Implement a Safety Environment Space for Vehicles

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***Abstract*—Billions of people have inhaled numerous harmful gases while driving or sitting both inside and outside of a car for a long time. In order to avoid inhaling harmful gases, this research implement an alarm system with a harmful gaseous substance sensor. By combining with windshield display technology, both driver and passengers are well informed about harmful gases concentration immediately. In addition, the system is integrated into smart device app and cloud system, which would provide further aids to the driver and passengers from remote. Since different windshields in different cars were required, this research accommodates various types of head-up display, develop air-substance sensor and interface set for smart devices so that implement a smart system for detecting toxic substances in the air of a car.**

***Index Terms*—safety environment space, sensor, remote monitoring, head-up display, app**

I. Introduction

Greenhouse effect contributes to elevating global warming. After being exposed to sunlight for more than an hour, the dashboard, seats, and air filter of a vehicle will release benzene [1], which is carcinogenic and may even cause miscarriage among pregnant women. Furthermore, people exposed to UV radiations in sunlight for long periods are prone to developing wrinkles, sunburn, or even severe diseases such as cataract, skin cancer, visual impairment, and damaged immune system. Decrepit cars are likely to develop holes through which engine exhausts may enter, potentially causing drivers or passengers to inhale excess amount of Carbon Monoxide (CO). A study indicated that a CO concentration of 667 ppm may cause up to 50% of the body's hemoglobin to convert into carboxyl hemoglobin, which may result in coma or death. In response to the aforementioned problems, this study proposes using Head-up Display (HUD) to devise a system that wirelessly transmits harmful gas information to users' smartphone device as a means of warning users of the potential danger they are exposed to. The primary objective of this study was to develop a system that automatically detects harmful gases in a vehicle and provide immediate information on the quality of such gases. In addition, the system was integrated with an automated warning notification system [2] and a remote monitoring platform [3]. By using the proposed system, users can be notified of harmful substances released into their vehicle, and use their smartphones to open the car windows to release the gases and lower the car temperature. Thus, car owners are prevented from inhaling toxic substances and exposing to high temperature when opening the car door.

Manuscript received January 1, 2016; revised September 14, 2016.

II. System Architecture

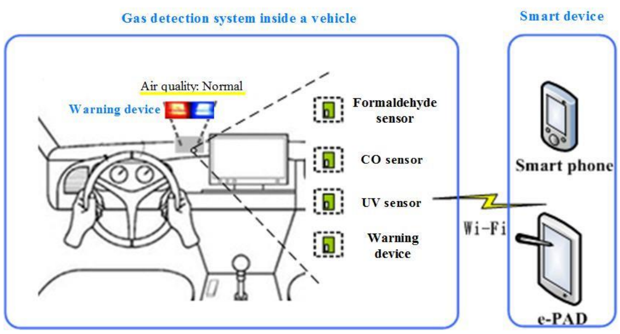

Figure 1. A schematic diagram of the gas sensor system inside a vehicle.

First, exhaust fan motors were used to collect gases in a car into a gas box, which contained a sensor that measures the CO, volatile organic compounds (VOC) [4], and humidity inside the car. The measured data were then integrated using a single chip to display the information onto an HUD, as shown in Fig. 1. Concurrently, these data were wirelessly transmitted to a repeater and then

doi: 10.18178/ijeee.5.2.110-113

uploaded to a cloud database through a wireless telecommunication system, thus notifying drivers of any abnormal smells or gases inside the vehicle. When the gas sensor system detects a gas concentration exceeding the threshold, the system immediately sets off the buzzer and warning light. Fig. 2 depicts the method of construction.

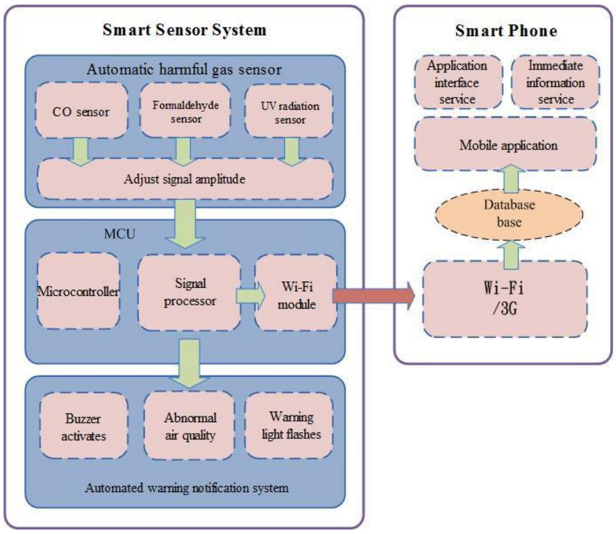

Figure 2. Architecture of the smart sensor system for automobiles.

III. Hardware Device

The sensor adopted in the proposed system primarily detects the presence of CO, UV lights, and formaldehyde.

The hardware device used in this study was designed in such a way that it is convenient, inexpensive, and can detect a wide range of area.

A. CO and Formaldehyde Sensors

The MQ series semiconductor gas sensors for detecting CO and formaldehyde were used in this study. Typical gas sensors are generally developed using the same approach; regardless, different models of gas sensors must be used for detecting different types of gases because the sensitivity of gas sensors toward different gases varies. To develop CO sensors, SnO2 semiconductor gas material is processed with ultra-fine particles, which are then doped to form SnO2 nanoparticles. SnO2 nanoparticles are then used as matrix, mixed with a catalyst, and subjected to sintering with the processed material for surface modification to produce a sintered CO sensor. Typically, semiconductor gas component is categorized as N- and P-type component. When N-type component is employed, resistance value decreases as gas concentration increases. For P-type component, resistance value increases as gas concentration increases. SnO2 semiconductor gas material is categorized as n N-type semiconductor that adsorbs oxygen at 200–300℃, causing the electron density of the semiconductor to decrease, thereby increasing the resistance value. When the semiconductor is exposed to flammable gas (CO) that provides electrons, the adsorbed oxygen is desorbed from the semiconductor. Subsequently, the flammable gas at a positively charged state attaches to the surface of the metal oxide semiconductor. When oxygen is desorbed, electron is released. When the positively charged gas adsorbs onto the surface, electron is also released, causing the electron density of the semiconductor to increase, decreasing the resistance value. When flammable gas is absent, the metal oxide semiconductor then adsorbs the negative ions of oxygen, returning its resistance value to the initial state. This is the fundamental principle of how semiconductor gas sensors detect flammable gases.

B. UV Sensor

UV radiation sensor is an optoelectronic device used for detecting UV lights. It is sensitive to UV lights, particularly to those generated during the burning of wood, fiber materials, paper, oil substances, plastic and rubber materials, and flammable gas. Voltage is generated between the cathode and anode of a UV sensor. When UV light shines onto the cathode through a quartz glass tube, the cathode emits photoelectrons because of its electron emissive coating. In a strong electrical field, the photoelectron is then attracted to the anode, moving toward it at a high speed. During this process, the moving photoelectron collides with gas molecules in the glass tube, ionizing the gas molecule. The electron generated during gas ionization collides with the gas molecule, repelling the photoelectrons and ions existing between the cathode and anode. Subsequently, optical discharge phenomenon is induced, generating a strong current within the circuit. Because of the optical sensor made of wide-bandgap semiconductor materials (e.g., diamond, silica carbide, III-nitride, wide-bandgap II–IV materials), UV sensors can detect UV lights without requiring optical filters.

C. Head-up Display

Developed based on the law of reflection, HUDs [5] are used to project information such as car speed on the windshield of a car, as shown in Fig. 3. The speed at which a car is travelling is displayed on the windshield, enabling drivers to view the information without having to look away from their usual viewpoints. Thus, driving safety is ensured. The projected text and image of a HUD are displayed approximately 1m away in front of the driver, who can then easily process both the road conditions and information presented in front of them while looking forward.

Figure 3. A schematic diagram of HUD.

IV. Interface Design

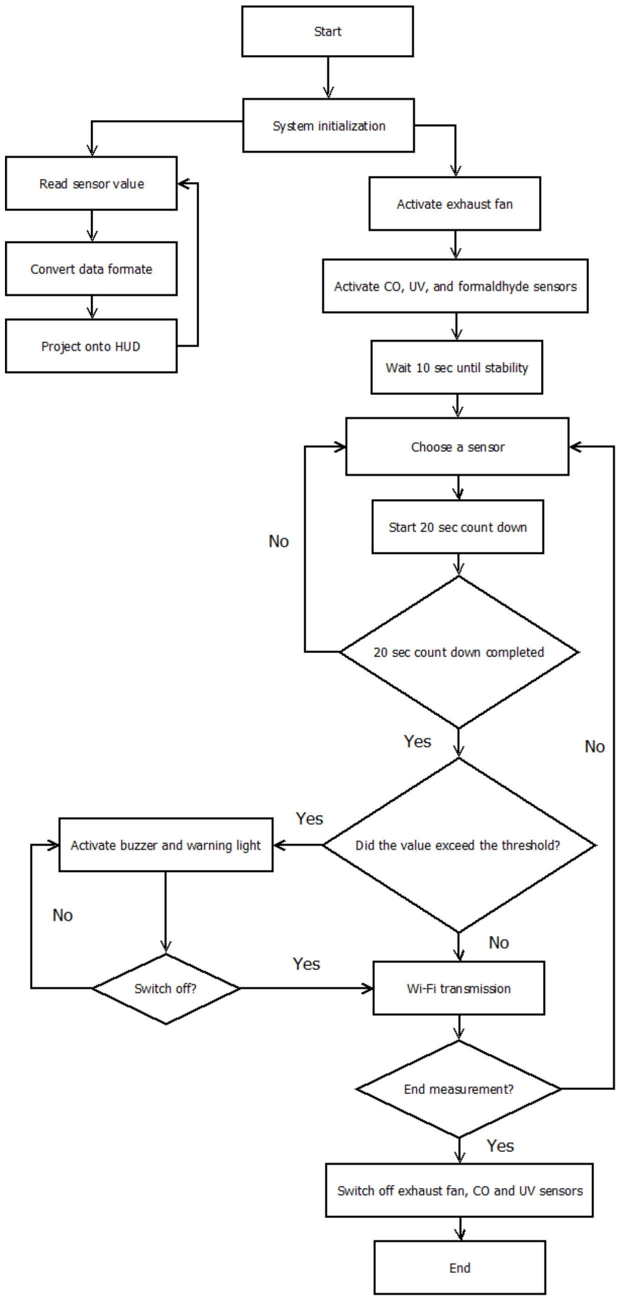

Figure 4. Firmware process flow.

Fig. 4 depicts the process flow of using the smart gas sensor system for automobiles. First, the system switches on the exhaust fan motor and activates the sensor, using an MCU [6] counter and external interrupt counter to count down 10 seconds. When the numerical readings of the sensor stabilize, the readings are then converted through the internal ADC of the MCU into numerical values, which are then assessed for whether the gas level exceeded the standard. If the value exceeds the standard, the warning light is activated until the gas reading falls below the standard. At the same time, such information is projected onto the HUD, informing the user about the interior state of the car. Regarding remote transmission, MCU and the wireless transmission module are first initialized before the wireless module can exchange information with user's mobile device. Concurrently, the information transmitted to the mobile phone is uploaded to a Web server, thereby completing remote transmission.

As shown in Fig. 5, when the sensor detects the presence of abnormal gases in the car, the MCU then calculates the measurement value through mathematical algorithms. Subsequently, the measured value is wirelessly transmitted to and displayed on user's Android smartphone/tablet [7]. If the sensor detects a value exceeding the safe value, the sensor system activates the buzzer, warning the user of the abnormality. When users receive this notification but fail to deactivate the alarm system, the sensor system will immediately upload the data to a cloud server, which then sends a notification to rescue units.

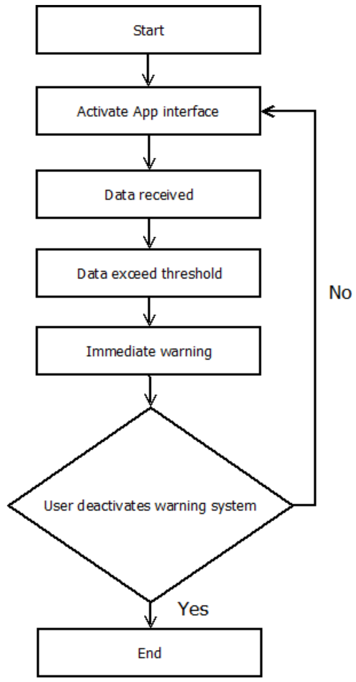

Figure 5. Software process flow.

V. Results and Discussion

The sensor components used in this study were calibrated by the manufacturer before being dispatched as final products. Moreover, because an exhaust fan motor and gas box were used to collect gases, the gas measurements obtained during the experiment were accurate, which facilitated the response of the proposed system to the changes in the gas level inside the car.

Regarding remote transmission, actual measurements showed that when users carrying a smart device approach the proposed system, the smart device will automatically detect the gas level in the car. In addition, the proposed system can engage in remote environmental monitoring within 3G/Wi-Fi network coverage, thereby enabling users to remotely control the system.

VI. Conclusion

The proposed gas sensor system is aimed at enhancing people's quality of life. In addition, the system is easy to use, rendering its software architecture applicable for future smart systems. Remote control enables measurements to be obtained within a safety range, which intangibly provided an additional barrier of protection for users, protecting them from being exposed to harmful substances. This system is beneficial for general publics. In future, through cooperation with automobile manufacturers, this system can be integrated with the air conditioning system and windows of a vehicle without changing the interior of the car to improve the quality of air supplied into the car. This system is economical, does not affect the overall value of a car, and ensures the safety and health of drivers and passengers, thereby protecting them from being exposed to toxic gases.

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