Design and implementation of intelligent monitoring system for public transport applications

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Abstract. With the rapid development of automobile technologies and great economic growth, cars have become more and more popular for their convenience. However, the increase in cars has caused serious air pollution and increased the probability of traffic accidents. This paper investigates the design and implementation of intelligent monitoring and early warning system, which can detect the traffic conditions and provide environmental monitoring data. To achieve a comprehensive monitor for both inside and outside the public transport, this system is based on the STC12C5A16S2 micro-controller and loaded with all kinds of sensors, such as alcohol sensors, temperature and humidity sensors, toxic gas sensors, photosensitive sensors and light sensors etc. If the system detects any abnormal situation, it will generate early warning signs in time to inform the driver and the traffic regulatory departments. Consequently, our intelligent monitoring system can protect the safety of passengers and reduce the incidence of traffic accidents.

Keywords: Public transport, Environment monitoring, Early-warning, Intelligent control.

1 Introduction

Chinese car market is experiencing explosive growth. Since 2009, China has surpassed the United States and became the world's largest automobile producer. Due to social progress, rapid economic development and continuous improvement of people's living standards, the number of cars has increased year by year. The popularization of cars has brought us a lot of conveniences, but it also causes potential dangers and air pollution.

To ease the traffic pressure, relieve air pollution and improve living standards and quality, part first-tier cities have implemented odd-even "traffic restrictions, which actively encourages people to use municipal public transportation to travel, advocate environmental

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protection, energy-saving, green travel, therefore, to promise the safety and comfort of public transportation [1] becomes an important-thing.

2 The system function

The main functions of the system are as follows: the intelligent alcohol sensor module, the intelligent oxygen sensor module, the intelligent temperature and humidity sensor module and the high beam sensor module etc.

The intelligent alcohol sensor monitoring module is used to detect alcohol for the drivers on duty. If the driver meet the criteria for driving [2], he can work normally and start public transportation. Otherwise, the system will directly issue an early warning number to the general dispatch center for dangerous driving warning and performing related responsibilities.

The intelligent oxygen sensor monitoring module is used to monitor the real-time oxygen content inside the vehicle. If the oxygen content is less than 18%, it will cause discomfort such as lack of oxygen for passengers. At this time, the system will automatically increase the air supply to provide fresh air.

The intelligent temperature and humidity sensor monitoring module is used to detect the real-time temperature and humidity inside the vehicle and the system offers capability to dynamically adjust temperature and humidity for vehicle based on real-time monitoring. When the outside temperature exceeds 26℃, the system automatically turns on the air conditioning to cool down, and intelligently adjusts the temperature between 24℃ and 26℃, which can make the passengers feel more comfortable.

The high beam sensor monitoring module is composed of distance measurement module and high beam control module. The distance measurement module is to detect that whether there is an approaching vehicle on the opposite side of the vehicle. If there is a vehicle A on the opposite side, and the vehicle B turns on its high beams while driving, this monitoring module will control the vehicle B to change the high beam to dipped beam light. There by, avoiding the occurrence of traffic accidents caused by the wrong use of high beams.

3 System hardware platform construction

This system uses STC12C5A16S2 micro-controller as the main MCU, which is a single clock (machine cycle) (1T) single-chip microcomputer (SCM). According to the preliminary investigation, the system is divided scientifically and reasonably. The system is mainly loaded with oxygen sensors, ultrasonic sensors, alcohol sensors, toxic gas sensors, photosensitive sensors, temperature and humidity sensors [3], which constitute the sensing layer of the system.

The system mainly relies on these sensors to complete on-site real-time monitoring and measurement of the application environment, collect relevant environmental factor data in real time. The system uses the corresponding data fusion processing algorithm to generate intelligent decision data for the collected data. The system compares the generated intelligent decision data with the set boundary value, generates the corresponding intelligent early warning in time, and completes the corresponding intelligent control operation.

4 System software design and implementation

This section is mainly focuses on the programmatic implementation of the system functions. The system is developed on Keil 4 using the C programming language.

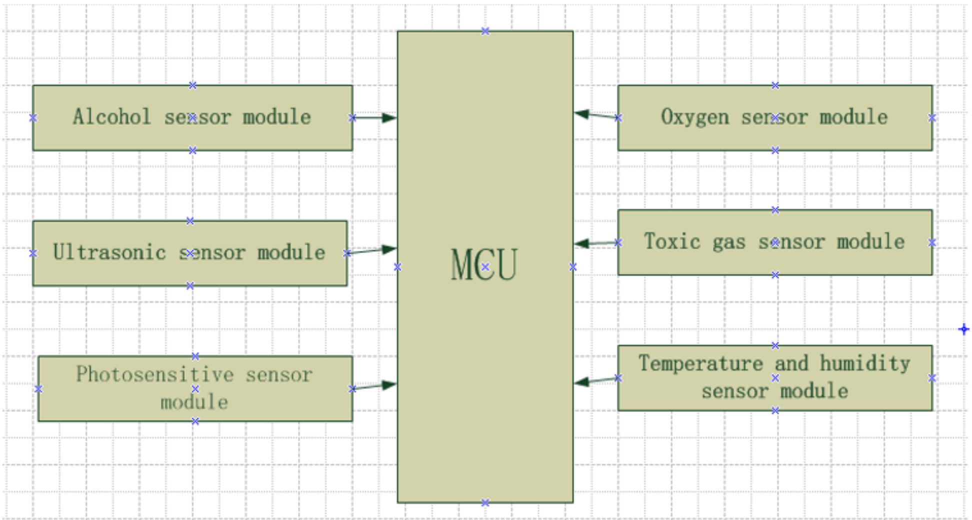

Fig. 1. System function module diagram.

4.1 The intelligent alcohol sensor monitoring module

The intelligent alcohol sensor monitoring module uses the MQ-3. MQ-3 uses SnO_2 which is low conductivity in clean air as the gas-sensitive material. When there is alcohol vapor in the environment where the sensor is located, the conductivity of the sensor increases with the increase of the concentration of alcohol gas in the air. Changes in conductivity can be converted into an output signal corresponding to the concentration of the gas using a simple circuit [4].

The system uses MQ-3 to measure the alcohol concentration, the results are transmitted to control center via compactor for further processing. The alcohol sensor module is installed in the driver's position. The driver must take an alcohol breath test before starting the car, and if the alcohol concentration reaches the national standard for drunk driving, early warning signals will be generated and transmitted to the traffic management center to notify the relevant personnel. At the same time, when driving, the alcohol detection module will keep working to prevent drivers from drinking secretly during work which may bring safety risks to passengers.

When the value of ADC1 is greater than 620, the system determines that there is alcohol and output the string "Alcohol detected" and the system generates early warning signals and transmits them to the traffic management center to notify the relevant personnel.

4.2 The Intelligent high beam monitoring module

The intelligent high beam monitoring module is designed for night driving. Light beam is very important for safe driving, especially for drivers who drive at night for long periods of time. At night, when two vehicles meet each other, the system use ultrasonic sensors[5] for ranging operations, and light sensors for detection to determine whether the vehicle has its high beams turned on. From a medical point of view, the wrong high beam will make the driver blind of the other side for about 2 seconds. That is very dangerous for driving. The vehicle traffic intelligence system will automatically turn off the high beam and switch to the low beam mode.

4.3 The temperature and humidity monitoring module

The system uses AM2321 as the digital temperature and humidity sensor, which includes a capacities humidity sensor and a high-precision integrated temperature element, and is connected to a high-performance microprocessor. The AM2321 has two communication modes: single bus and standard I^2C.In the system, select to work in single bus mode by pulling down the SDA pin, the signal can travel over 20 meters. Moreover, multiple temperature and humidity sensor modules are installed in the system to monitor the real-time temperature and humidity data in the vehicle [6].

In addition, the AM2321 sensor includes four pins, VDD, SDA, GND and SCL. Among them, VDD is directly connected to VCC5.0, SDA is used to receive the temperature and humidity values from the sensor, GND is directly grounded, and SCL is used to select the sensor communication mode and the communication line for I^2C communication. If the system needs to change the communication method, please re-power on and select the communication method according to the operation requirements.

When SCL stays at the low level for 500ms or keeps at the low level when power is on, it means that the user chooses single-bus communication, otherwise it is I^2C communication. After selecting the general mode, the sensor communication mode remains unchanged during the power-on period. If we want to change the communication mode, we need to re-power on and select the communication mode according to the operation requirements. When I^2C communication is selected, SCL is used for communication synchronization between the microprocessor and AM2321. Here, the Read_Sensor () function is mainly used to read the data collected by the sensor, and Read_SensorData (void) is mainly used to identify whether the transmitted 40-bit data is "0" or "1", which is composed of 8 bits of high humidity + low humidity Low 8 bits + high temperature 8 bits + low temperature 8 bits + 8-bit check code. If there is no error in the data after verification, the data collected by the temperature and humidity sensor will be saved, and at the same time, the system will be converted and output correctly, and the temperature and humidity value of the internal environment of the bus will be monitored in real-time and compared with the critical value. Once the threshold is reached, the system will automatically adjust the air-conditioning temperature of the bus system and dynamically adjust to ensure that the internal temperature of the bus remains between 24℃ and 26℃.

4.4 The intelligent oxygen monitoring module

The intelligent oxygen testing module uses ES1-O_2-25%-TB200Y as the oxygen sensor which monitors the real-time oxygen concentration in the vehicle. In the first-tier cities of Beijing, Shanghai and Guangzhou, during the morning and evening rush hours, people often rely on people and crowded in public transportation. Due to the effects of human respiration, there will be less and less oxygen in vehicles, and more and more carbon dioxide. Because of the greenhouse effect of carbon dioxide, the ambient temperature in public transportation is getting higher and higher, and the oxygen content is getting less and less, which will cause some passengers to feel uncomfortable and even faint[7].

According to medical knowledge, if passengers are in an environment with an oxygen concentration of less than 18%, the human body's intake of oxygen is insufficient, the oxygen partial pressure in the blood is too low, and the blood menstrual protein is in an unsaturated state. There is a certain change in hypoxia, showing corresponding physical discomfort and hypoxia symptoms. Finally, the system generates an early warning in time and informs the driver, which is based on the real-time data collected by the oxygen sensor. The transportation system can increase the air supply through automatic or manual methods, thereby dynamically adjusting the oxygen concentration and increasing the comfort of everyone in the vehicle[8].

5 System experiment

The experimental scenario is described as follows: We carried out experiments in the laboratory which is used to simulate the scenes of different working hours of public transportation. The simulated periods include morning, noon, and night[9].

Setting and participants: the experiments were carried out at a 10 square meters of laboratory in Guangzhou to simulate the environment. The working hours of the staff are generally from 9:00 to 17:00, and the morning rush hour is generally from 7:00 to 9:00. We deployed the intelligent monitoring and early warning system in the laboratory and turned it on. The system detects the real-time indoor temperature and distance between adjacent vehicles. According to the climate of Guangzhou, when the outdoor temperature is above 26℃,the air condition opens automatically. When the speed is under 40km/h, it should keep the distance above 30 meters. Due to the limitation of the laboratory, we reduce the distance collected by the acoustic sensor by 10 times. That is, when the distance between two vehicles is less than the safe distance of 30 meters, the system will generate an early warning buzzer in time to remind the driver pay attention to keep a safe distance. As shown in the figure below, according to the monitoring data, the system will automatically turn on the air condition and remind the driver to slow down and keep a safe distance.

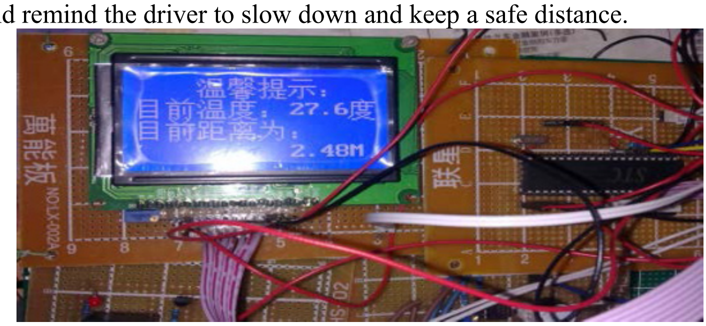

Fig. 2. Sensors collect data in real time.

As time went by, the number of passengers is increasing, and the morning rush hour comes. Under the influence of respiration, there is less and less oxygen in the room, and more and more carbon dioxide is exhaled. At the same time, the indoor temperature is becoming higher and higher. As shown in the figure below, when oxygen concentration is lower than 18%, the system will automatically accelerate air movement. At the same time, it dynamically adjusts the temperature to a comfortable value for the human body.

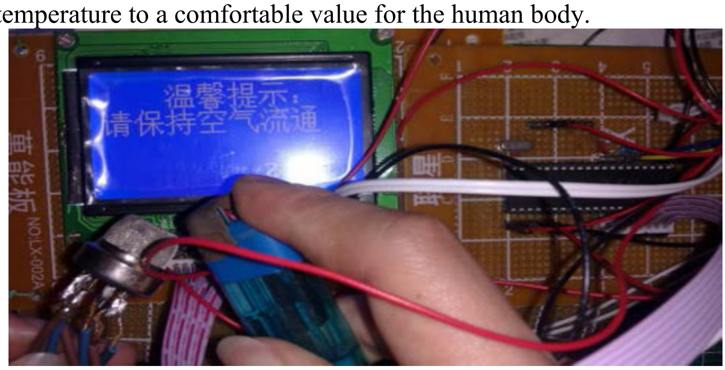

Fig. 3. Oxygen and toxic gas detection.

In night, buses are limited to a maximum speed of 40 km/h in urban areas and 50 km/h in suburban areas. When two vehicles pass each other, if the system detects that there is a vehicle on the opposite side and the high beams are turned on, the system will automatically switch to the low beam. It can avoid their high beams influence others and reduce the probability of accidents [10].

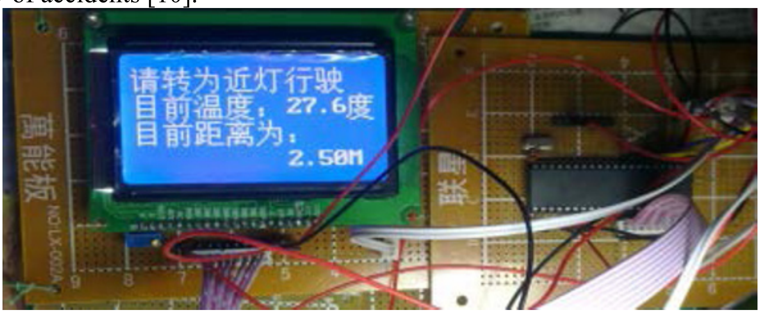

Fig. 4. High beam test.

6 Conclusion

With the development of the Internet of Things, the public transportation can not only bring convenience to the transportation of citizens, but also achieve the effect of energy-saving and environmental protection. In the early morning, before the city has yet to wake up, vehicles have already passed through the roads between buildings. Public transport plays an indispensable role in our daily traveling, and an intelligent public transportation system can help people achieving the journey of easy-to-reach and enjoyable walking.

According to the research, the system applies the Internet of Things technology, intelligent monitoring, and intelligent control to the public transportation system and design intelligent monitoring and early warning system for transport applications. Finally, the intelligent monitoring and early warning system can dynamically adjust the environment in the bus and improve the system performance of buses and enhance passenger experience and comfort.

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