Design of Intelligent Anti-suffocation System in Vehicle

ZHENG LI¹a, YUN CAO²b*, ZHULE JIN³c

¹ Institute: School of Mechanical Engineering, Nanjing University of Science and Technology, Nanjing, China
² School of Mechanical Engineering, Nanjing, China
³ School of Mechanical Engineering, Nanjing University of Science and Technology, Nanjing, China

a 2711171685@qq.com, b cy1990@njust.edu.cn, c 718963471@qq.com

Abstract—With the progress of society, more and more families take cars as the main means of transportation. At the same time, due to the negligence of some parents, there are more and more suffocation accidents caused by children left in the car and adults resting in the car. At present, the research can only detect people who are moving around in the car, but not those who are resting in the car. At present, many systems are detecting and alerting, rather than directly solving the problem. The people left in the car with engine cut off and all the doors closed. The capacity of the car battery is very small, which requires the system operates with minimal power consumption. This problem is not considered in the current relevant research.

To solve the above problems, this paper designs a system based on low power consumption dual microprocessor, combined with power management program, equipped with carbon dioxide sensor, temperature sensor and camera, which has low power consumption and can detect people resting and staying in the car at the same time. The system can effectively solve the shortcomings of the current research in view of the two situations of people resting and staying in the car at the same time.

1. INTRODUCTION

With the continuous development of society, cars have become the choice for more and more families to travel, which greatly facilitates people's life. But at the same time, the incidence of traffic accidents is also increasing. In recent years, there are more and more accidents in which children are left in the car to suffocate and die, and adults suffocate when they rest in the car, which has brought harm to countless families. The closed environment in the car will lead to heatstroke, overheating, dehydration, suffocation and death of people staying in the car. Therefore, a system that can detect and execute is particularly important.

At present, the relevant research on the detection of people in the car can only detect the people moving in the car, not the people resting. In the paper A Mechatronic System to Prevent Death due to Suffocation in a Locked Car, motion sensor and temperature sensor are used for detection, which can not deal with the situation that someone is asleep in the car[1]. In the paper Child Presence Detection and Alerting System in an Unmanned Car, the message is sent to adults by detecting the activities in the car, without considering the sleeping people[2].

In addition, the current research is only to detect the issue and wait for rescue, which does not directly solve the problem. In the paper Design of Anti-suffocation Monitoring System in Vehicle, although the system has an executive module, it can only give an alarm when the vehicle has no sunroof, which also has shortcomings[3]. In the paper Alert System for Child in Car Using NodeMCU,
parents are informed by sending a message that they can remotely control the steering gear to open the window to prevent suffocation, but there are also situations where parents can't receive the message[4].

In order to solve the above problems, the system designed in this paper is composed of detection module, control module and execution module. The system can make corresponding judgment according to the situation, so as to make the window open and close, rather than only detect whether there are people without solving problems. For safety and low power consumption, the system adopts dual MCU design. MCU 1 controls the working mode of MCU 2. Only when the interior environment meets the preliminary preset conditions, MCU 1 will wake up MCU 2 through the serial port, perform further detection and output the corresponding results. The system can effectively reduce accidents.

2. SYSTEM DESIGN SCHEME
The system consists of detection module, main control module and execution module. The three parts are connected through control bus, data bus. The detection module is composed of carbon dioxide sensor, temperature sensor, sound sensor and camera, the control module is composed of MCU 1 and MCU 2 and their peripheral circuits, and the executive part is composed of relay and motor. The detection module can be installed at any position in the vehicle, and the execution module needs to be installed inside the car door. The opening and closing of the car window can be achieved by controlling the opening and closing of the corresponding relay through the control signal sent by the control module.

The system designed in this paper takes dual MCU as the control core and sensors for in car environment detection. MCU 1 is a low-power processor. MCU 1 and its peripheral circuit are mainly responsible for the detection of in car temperature and carbon dioxide content, and has been in operation state during the operation of the system; MCU 2 and its peripheral circuit are responsible for the detection of people left in the vehicle. MCU 2 communicates with MCU 1 through the serial port. During the system operation, MCU 2 is in the sleep state. When the preset conditions are met, MCU 1 wakes up MCU 2 through the serial port to release the sleep state of MCU 2. After MCU 2 enters the working state, it carries out the detection of people left in the vehicle, and outputs corresponding instructions in combination with the data detected by MCU 1, Make the relay perform corresponding action. This design can not only meet the normal function, but also achieve low power consumption design. The overall design structure of the system is shown in the figure.

![System design scheme](image)

Figure 1. System design scheme

3. HARDWARE DESIGN

3.1. Environment Monitoring Module
The interior environment monitoring module consists of temperature sensor, carbon dioxide sensor, sound sensor and camera. The temperature sensor and carbon dioxide sensor are respectively connected with MCU 1, and the sound sensor and camera are connected with MCU2[5].
1) Temperature sensor: Temperature sensor is a sensor that can sense the temperature change and convert the temperature into output voltage signal. The temperature sensor used in this paper is DS18B20 digital temperature sensor. The measuring temperature range of DS18B20 sensor is between minus 55 °C - 125 °C, and the sensor has high precision, low energy consumption, high stability, strong anti-electromagnetic interference ability and standard digital output[6].

2) Carbon dioxide sensor: Mh-z14a carbon dioxide gas sensor is a general intelligent small sensor. It uses the principle of non dispersive infrared to detect CO2 in the air, and has good performance. With built-in temperature compensation, digital output, analog output and PWM output, it is convenient to use. The sensor is a high-performance sensor made by combining mature infrared absorption gas detection technology with precise optical path design and excellent circuit design.

3) Sound detection module: Ky-037 sound sensor can detect the sound of the surrounding environment, with adjustable sensitivity, working voltage of 3.3v-5v, and the output form is digital switching output.

4) Camera: OV5640 camera adopts 1.4um × 1.4um pixel size, with high sensitivity, low crosstalk and low noise; automatic image control functions; automatic exposure, automatic white balance, automatic elimination of light fringes, automatic black level calibration, automatic band-pass filtering, etc.; the port supports image quality control: color saturation adjustment, tone adjustment, gamma calibration, sharpness and lens calibration, etc., Flash, auto focus, image zoom, translation and window settings support image compression, JPEG image data can be output, digital video interface and Mipi interface are supported, embedded microprocessor is provided, active crystal oscillator is integrated, LDO is integrated without external clock, and only 3.3V power source is required to work normally[7].

3.2. Main Control Module

The main control module is controlled by dual MCU. MCU 1 selects stm32f103zet6. The central processor of the chip is 32-bit Cortex-M3 based on arm, embedded with 8MHz RC oscillator, and the maximum working frequency is 72MHz. Flash memory between 256 and 512 bytes, 64K byte SRAM, 3 analog-to-digital converters, 3 line peripheral interfaces, 2 single and two-way two-wire synchronous serial bus interfaces, 4 FSMC interfaces, 11 timers, 5 serial ports, 1 controller area network interface and 112 GPIO ports are integrated on the chip[8].

MCU2 selects imx6ull from NXP company, which is a low-power, high-performance and low-cost application processor based on ARM cortex A7 core. The core can reach 900 MHz, parallel 24bit RGB LCD interface, 1366 × 768 resolution, 8 / 10 / 16 bit parallel camera sensor interface and up to 8 UART interfaces.

3.3. Execution Module

The execution module consists of two relays and a motor. The control signal from MCU 2 controls the relay. When the relay is closed, motor M is connected to the power supply[9]. The two relays control...
the forward and reverse rotation of the motor respectively, so as to control the lifting and lowering of the window.

![Diagram](image)

**Figure 3. Execution module**

### 4. SOFTWARE DESIGN

In the pictures below, we use gray fill indicates that the carbon dioxide concentration and temperature is out of range. The system based on Dual MCU designed in this paper has 5 working conditions:

Case 1: when the carbon dioxide concentration in the car is lower than 3% and the temperature is lower than 30 °C, MCU 1 works normally and MCU 2 is in sleep state. At this time, the relay does not act, as shown in Figure 4;

![Diagram](image)

**Figure 4. Case 1**

Case 2: when the carbon dioxide concentration in the car is lower than 3% and the temperature is higher than 30 °C, MCU 1 works normally and wakes up MCU 2. When no person is detected, the relay does not act, as shown in Figure 5;

![Diagram](image)

**Figure 5. Case 2**

Case 3: when the carbon dioxide concentration in the vehicle is lower than 3% and the temperature is higher than 30°C, MCU 1 works normally and wakes up MCU 2. When a person is detected, the relay acts to open the car window one-fifth, as shown in Figure 6;

![Diagram](image)

**Figure 6. Case 3**

Case 4: when the carbon dioxide concentration in the vehicle is higher than 3%, MCU 1 works normally and wakes up MCU 2. When no person is detected, it is also possible that someone is asleep.
in the vehicle, so the carbon dioxide concentration will. The relay will act to open the car window one-fifth, as shown in Figure 7;

![Figure 7. Case 4](image)

Case 5: when the carbon dioxide concentration in the vehicle is higher than 3% and the temperature is lower than 30°C, MCU 1 works normally and wakes up MCU 2. When a person is detected, the relay works to make the performs action to half open the car window, as shown in Figure 8;

![Figure 8. Case 5](image)

The system also adds a feedback function. In the above cases, when the window is opened, if the temperature and carbon dioxide concentration in the car do not tend to the normal value, the MCU 2 control relay continues to make corresponding actions to make the temperature and carbon dioxide concentration tend to the normal value.

5. CONCLUSION
The system designed in this paper relates to the field of automobile safety. It mainly prevents the occurrence of high temperature and suffocation accidents caused by children left in the car and adults sleeping in the car.

The system uses dual MCU design and MCU 1 low-power chip as the main control to control the work and sleep of MCU 2, so as to save battery power. Assuming that the car battery is 12V and 60ah, the working voltage of MCU 1 is 3.3V and the normal working current is 20mA, so the working time is 454 days. Therefore, the battery consumption is very small, which can completely avoid the battery loss caused by working during parking. Most of the related similar products use human body infrared sensors, gas sensors and other means to detect the personnel in the car, which requires a process, which may cause harm to the human body, and it is impossible to accurately judge whether the detained personnel in the vehicle are only children. Therefore, the system is more efficient and safe, and the combination of the system and the tachograph which has a wide market foundation makes it more convenient and practical, and has high popularization and application value. On the premise of wide application of the system, it can be expected that the accidents of children in the car due to asphyxia and dehydration will be improved.

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