respectively connected to the corresponding STM32F103ZET6. “MISO”, “MOSI”, “SCLK” and “CS” pins are respectively connected to the SPI communication pins of STM32F103ZET6. Through the ATK-ESP8266 module and the PC end wireless TCP communication, the real-time video data is sent to the PC end and displayed.

3.6 ATK-OV7725 camera module
The ATK-OV7725 camera has an infrared filter, which can filter out stray light, correct color casts, and improve the clarity of video images. The working mode of the camera is set to OV7725_VGA mode in this system. The STMF103ZET6 development board and the camera use the SCCB serial camera control bus [4]. OV_SCL is the data line for transmitting the clock signal, and OV_SDA is the data line for transmitting the data signal. The SCCB communication is transmitted every time 9-bit data, the first 8 bits are data bits, and the 9th bit is invalid.

4. System software design
The main control board used in the system is the STM32F103ZET6 development board. First, it can initialize the internal devices and peripherals. The ATK-ESP8266 Wi-Fi module is connected to the PC by TCP. After the connection is successful, the STM32F103ZET6 communicates with the OV7725 camera module through SPI communication to obtain the camera image. The information is stored, and the image data is sent to the PC in the form of TCP packets through the ATK-ESP8266 Wi-Fi module. The PC receives and decodes the video, displays the image, realizes real-time remote monitoring, and the infrared remote control gives an order.

When the received instruction is “1”, it means that the cart executes a left turn instruction. When it sets the logic input of L298N to 1001, the left motor rotates forward, the right motor reverses, and the car is controlled to turn left through PWM. When the received command is “2”, it means that the cart executes the forward command. When it sets the logic input of L298N to 1010, and both the left and right motors rotate forward, and the car is controlled to move forward through PWM. When the received command is “3”, it means that the car executes the stop command. When it sets the logic input of L298N to 0000 to disable the motor, and the PWM output control is also invalid. When the received instruction is “4”, it means that the cart executes the backward command. When it sets the logic input of L298N to 0101, the left and right motors are reversed, and the carriage is controlled to move backward through PWM. When the received instruction is “5”, it means that the cart executes a right turn instruction. When it sets the logic input of L298N to 0110, the left motor reverses, the right motor forwards, and the cart is controlled to turn right through PWM. When the received command is
“DOWN”, it means the car has entered the speed control command mode. When continuing to receive “VOL+”, the acceleration command is executed. When the “VOL-” is received, the deceleration command is executed. When the received command is “6”, the pan-tilt will execute the left shift command and automatically adjust the PWM duty cycle to control the movement of the steering gear. When the received command is “7”, the pan-tilt will execute the right shift command and automatically adjust the PWM duty cycle to control the movement of the steering gear. When the received command is “8 and 9”, the pan-tilt will execute the upward movement command and automatically adjust the PWM duty cycle to control the movement of the steering gear. When the received command is “0”, the pan-tilt will execute the downward movement command and automatically adjust the PWM duty cycle to control the movement of the steering gear.

The distance measured by ultrasonic sensor is stored in microprocessor in real time. When the distance is less than the safe, the system will stop the execution of other instructions and give priority to the back instruction of the car. The system continues to cycle based on the above process.

5. Conclusion
In this paper, a remote-control smart car with STM32F103ZET6 as the core is designed with the idea of modularization. It takes ATK-OV7725 as machine vision module and cooperates with ATK-ESP8266 Wi-Fi module to realize the purpose of video transmission. Real-time video monitoring is realized through TCP data packet transmission to the PC and video decoding. Infrared remote control can control the forward and backward operations of the car and the movement of the PTZ. The coordination between the various modules is good with superior performance and low cost, and the practicability is strong.

References:
[1] Ye MJ, Huang Yl, Lei GH. 2020. Design and implementation of smart car system based on OV7725 camera[J]. Journal of Hubei Normal University (Natural Science Edition), 40(02): 82-87.
[2] Li RF, Han YG, Liu YX Wu Shaowei. 2020. Software design of mobile ball picking smart car based on machine vision [J]. Electronic Testing, (12): 71-72+136.
[3] Chu SJ, Xu ZH. 2020. Research on the design and development of smart cars[J]. Communication Power Technology, 37(04): 48-49+51.
[4] Chen WX. 2019. Discussion on multifunctional intelligent car based on 51 single chip microcomputer [J]. Modern Information Technology, 3(23): 25-29.