Multi-Dimensional Integrated Sensing and Danger Warning System for Automotive Closed Environment

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Abstract. According to statistics, Chinese media reported that in recent years, the number of severe traffic accidents caused by fatigue driving has reached a staggering 141, including 113 people unfortunately died. Children aged 3 and under accounted for 68.7% of the total number of trapped children in the statistical cases, and the main causes of death of children locked in cars were heat stroke and suffocation due to insufficient oxygen in the car. At the same time, there are problems such as stolen cars or car parts.Based on this, aiming at the safety warning problems related to family cars, this project uses sensors and other elements in the car through real-time perception of gas, load, temperature and other elements, and establishes the perception model, fits the data and algorithms to carry out intelligent analysis, trying to achieve the following functions: The first is to use load judgment, infrared detection, pressure sensing and other sensing means to realize the detection of children left in the car and danger alarm; Secondly, according to the multi-dimensional perception inside and outside the vehicle, the comprehensive judgment analysis is carried out to realize the theft warning function of the vehicle and its related parts. At the same time, in order to ensure real-time accurate judgment and early warning, a mechanism to prevent misjudgment has been established. The embedded devices used in our design are small and can be installed in the car without any impact on the exterior beauty of the car.

Keywords: Car airtight, children left behind, vehicle theft, high accuracy

1 Introduction

With the rapid development of economy and society, the automobile market continues to grow, and the number of family cars is also increasing. However, due to the increase in the number of family cars brought more and more problems, children are forgotten and mistakenly locked in the car, fatigue driving and other problems plagued many people[1].

With the popularity of cars, domestic and foreign research continues to advance, the existing car detection device can no longer be the only guarantee, the current market known vehicle anti-theft means of mechanical anti-theft devices, risk detection devices and so on. These anti-theft systems are too simple to protect the car itself or the property inside in an increasingly complex urban environment[2]. In foreign countries, automobile detection technology after several generations of development, has developed from the original mechanical automobile

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anti-theft system to the latest GSM/GPS based network automobile detection system, while in China, due to price and technical reasons, ordinary electronic automobile detection devices still occupy the mainstream position.

Based on this, we aim at the family car safety warning problem, through the real-time perception of gas, load, temperature and other elements in the car, and establish a perception model for intelligent analysis, trying to achieve the following functions: through the orientation judgment, infrared detection and other sensing means to detect the children left in the car, to achieve danger alarm[3]. According to the internal and external multi-dimensional perception of the vehicle, the comprehensive judgment analysis is carried out to realize the vehicle theft alarm and early warning function.

2 Method

2.1 Research idea

In order to solve the above problems, we first investigated the gas and temperature status of a normal vehicle when it is stationary and the time it takes for vehicle gas and temperature to stabilize after it is stationary, collected relevant data, and determined the reasonable and irrational fluctuation range. Collect enough sample data for analysis. Using the standard values obtained from the analysis as parameters, we then carry out the following research process.

Firstly, the number of pressure sensors installed on the vehicle should be optimally distributed in the vehicle to detect the possible location of all children[4].

Secondly, the practice of data collection to obtain the best location for the installation of temperature module and gas detection module, so that it will not be affected by the abnormal data of air conditioning or other external factors, the collection of the most average data, to ensure the stability of the system.

Then there is the core data processing. Compare the collected data in the central module with the legitimate data value obtained from the research practice, so as to get the current situation of the car.Finally, the information is sent to the outside, and the popular and mature iot card is used to send early warning and information functions to the outside.

2.2 Gas concentration change

When the vehicle is stationary and empty, the gas and temperature in the car will not change particularly large within a certain range, and when someone is in the car, the oxygen and carbon dioxide in the car gas will be consumed and produced at a greater speed.

Set up a hazard alarm system, which is triggered when the oxygen concentration drops below a certain level (the car siren system can be connected and the warning is issued on the relevant equipment). This module is suitable for:

1. Children and babies are forgotten in the car

2. Driving with the Windows closed for a long time (the concentration of the relevant gas will have potential or obvious effects on human health, such as too low oxygen concentration, loss of judgment, slow reaction, etc.).

3. If the car is forced into the night, the gas concentration or temperature in the car will change drastically, which can trigger the alarm of the siren system Check the presence status of the person inside the car:

The pressure module is added under the seat cushion of the car to feedback the weight to the main board, and according to the change in gas concentration, it can be specifically determined whether there is someone present, and will not accidentally trigger the alarm system[5]. The response of the human body to different oxygen concentrations is shown in Table 1.

Table 1. Human reaction at different oxygen concentrations

Oxygen concentration	Human signs (under atmospheric pressure)
100%	6 minutes to death (absolutely confined environment)
50%	Fatal/Cured after 4 to 5 minutes with treatment
>23.5%	Oxygen-rich environment
20.9%	Normal oxygen concentration
19.5%	Minimum allowable oxygen concentration
15~19%	Reduce work efficiency
10~12%	Shortness of breath, purple lips
8~10%	Mental retardation, vomiting
6~8%	Eight minutes life-threatening
4~6%	Convulsions in 40 seconds, respiratory arrest

2.3 Pressure sensing setup

The purpose of the car seat pressure sensor is to detect whether the passenger sitting in the front passenger seat has the correct sitting position and realize the function of seat status monitoring. According to the seat structure, foam type and mask type of different models, the seat pressure sensor needs to be specially designed to ensure the installation of the seat and make the sensor play its best performance. For the safety of passengers, advanced car seats are generally equipped with pressure sensors for sensing whether there are passengers in the seat. When there is a passenger sitting in the seat, the pressure sensor is sensitive to pressure and outputs a switch signal to the alarm. However, the vertical arrangement structure of the sensor unit of the traditional car seat pressure sensor will cause the sensor to fail to collect signals due to the foam of the seat and the change of the passenger's sitting position, thus affecting the sensitivity and reliability of the sensor.

We incorporate thin-film contact sensors whose contacts are evenly distributed over the force surface of the seat to generate a trigger signal when the seat is subjected to external pressure, which is placed on the seat and pedals to confirm that there is someone in the car.

2.4 Template integration

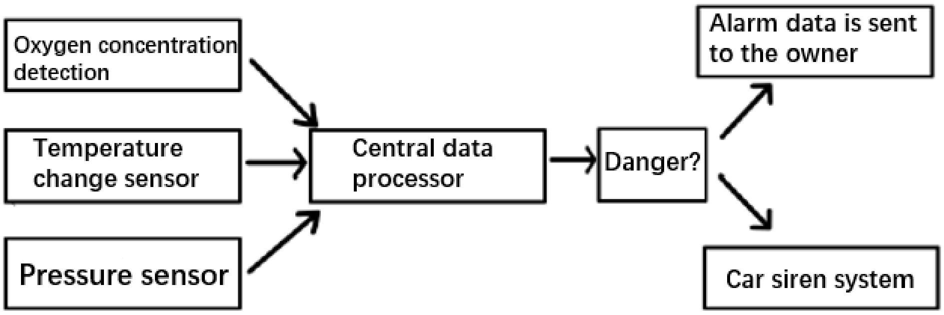

Fig.1. Modular structure

The modular structure is shown in Figure 1 above.

Key algorithms:

Sqoop: Use Sqoop to migrate local databases.

HDFS: The HDFS(Distributed storage technology) is used to store previously obtained data in the Hadoop system.

MapReduce: Uses the MapReduce distributed computing framework to map small tasks and then perform protocol calculations.

2.4.1 Detect if the personnel module is operating

Pressure sensors are installed on the seat and foot parts of the car to detect whether there are objects or people in the car, and the oxygen detection system can determine whether there are organisms in the car. The gas in the stationary unmanned vehicle will not change greatly, and if the oxygen concentration is detected to be consumed at a certain rate, the alarm system will be triggered[6]. The program is designed to start operation after disconnecting the car power supply system for a few minutes, the detailed data can be detailed in the later data collection process, and the gas concentration levels off after a few minutes.

2.4.2 Monitoring the operation of vehicle safety module

The vehicle is in a stationary state, and an alarm is issued if the environment is broken (detection: double detection of temperature and gas concentration to prevent misjudgment).After opening the door or being forced into the car, the temperature and oxygen concentration will change dramatically compared to the original, and it can be judged that the car is about to be used.

The power supply system uses battery and car USB dual power supply. After the vehicle engine is stopped, the battery is supplied by the on-board power supply system.

Owner detection: the owner needs to insert the USB power supply immediately after getting on the car, if the detection battery is in power supply and use does not power the system, it can issue an alarm to the owner, if the user forgets, after receiving the alarm, confirm that my driving has no impact. The security module is shown in Figure 2 below.

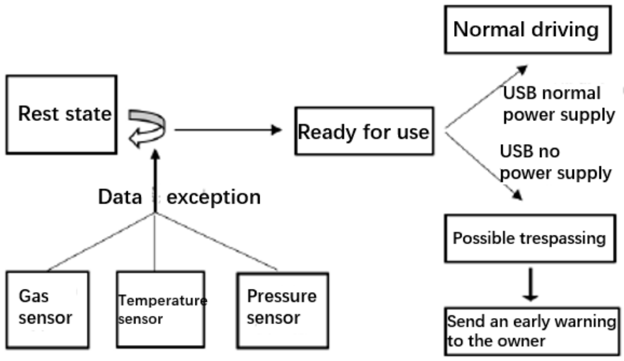

Fig. 2. Security module

3 Experiment

We also designed dangerous driving behavior detection technology, based on which we conducted validation tests on actual roads. The targets detected in the implementation of dangerous driving behaviors include distracted driving, speeding, emergencies, etc.

In the experiment, two drivers and markers are required to participate in the test. The driver drives an ordinary family car on an empty road, makes a phone call during normal driving, operates a mobile phone to reply to a text message, and randomly adds a sharp deceleration and a sharp turn[7]. When the marker feels that dangerous driving behavior is occurring, mark the type of dangerous driving behavior. We consider the time period of dangerous driving behavior events that contains artificially marked time points to be correct detected events (TP), while only the dangerous driving behavior events detected by the system that are not artificially marked within the time period are regarded as false positive (FP), and only the dangerous driving behavior events manually marked are not detected by the system as missed positive (FN). On this basis, we put forward two effectiveness measurement indicators: recall rate and accuracy rate[8]. Our experimental results are shown in Table 2, 3 and 4 below.

3.1 Distracted driving detection

We started with distracted driving detection, using other apps on the phone while driving the car on the road. Pull over to the side of the road and use other apps on your phone. The results of the distracted driving test are shown in Table 2.

Table 2. Distracted driving detection result

Test specification	System test result	Manual labeling result
Operate other apps while driving	Ten true	Ten true
Roadside parking operates other applications	Ten holidays	Ten holidays

Through testing, we found that both the recall rate and the accuracy rate are 100%. Through analysis, we believe that the rules for distracted driving are very simple, the detection scheme to detect whether the app has retreated to the background is completely accurate, and the judgment of whether the car is moving is also effective.

3.2 Overspeed test

Because the observer's subjective feeling is unable to directly obtain the accurate value of the vehicle's traveling speed, it is impossible to clearly determine whether the vehicle is really speeding[9]. Therefore, we introduced a relatively mature AmAP assisted test in the industry to play voice reminders when the speed exceeds the current road speed limit. The experimental results are shown in Table 3.

Table 3. Overspeed test result

Dangerous driving behavior	Amap decision times	System decision times	Same number of times	Recall rate	Accuracy rate
overspeed	30	29	28	93.3%	96.7%

From the table, we can see that the dangerous behaviors detected by the system are roughly consistent with the results of the Autonavi map, so we believe that the speeding behaviors can be effectively detected.

3.3 Test for other dangerous situations

Different from dangerous driving on the road, when there are emergency situations such as sudden braking or sharp turning, and when the vehicle stops, children will be left behind in the car, theft will occur in the car, etc. We conducted relevant experiments, and the experimental results are shown in Table 4.

Table 4. Sampling experiment result

Dangerous behavior	Manual mark count	System decision times	Recall rate	Accuracy rate
Slam the brakes on	40	36	90.0%	100%
Infrared thermal imaging	27	24	81.5%	91.7%
Fatigue detection during parking	30	21	60%	85.7%

For the situation of sudden braking, 4 out of 40 tests we conducted missed detection, no wrong detection, and the recall rate has reached 90%. For whether there are children in the car, we conducted infrared thermal imaging, and the accuracy rate has reached 91.7%, achieving the expected effect. For fatigue monitoring, the accuracy rate is 85.7%. We believe that this may be because the reference sample is insufficient and the data collection fails to cover various types of driving patterns.

4 Conclusion

The project is based on the car hazard detection problems on the market, such as: dangerous situation detection, children forgotten in the car, body parts stolen design, relying on the car gas concentration, temperature, load, infrared and other multi-dimensional judgment, sensing the safety of the vehicle, and provide corresponding alarm measures, if the equipment itself due to misjudgment, the alarm can also be lifted according to the owner's operation. The implementation of this function relies on existing embedded devices, sensors, various detection modules and iot cards. The device makes corresponding judgments through the data arithmetic transmitted to the motherboard[10]. The source of the input data is to compare the various data collected by the central module during the experiment with the legitimate data values obtained in the research practice, thus determining the most likely current state of the vehicle.

Our team believes that the system can effectively solve the simple problem of left-behind children in cars and car-related theft in society, effectively improve the life safety of citizens, and realize the popularization and networking of products as far as possible, and can be updated in time with the development of The Times.

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