Research on the Sensor-Based Automotive Interior Safety Alarm System

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Abstract. With the continuous development of the automobile industry, almost every family has a car, so the car safety issue is gradually highlighted. Driving for a long time produces drowsiness; many owners simply sleep in their car, especially younger children who are more prone to fatigue. In our lives, car asphyxiation accidents caused by high temperature and high concentration of carbon monoxide are very common. The automobile has been integrated into people’s life, and its related demands are more diversified. The automobile industry is about to enter the “post-automobile era”. The problem of the interior safety of automobiles is what we need to solve urgently. It is an important means for people to know the safety problems inside the car correctly and take precautions against them. In this document, the status quo of the automotive interior safety problems are described and analyzed. Based on the actual situation, a sensor-based automotive interior safety alarm system is proposed to promote the development of automobile safety industry.

1. Introduction
With the diversified development of modern society, people’s living standards are continuously improving. Nowadays, automobiles are not a luxury product anymore, and the popularizing rate of the automobile is also gradually increasing. Cars have brought great convenience to our life, meanwhile, along with potential safety hazards everywhere, which has aroused widespread concern in society. At present, the well-known automobile safety devices such as airbags, safety belts, and child safety seats can only deal with particular automobile safety problems. Extreme outside temperature, or improper use of central air conditioner in the car, will sharply increase the temperature and the carbon monoxide concentration. Some serious safety accidents will be caused if the ventilation window is not opened timely or relevant measures are not taken.

2. Automotive Interior Safety Issue

2.1. Explanation and Analysis of the Current Situation
At present, China has become a major country in automobile production and sales in the world. The data show that the annual automobile production and sales reached 27.809 million and 28.081 million respectively in 2018, ranking first in the world for ten consecutive years. With the increase of automatic automobile production and sales, the number of automobile ownership has also increased year by year, which means that automobile asphyxiation accidents arising from the imperfect interior safety system will significantly increase. The followings are the analysis of the current situation of automobile asphyxiation accidents:
Automobile asphyxiation accidents may occur throughout the year, and it is easier to happen during the period of high temperatures in summer. However, such accidents have also occurred at a low temperature of 16℃, according to the literature.

Automobile asphyxiation accidents cannot be avoided entirely through opening windows for ventilation. In addition to the influence of carbon monoxide in automobile exhaust, the temperature is also one of the critical factors to cause accidents [1]. For example, in July 2001, a grown man from the United States fell asleep in his automobile in a supermarket parking lot. Unfortunately, he eventually died from Heatstroke even if the window was open. Affected by the greenhouse effect in automobiles, when the outside ambient temperature of the car goes very high, the inside temperature of the sealed automobile will rise sharply. According to experiments, exposing a vehicle to places in direct sunlight, when the outside ambient temperature of the car is only 26.7℃, the inside temperature can rise rapidly to 34.6℃ within 2 minutes, 37.2℃ after 10 minutes, and 50.6℃ after 1 hour, which is enough to cause the Heatstroke. If people continue to stay in their car, their lives will be in danger. The graph of the temperature change in automobiles over time is shown in figure 1.

(3) Children are the usual victims of automobile asphyxiation accidents. That is because children are weak in action; they cannot have a self-rescue. When the automobile stops and is not in flameout, the carbon monoxide concentration or the temperature inside the car will continue to rise. If children stay in the car for a long time, the uncomfortable environment will be harmful to them, even to their lives [2]. Over the years, automobile asphyxiation accidents of children have occurred all over the world. For example, in June 2018, a 5-year-old girl from Thailand was forgotten in the automobile and eventually died from asphyxiation. In June 2019, a 7-year-old boy from Huai’an, Jiangsu, got into the trunk of the automobile and died from asphyxiation a few hours later. Take the United States as an example; following its relatively completed statistics, they found that children die from the suffocation of Heatstroke inside the automobile every nine days. The change curve of the number of American children deaths from the Heatstroke inside the automobile is shown in figure 2, it can be seen from the figure that the number of children that die from automobile asphyxiation has been generally upward with the popularity of the automobile.

Figure 1. Graph of the temperature change in automobile over time (Data Source: Internet).
2.2. Public Attention and Analysis

In our modern society, the public is pursuing the convenience and comfort of automobiles. Meanwhile, the requirements for automobile safety are also higher than ever before. We can obtain the number of documents published on “Automobile Safety” in recent years by using the retrieval function of CNKI to search for the theme “Automobile Safety” and carry out quantitative visual analysis on all retrieval results. As shown in figure 3, it can be analyzed from the figure that accidents of automobile safety frequently occurred with the increase of automobile ownership. People pay close attention to automobile safety, which reflects that the automobile safety system still needs to be improved. To improve the safety performance of automobiles, we must start from the three aspects of electronic control technology: electronization, intelligentization, and networking.

3. Automotive Interior Safety Alarm System

3.1. Research Purpose

The research of this system aims to solve the problem that there is no safety guarantee for the people in the car when the environment in the vehicle is unsuitable, and to improve the automobile safety alarm system. The system integrates sensors, communication, and executive modules for measuring temperature and carbon monoxide concentration, which can be used for real-time monitoring, accurate judgment, and the timely alarm. It is also simple to operate, making users feel better. The system is a new product created with the development of science and technology and catering to people’s needs. It
can effectively avoid automobile asphyxiation accidents and provide a comfortable environment for owners and their families.

3.2. System Composition
This system, an automotive interior safety alarm system that can effectively avoid automobile suffocation accidents, consists of a single-chip microcomputer (micro), carbon monoxide sensor, temperature-sensitive sensor, GPS module, 4G/5G module, and power module [3]. As shown in figure 4 the system can monitor the value of temperature and carbon monoxide concentration in the automobile in real-time. When a particular set value of the system is exceeded, the inside environment of the automobile is likely to make members in danger. Then the system will give an immediate alarm through the mobile App to remind the owner [4].

![Figure 4. Design drawing of system composition.](image)

3.3. Design of Sensor Modules
(1) Temperature-sensitive sensor
A temperature-sensitive sensor can detect the inside ambient temperature of the automobile in real-time, input the signal into the micro single-chip microcomputer, and display the interior temperature of the automobile through an application. If the inside temperature of the automobile is too high, the system will give an alarm through the mobile App to remind the owner [5].

(2) Carbon monoxide sensor
The carbon monoxide sensor can monitor the carbon monoxide concentration in the automobile in real-time to check the safety of the automotive internal environment. Acute carbon monoxide poisoning has the highest incidence and mortality rate of acute occupational poisoning in China, and it is also the primary inducement of accidental poisoning in other countries. When the automobile fuel is not enough, the carbon monoxide generated in the automobile exhaust can easily enter the automobile through the air conditioning system, thus causing the increase of carbon monoxide concentration in the automobile. Therefore, it is essential to consider a carbon monoxide sensor as an essential part of this system and to install it in automobiles.

3.4. Working Principle
This automobile alarm system adopts embedded technology and sensor technology, with embedded technology as the core. The system uses a temperature-sensitive sensor and a carbon monoxide concentration sensor to monitor the carbon monoxide concentration, the temperature data in the automobile in real-time, and the monitoring results are sent to the single-chip microcomputer for real-time processing [6]. The single-chip microcomputer analyzes the collected data and compares them with the existing database, and transmits the obtained information to the terminal (mobile phone App) through 4G/5G module. By doing so, it achieves the functions of real-time display of temperature and carbon monoxide concentration and warning the owners to open the window for ventilation [7, 8].

As shown in table 1, the mobile phone App displays the corresponding warning level according to the set data range. The green sign refers to the safe automobile interior environment; the yellow sign
means warning. Now, the App warns the owner through a pop-up window, and the red sign means alarm, the App will alert the owner immediately.

Table 1. Three alarm levels based on temperature and carbon monoxide concentration.

| Temperature (℃) | Carbon monoxide concentration (mg/m³) |
|-----------------|--------------------------------------|
| Green (safety)  | ≤33℃                                 |
| Yellow (warning)| 34℃-38℃                              |
| Red (alarm)     | ≥39℃                                 |
|                 | Green (safety) 0-19mg/m³               |
|                 | Yellow (warning) 20mg/m³-29mg/m³       |
|                 | Red (alarm) ≥30mg/m³                    |

At the same time, the system can accurately transmit the location information of the automobile to the owner through GPS module and 4G/5G communication module, so that the owner who is far away from the automobile can quickly locate the car and avoid danger in time [9].

3.5. Software Design
The automotive interior safety alarm system is designed to have the function of detecting the temperature and carbon monoxide concentration, determining whether the data is normal and being able to give an alarm in time. So, it is necessary to use program design to analyze the signal input by the sensor [10]. Some of the designed procedures are as follows:

```c
void range() {  
  if(CO>=CO_s3 || Temp>=Temp_s3)  
    // If the value of current carbon monoxide concentration or temperature exceeds the maximum safety threshold set by the system  
    alarm_3=1;  //App alarm  
  else if((CO>=CO_s1 && CO<=CO_s2) || (Temp>=Temp_s1 && Temp<=Temp_s2))  
    // If the value of current carbon monoxide concentration or temperature falls in the warning range  
    alarm_2=1;  //App pop-up warning  
  else {  // If the value of current carbon monoxide concentration or temperature falls in the safety range  
    alarm_1=1;  //App displays "safety"  
    alarm_2=0;  //Pop-up warning closed  
    alarm_3=0;  //Alarm off  
  }
}
```

4. Promotion and Practical Significance
On the theoretical level, the proposal of this automotive interior safety alarm system makes a new supplement to the development of the automobile safety industry and provides innovations and further develop ideas for the perfection and research of the automobile safety system, as well as provides a new breakthrough point for the research and development of computer control systems.

The improvement of people’s living standards and the popularization of the automobile are facts. The automobile asphyxiation accidents are gradually increasing because a large number of parents lack safety knowledge about children's riding, or parents are in a state of carelessness, distraction, and stress.

On the practical level, the development and market application of the automotive interior safety alarm system will focus on solving the internal safety of automobiles. Its development and implementation will significantly reduce asphyxiation death accidents in cars and ensure the safety of the owners and their families. Improve the user’s sense of security when riding and promote the comprehensive, convenient, and comfortable development of modern automobile safety system technology to a higher level [11].
To sum up, it can be seen that the proposal and introduction of the automotive interior safety alarm system can promote the development of the automobile safety research industry and play a particular supplementary role in the theory. From the perspective of practical significance, it can prompt more people to pay attention to the automotive interior safety issues, give people a deeper understanding of the automotive interior safety precaution measures, help to reduce the automotive interior safety accidents and promote the harmonious development of society. It has a big promotion and practical significance.

5. Conclusion
In this document, the status of automotive interior safety issues is explained and analyzed. Furthermore, the system composition and working principle of the automotive interior safety alarm system is put forward after investigating the degree of public attention and thinking deeply. The system requires high sensitivity of sensors. If the high sensitivity of sensors is failed, it is easy to cause system misjudgement, which requires further development of sensor technology. The design of this alarm system is of considerable significance to reduce automobile asphyxiation accidents.

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