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RESEARCH ARTICLE

DESIGN AND IMPLEMENTATION OF A FATIGUE DRIVING REMINDER SYSTEM

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Abstract

With the rapid development of the social economy, the number of motor vehicles is increasing daily. According to statistics, China has ranked first in the world for automobile sales; however, this growth has also led to a rise in traffic accidents. Fatigue driving is one of the leading causes of these accidents. To safeguard people's lives, health, and property, and to reduce traffic accidents caused by fatigue, we have designed a fatigue driving reminder device based on the STM32 microcontroller unit (MCU). The device utilizes a pressure sensor and a timer for data collection. The STM32 processes this data to determine when the buzzer should sound an alert. Additionally, the device incorporates a photoresistor to measure external light levels; when these levels are low, an LED light is activated to remind the driver.

Introduction:-

The number of traffic accidents caused by fatigue driving in China has been steadily increasing each year. Data indicate that there are approximately200,000 traffic accidents resulting in more than60,000 fatalities annually[1]. Previous statistics show that fatigue driving is a leading cause of death in various traffic accidents. According to physiologists, when drowsiness sets in, individuals may experience short episodes of sleep lasting5 to10 seconds[2]. Even if the driver is actively engaged, the brain enters a restful state during these moments. In light of the significant safety hazards posed by fatigue driving, this system is designed to construct a fatigue driving reminder device to ensure the safety of all vehicle occupants and to mitigate the risks associated with fatigued driving[3]. The fatigue driving reminder device greatly enhances the safety of both drivers and passengers, aiming to reduce the incidence of tragic accidents stemming from fatigue. Based on the STM32 microcontroller, this device primarily employs embedded and sensor technologies, encompassing both hardware and software components. This design provides a fatigue driving reminder device that is simple to operate, cost-effective, and highly practical, facilitating the effective implementation and evaluation of its application.

Overall System Design

The fatigue driving reminder device designed in this paper takes into account several factors that impact driver safety. When a driver becomes fatigued, the pressure exerted on the steering wheel tends to increase; thus, a pressure sensor has been strategically placed in the steering wheel to facilitate pressure data acquisition. Additionally, various driving scenarios can occur at night when outside light levels are low[4]. Enhancing the brightness of the external environment can effectively improve driver alertness and reduce fatigue; therefore, the system is equipped with a light sensing function that automatically adjusts the brightness of the surrounding environment. To provide timely

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alerts to the driver, a buzzer alarm function is also included in the system. The overall design scheme for each hardware module and the system's block diagram are depicted in Fig.1.

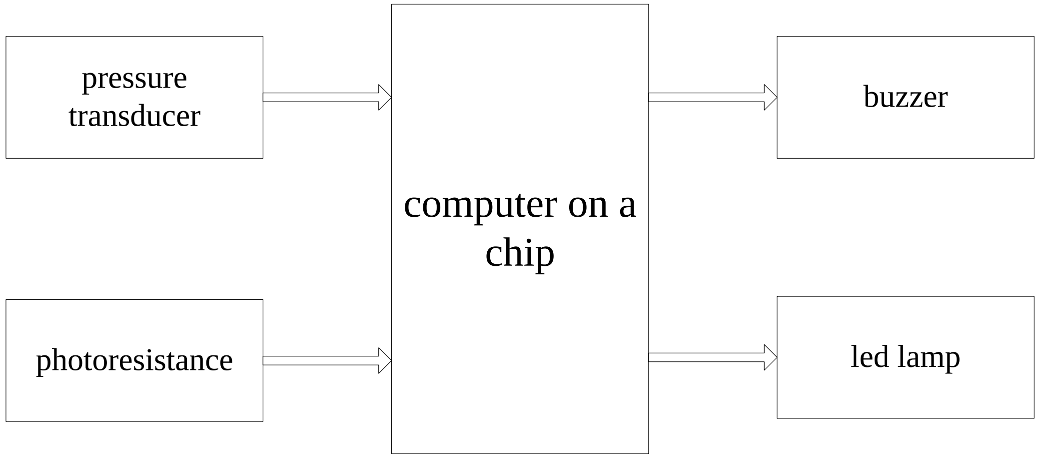

Fig. 1:- Overall block diagram of the system.

Hardware Design

The hardware design of the system incorporates the STM32F103 series microcontroller, pressure sensor, photoresistor, timer, and buzzer.

STM32F103 Microcontroller

The STM32F103 microcontroller has gained popularity in recent years due to its robust performance. It features a powerful Cortex-M3 data processing core and integrates a wide range of peripheral functions, including multiple timers and communication interfaces such as I²C and SPI[5,6]. The microcontroller operates with low power consumption and includes built-in modes for sleep, shutdown, and standby, along with a Vbat pin for RTC (real-time clock) and backup register power[7]. The circuit diagram for the main control pins of the microcontroller is illustrated in Fig.2.

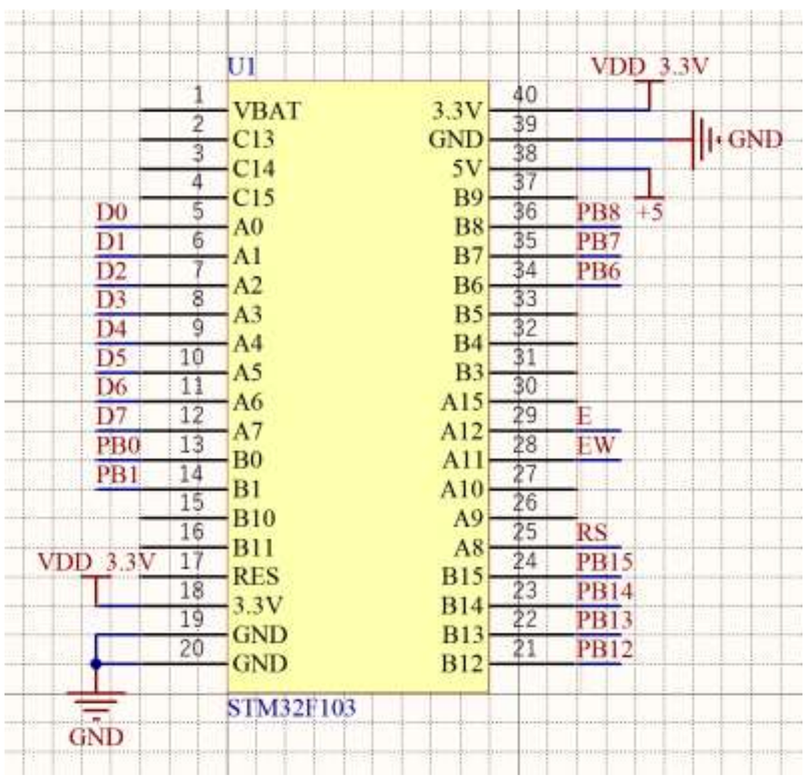

Fig. 2:- The main circuit diagram.

Light Intensity Sensor

For the light intensity sensor, a photoresistor has been selected based on the principle of the internal photoelectric effect. This sensor component exhibits a high sensitivity to low light levels, producing an output signal that is proportional to solar irradiance within a linear range. Electrode leads are installed at both ends of the semiconductor photosensitive material, allowing the photodiode to convert visible light into an electrical signal. This electrical signal is then processed by the sensor system, which outputs the required binary signal. The photosensitive diode is encapsulated in a housing with a transparent window to form the photoresistor.

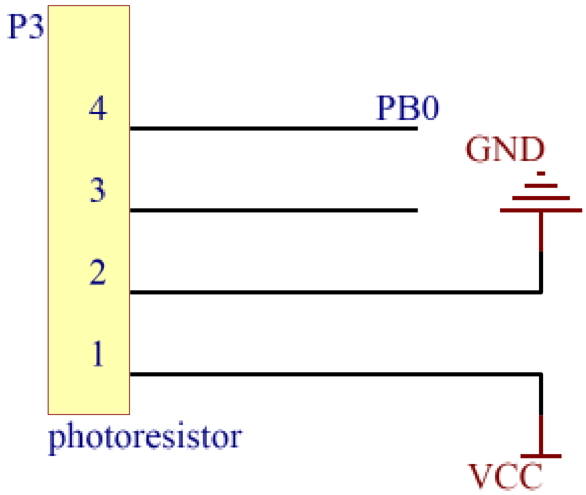

Fig. 3:- The circuit diagram of photoresistor.

The four pins of the photoresistor are connected to the corresponding pins on the microcontroller. Under normal operating conditions, a threshold for light intensity is established. When the external light falls below this threshold, the system activates the LED to draw the driver's attention.

Pressure Sensor

The pressure sensor module utilized in this system is based on an electronic scale that employs a microcontroller. This modern weighing instrument integrates various technologies, including detection and conversion, computer technology, information processing, and digital technology. The electronic scale features a resistance strain sensor paired with an HX711 chip, which is designed using Hisense's integrated circuit patent technology. The HX711 is a24-bit A/D conversion chip that efficiently converts voltage signals to digital signals, which are subsequently processed and packaged by the STM32 control module. It is specifically tailored for high-precision electronic scales. The interface and programming between the HX711 chip and the STM32 microcontroller are straightforward; all control signals are managed via the pins, eliminating the need to program the internal chip registers.

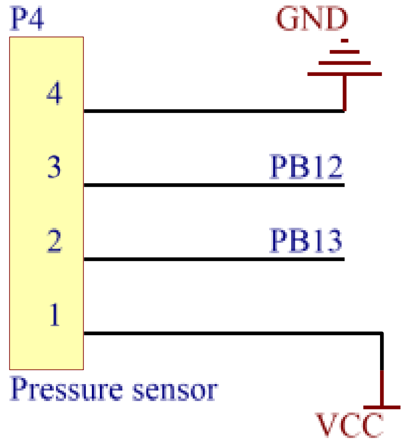

Fig.4:- The circuit diagram of pressure sensor

Alarm Module

The sound generation mechanism of the buzzer consists of a vibration element coupled with a resonance device. In this system, a passive piezoelectric buzzer is utilized for the fatigue driving reminder device. The operational principle involves feeding a square wave signal into the resonance device, which then produces an acoustic signal output.

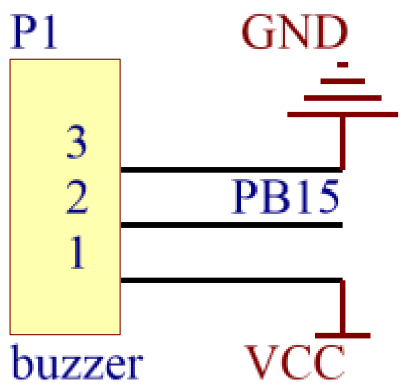

Fig. 4:- The circuit diagram of buzzer.

The sound emitted by the buzzer is controlled based on data processed from the pressure sensor module. The system evaluates the threshold of the change data stored in memory, and the sound output varies depending on the level of this change data. The buzzer effectively alerts the driver, indicating whether they are in a state of fatigue driving.

System Software

DesignThe software development for the fatigue driving reminder device is carried out using the C programming language, specifically embedded C. This approach offers excellent portability, high operational efficiency, and direct hardware access.

Overall Program Design

The main workflow of the program begins with powering the system. The controller then initializes the ADC peripherals, control pins, and other essential components. It subsequently manages the HX711 module, photoresistor, and timer to complete data acquisition. The data collection process involves two distinct tasks.

Pressure Acquisition. The pressure sensor is installed in the steering wheel. Initial measurements are taken to determine the normal pressure exerted by several drivers on the steering wheel. The average pressure value from these groups is established as the pressure threshold for fatigue detection.

Light Intensity Collection. The photoresistor is positioned outside the vehicle. A normal light intensity value is established, which serves as a baseline for comparison with varying light levels.

Once the data is collected, the controller converts the pressure value into a digital signal using the A/D conversion function of the HX711. The STM32 microcontroller receives this pressure value and compares it to the predefined threshold. If the pressure value exceeds the threshold, the buzzer is activated as an alarm. Conversely, when the light intensity falls below the threshold, the LED is illuminated. Additionally, if a predetermined time elapses, the buzzer alarm is triggered.

In this overall framework, the STM32F103 microcontroller is selected for its extensive functionality, strong real-time performance, and cost-effectiveness. It is widely used in the market and preferable to other microcontrollers, such as the51 microcontroller, Arduino, or Raspberry Pi, especially under conditions where memory and flash requirements are minimal. The entire main program execution process is illustrated in Fig.7.

Light Acquisition Subroutine

Flow DesignUpon powering on the system, the controller initializes the IO pins, ADC peripherals, and other components, setting up the ADC sampling rate and data format. The software program executes by configuring the internal registers of the ADC and controlling the ADC sampling through software triggers. A control pin manges the ADC data conversion; whenever a high signal is applied to this control pin, the ADC performs a data conversion. Periodic triggering of the ADC control pin is managed via a timing mechanism. The light collection process is represented in Fig.8.

Pressure Acquisition Subroutine Flow Design

After the system is powered on, the first step is to initialize the I2C communication and develop the read and write data functions along with the communication timing.The STM32 controller is responsible for initializing the HX711 module pins and then sending a startup command to the HX711 in accordance with the I2C protocol.

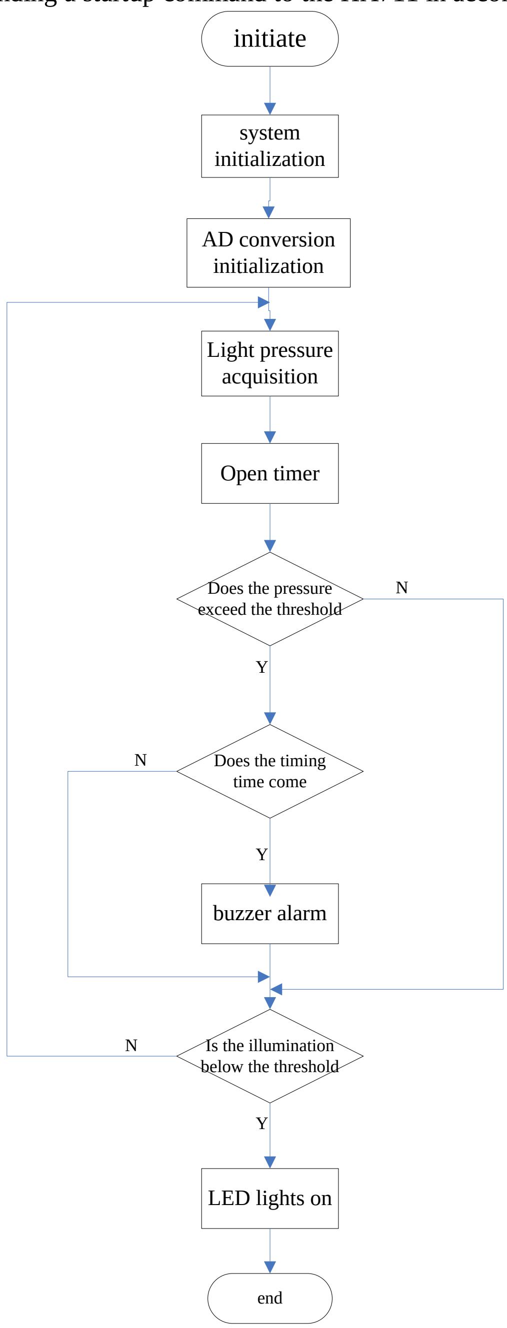

Fig. 7:- The main flow chart of program.

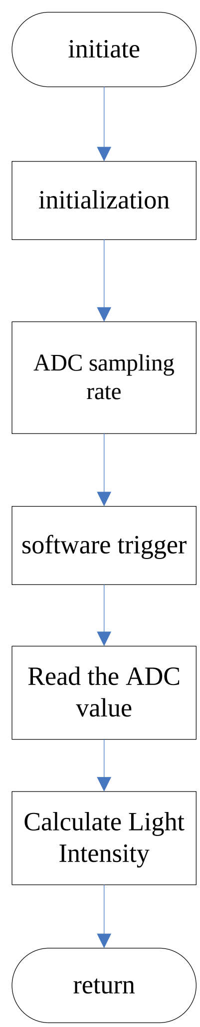

Fig. 8:- The flow chart of light intensity.

The HX711 chip then transmits the collected data to the STM32 master controller, where the data is read as a16-bit digital signal that must be converted to obtain the correct pressure value. The pressure acquisition process is illustrated in Fig.9.

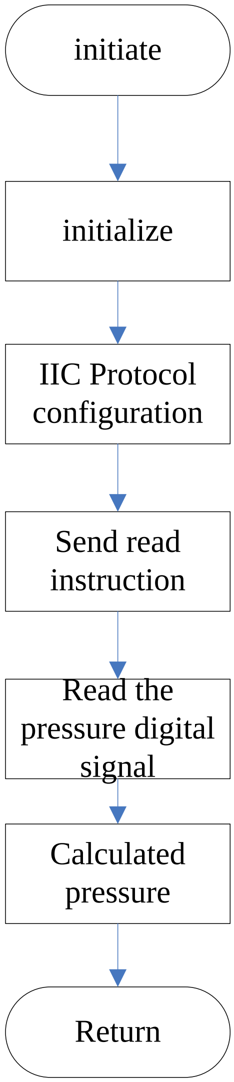

Fig. 9:- The flow chart of presser program.

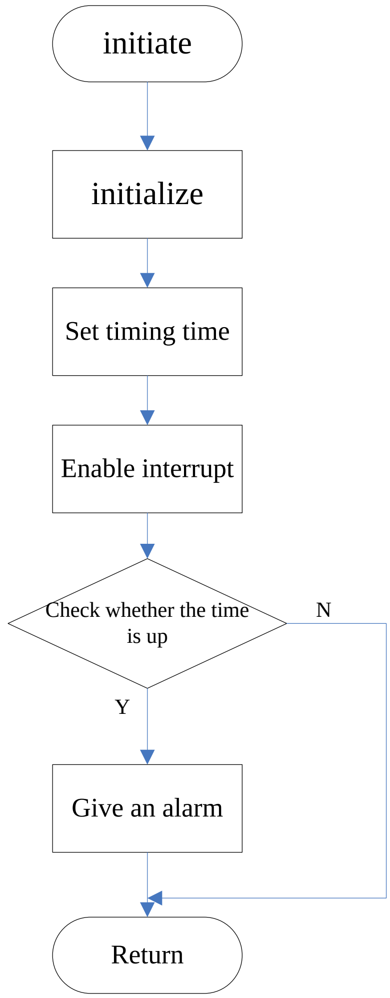

Fig. 10:- The flow chart of alarm.

Timeout Driving Alarm Process

DesignTo mitigate the risks associated with prolonged driving and potential accidents due to driver fatigue, a timing alarm reminding function is incorporated into the system. This timing function is realized using the internal timer of the STM32 master controller. Upon system startup, the timer undergoes basic initialization, enabling it to generate interrupts at one-minute intervals to count the driving duration. Drivers can set a count value to control their driving time cycles. Once the count reaches the predefined time limit, the alarm prompts the driver that they have exceeded the normal driving duration. The timing process is depicted in Fig.10.

Conclusion:-

With advancements in computer technology and communication, the Internet of Things (IoT) is evolving rapidly, playing a vital role across various industries and providing robust technical support for the transformation and upgrading of traditional sectors. The design of this fatigue driving reminder device addresses the critical issue of driver fatigue. Utilizing the STM32 microcontroller alongside various sensor modules, the device aims to promote driver safety and enhance the personal safety of passengers by providing real-time alerts.The embedded technology applied within this fatigue driving reminder system is instrumental in preventing dangerous accidents, as it monitors the driver's environment effectively. However, there remains significant room for improvement in the design. To ensure the device is better suited for real-world driving conditions, further research is needed to enhance the accuracy, stability, response speed, and anti-interference capabilities of the system. Future work will focus on optimizing these aspects to maximize the device's utility and ensure it can fulfill its intended purpose more effectively.

Reference:-

[1] Huang, A. , et al. "Design of Fatigue Driving Behavior Detection Based on Circle Hough Transform." Big data 11 1.2023, 1-17.

[2] Qu, Jiaxiang , Z. Wei , and Y. Han . "An embedded device-oriented fatigue driving detection method based on a YOLOv5s." Neural computing & applications 36.7. 2024, 3711-3723.

[3] Zhang, Meiyan , et al. "Research on Driver's Fatigue Detection Based on Information Fusion." Computers, Materials & Continua 79.4. 2024, 1039-1061.

[4] Xu LiSheng, Zhang Wenxun,Pang Yuxuan, et al. Driver Drowsiness Detection Algorithm Using Short-Time ECG Signals[J]. Journal of Northeastern University(Natural Science), 2019, 40(7): 937-941.

[5] Chen, Hao , et al. "Design of electrical cabinet wire cutting machine based on STM32."Journal of Physics: Conference Series, 2024.

[6]Huang C, Zhao Y H, Zhang H, M., et al. Development and testing of an online constant temperature spectral analysis system based on STM32 microcontroller. Spectroscopy and Spectral Analysis, 2023, 43(09):2734-2739.

[7] Cao W Y, Wang T, Ma H L., et al. Portable indoor air quality detection instrument based on STM32 microcontroller. Transducer and Microsystem Technology, 2022, 41(11):101-104.