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An Improved Smart Helmet for Safe Travel of Deaf People Based on Embedded System

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***Abstract*—An improved smart helmet for deaf people to travel safely based on embedded system is proposed in this paper. The helmet designed in this paper includes solar charging, distress confirmation, steering detection, horn prompt and other functions. The distress confirmation function will give an audible and visual alarm when the head of rider is hit strongly and send positioning and rescue information to the set emergency contact. At the same time, the steering detection function will detect the head posture and prompt the passers-by behind through LED. In addition, the horn prompt function will collect and filter the surrounding sound information, and when a car whistles, the rider is prompted by the vibration motor inside the helmet vehicle location information enables it to avoid in time. Experiments show that the helmet we designed can better meet the needs of deaf people and fully protect the safety of deaf riders.**

***Keywords*—Embedded system, Deaf people, STM32 chip, Smart helmet**

I. Introduction

With the rapid development of science and technology in our country, the traditional helmet in life has poor air permeability and single function. Although it is convenient to use, it has no auxiliary functions. The emergence of smart helmets makes this field more colorful[1]. It is a group of technicians who use high-tech products to upgrade an ordinary helmet to an integrated intelligent helmet with multiple functions. The emergence of the new term "smart helmet" soon became popular in all fields, including military affairs, fire protection, security, electric power, mines, customs, transportation and other fields[2].

With the increasing level of world technology, intelligent products and devices are becoming more and more popular, and smart living has become a hot topic. Traditional helmets have poor breathability and limited functionality. Although they are convenient to use, they have almost no additional features. Once smart helmets emerged, they quickly became popular in various fields, including security, military, firefighting, mining, electricity, customs, transportation, and more.

The current mainstream smart helmets either have a single function or only focus on theoretical research on helmets with complex functions, and their functions mainly target the general cyclist group, including Bluetooth communication, video, positioning, brake prompts, pulse sensors, eye tracking devices, mood detection, temperature measurement, etc. Compared with traditional cycling helmets, current smart helmets provide convenience and safety for users. However, these complex functions are essentially not practical, and will also increase the cost price of helmets, resulting in high prices and inability to be suitable for deaf cyclists with hearing impairments. Therefore, it is necessary to design an intelligent helmet for deaf people's safe travel, taking into account their travel needs.

Through research by domestic and foreign scholars and corporate institutions, smart helmets have been found to be effective in various fields such as fire protection, transportation, mining, and more.

Significant progress has been made in areas such as security, with the addition of various sensors or devices to traditional helmets, providing increased security for users. However, there are still several issues with intelligent helmets in the transportation field:

(1) Regarding the turn signal display function, helmets that have been launched can only use wireless remote control modules or matching apps to control the display of turn signals, which is inconvenient to use and prone to danger, while other smart helmets that include automatic steering are mostly in the crowdfunding or theoretical stage.

(2) Some smart helmets also have functions such as Bluetooth communication, video, positioning, brake prompt, pulse sensor, eye tracking device, emotion detection, temperature measurement, etc. However, they are still in the theoretical research stage and these functions are complex and lack specificity, which increases the cost and weight of the helmet, resulting in poor user experience.

(3) There is no smart helmet designed specifically for deaf cyclists.

Currently, cycling has become an increasingly popular way of travel and exercise around the world. However, due to the hearing impairment of deaf people, more than 95% of deaf people are difficult to hear the sound of whistling and shouting, and are unable to communicate with pedestrians around them when making turns or when the road is crowded, and it is also difficult to call for help from the outside world when they are in danger on a ride, which creates a major threat to the personal safety of deaf riders. According to a survey conducted by the China Disabled Persons' Federation, more and more deaf people are choosing to travel by bicycle and electric moped. In the past three years, the number of deaf workers in takeout, express delivery and other industries has increased year by year, but there are more and more traffic accidents when deaf people go out[3].

With the rapid development of science and technology, intelligent life is popular all over the world. Smart helmets have been widely used in transportation, security, military, fire protection and other fields. In the fields of transportation, the existing smart helmets either have a single function or only theoretically study helmets with complex functions[4]. They are not highly practical and there are no smart helmets designed for the characteristics of the deaf people. At present, the mainstream smart helmet mainly aims at ordinary cyclists, including Bluetooth calling, video, positioning, brake warning, eye tracker, pulse sensor, etc. Compared with the traditional riding helmets, the current smart helmet provides convenience and safety for users, but these complicated functions also increase the cost price of the helmet, which leads to its high price and is not suitable for deaf riders with hearing impairment[5]. Therefore, after studying the development status of related products at home and abroad, it is very necessary to design a safe travel intelligent helmet for deaf people combined with the travel needs of deaf people[6].

II. DESIGN OF INTELLIGENT HELMET SYSTEM FOR DEAF SAFE TRAVEL

Design a smart helmet with solar power supply, horn prompt, distress confirmation and steering detection for deaf people to travel safely which can provide convenience for users and ensure the personal safety of hearing-impaired people to the greatest extent during riding. According to the functional requirements of smart helmets, this paper presents the design of smart helmet for deaf people's safe travel based on STM32[7].The research content mainly includes the following parts: firstly, after further analysis of the shortcomings of the existing smart helmets, determine the research objectives of the subject, and completed the hardware system design of the smart helmet for deaf people to travel safely[8].

The system uses STM32F103C8T6 single-chip microcomputer as the main controller. And the circuit construction includes power module, microphone module, vibration module, pressure detection module, GSM module, sound and light alarm module, GPS module and mpu9250 attitude detection module[9]. Secondly, after designing and building the hardware circuit of the system, the software design and programming are completed, and the functions of whistle warning, distress alarm and steering alert are realized. The main manifestations are: collect the sound of vehicle whistle and prompt the direction of whistle, if the collection pressure exceeds the threshold, send the positioning distress message, turn on the sound and light alarm, press the button to cancel the alarm, send a safe message, the mpu9250 is used to collect the head motion posture[10]. When the rider turns, the direction will be displayed on the LED to prompt the vehicles and pedestrians behind. Finally, on the basis of completing the hardware and software design, the system is tested and analyzed, and the test results prove that the system effectively realizes the functions of solar power supply, horn prompt, distress alarm and steering prompt, meet the design requirements[11].

This design is composed of microcontroller (CPU), power module, GSM module, GPS module, pressure detection module, audible and visual alarm module, key module, microphone module, vibration module and steering prompt module, which realize the functions of solar power supply, distress alarm, steering prompt and horn prompt. The function of the system and its working process are shown in Figure 1.

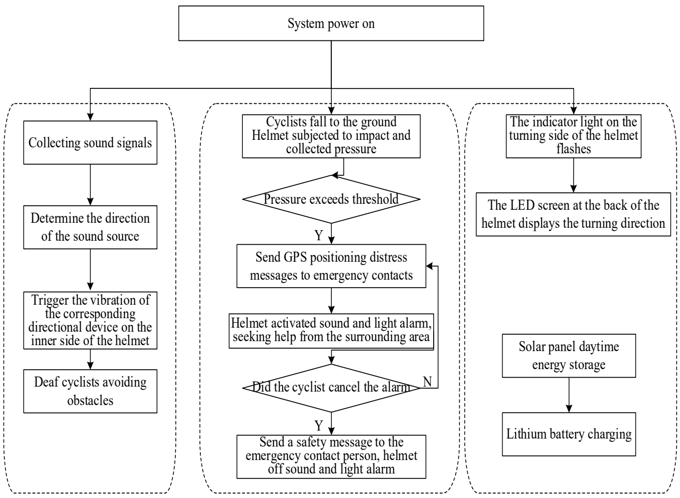

Figure 1. System function and its working process

A. Whistle prompt function

After the system is powered on, collect external sound signals through two electret microphones, after amplifying and filtering the signal, transmit the data to STM32 MCU, the MCU determines whether the two groups of data transmitted exceed the set threshold[12]. If more than, determine that there is a car whistle in this direction, the MCU sends commands to control the vibration of the vibration motor in the corresponding direction, this prompts the rider to avoid the direction of the coming vehicle behind[13].

B. Distress alarm function

After the system is powered on, the pressure on the helmet is collected through the pressure detection module[14]. If the pressure collected when the rider is impacted exceeds the threshold, send the latitude and longitude distress message parsed by the GPS module to the set contact through the GSM module and turn on the audible and visual alarm to call for help around. When the user presses the key, the audible and visual alarm is canceled and send SMS to contact person to report safety[15].

C. Steering prompt function

After the system is powered on, the head movement posture is detected by mpu9250, and the head motion Angle is analyzed. When the Angle is within the left turn or right steering Angle, the corresponding LED light is lit.

III. Hardware Design of Smart Helmet for Deaf People's Safe Travel

The smart helmet system for safe travel for the deaf people is mainly composed of the following modules: main control module STM32F103C8T6 minimum system, power module, attitude detection module, pressure detection module, microphone module, GPS module, audible and visual alarm module, key module, GSM module. The effect of sound source localization is shown in Figure 2

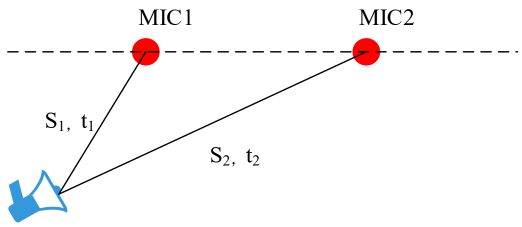

Figure 2. Schematic diagram of sound source localization

A. Master controller

The STM32F103C8T6 microcontroller is used as the main control chip. The STM32F103 series is based on the ARM Cortex-M3 core specially designed for embedded applications requiring high performance, low cost and low power consumption. It is powered by a wide voltage of 2.0-3.6v and the maximum working frequency can reach 72mhz, with 128K in-board Flash,20K in-board RAM,32 I/O,3 universal timers (TIM2, TIM3, TIM4),1 advanced timer (TIM1),2 SPI interfaces,3 USART,2 12-bit ADC channels, and 7-channel DMA controller and other rich resources, it can be seen that the controller can meet the functional and performance requirements of the system.

B. Power module

Through the analysis of system requirements, especially the GSM module requires large starting current, and the microphone needs a stable power supply with small ripple to collect sound signals, and realize the function of solar power supply, the power modules used by the system mainly include 12V solar panels, voltage regulator with MPPT function, schottky diode, 5A current limiting and voltage reducing module and two strings of 3.7V lithium batteries.

C. Hardware implementation of whistle prompt function

The system realizes the whistle prompt function through the microphone module and the vibration module, which is to collect external sound signals, after amplification and band-pass filtering, the data is transmitted to the single chip microcomputer, if the amplitude of the sound signal exceeds the set threshold, the MCU calculates and judges the sound direction, control the vibration of the vibration motor in the corresponding direction to prompt the rider to whistle in the direction and avoid.

D. Hardware implementation of distress alarm function

The system realizes the distress alarm function through the pressure detection module, GSM module, audible and visual alarm module, buttons and GPS module, collect helmet pressure. When the rider is hit hard, send the latitude and longitude distress message parsed by the GPS module to the set contact through the GSM module and turn on the audible and visual alarm to call for help around. When the user presses the key to cancel the sound and light alarm ,and send a text message to the contact saying that he is safe.

E. Hardware implementation of steering prompt function

The steering prompt module is composed of mpu9250 and LED lights, the head movement posture of the rider is detected through this module. When they were turning, the left and right steering information is displayed on the LED light. This paper uses mpu9250 to detect the head movement posture and according to its output data to solve the head movement Angle. When the Angle is within the left turn or right turn Angle range, the corresponding LED light is on.

IV. Design of Intelligent Helmet Software for Deaf People's Safe Travel

This paper uses Keil uVision5 software to write programs. It supports editing, compiling, downloading and online debugging of programs. The project requires to realize the functions of solar power supply, horn prompt, distress alarm and steering prompt. This system includes the main controller stm32f103c8t6 minimum system, power module, vibration motor, microphone module, pressure detection module, GSM module, audible and visual alarm module, keys, GPS module, mpu9250 attitude detection module, LED lamp. The main program flow chart of the system is shown in Figure 3.

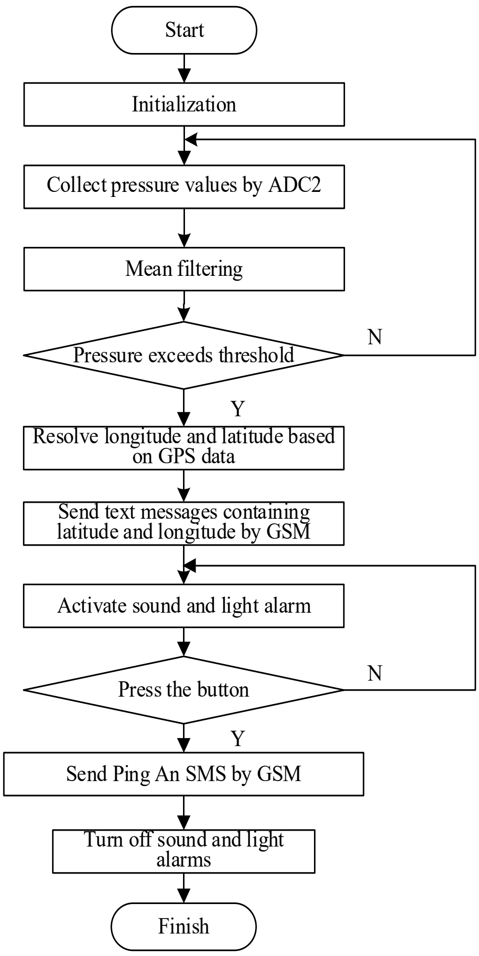

Figure 3. Flow diagram of the main program

V. System test and analysis

A. Testing environment

This paper uses datascope multifunctional serial virtual oscilloscope software to observe the output data waveform of microphone module. The software supports refreshing data of 10 channels at the same time, supports data import and export in multiple formats such as. Csv text tables. Also, it supports chart data observation and is easy to use. Compared with the serial port debugging assistant, it can directly see the data waveform. It is especially suitable for data measurement and observation with rapid and irregular changes in sound signals.

In the experiment, we first used Datascope software to test the microphone module and provided the testing steps and results. The installation positions of helmet functional components are introduced in Table I. The output waveform test in the horn sound environment is shown in Figure 4. The output waveform test in the horn environment after connecting the filtering circuit is shown in Figure 5. The physical front of the system circuit is shown in Figure 6. The physical reverse of the system circuit is shown in Figure 7. By using the computer port power supply and the test results of the power supply module in this article, whether or not the filtering circuit is tested in a silent/horn environment, it can be inferred that the power supply module designed in this article has small ripple and good stability, Subsequently, the steps for testing the distress alarm function were introduced, and a test effect diagram was provided.

TABLE I. Installation Positions Of Helmet Functional Components

device	size	weight
carbon fiber helmet	280x230x165mm	280g
high performance embedded chips	85x58x23 mm	50g
pressure strain gauge	7.3x4.1x1mm	2g
graphene wireless power bank	85x58x23mm	180g
mpu6050 sensor	15x20x1mm	8g
digital motor	10x10x2.7 mm	2g
heart rate, blood oxygen, and blood pressure monitoring modules	39x60x1.5mm	30g
voltage stabilizing module	36x17x7mm	5g
DuPont Line	30x1.5x1.5mm	10g
noise sensor	100x20x10mm	20g
SIM800A development board	50x48x1.5mm	30g
LED board	320x160x5mm	20g
Flexible solar panels	80x55x2mm	15g
thin film matrix keyboard	80x60x2mm	15g
sound and light alarm device	20x10x10mm	5g

In the functional testing phase, the main steps involved are as follows.

Firstly, we connect the hardware of the microcontroller, power module, pressure detection module, GSM module, GPS module, buttons, etc., and use ST Link to burn the program into the STM32 microcontroller.

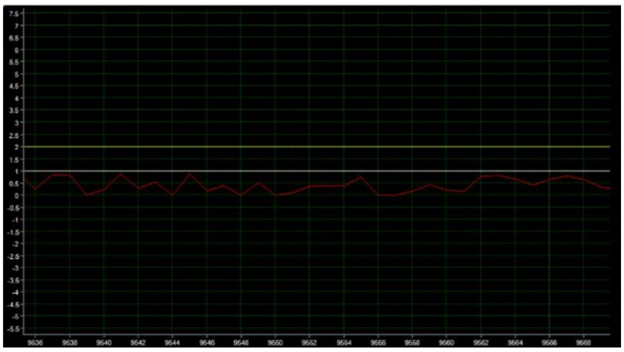

Figure 4. The output waveform in the honking environment

Then, we apply pressure to the pressure detection module. When the pressure value exceeds the set threshold, we can observe that the microcontroller sends a distress message with latitude and longitude to the contact person through the GSM module, and at the same time, the sound and light alarm is activated.

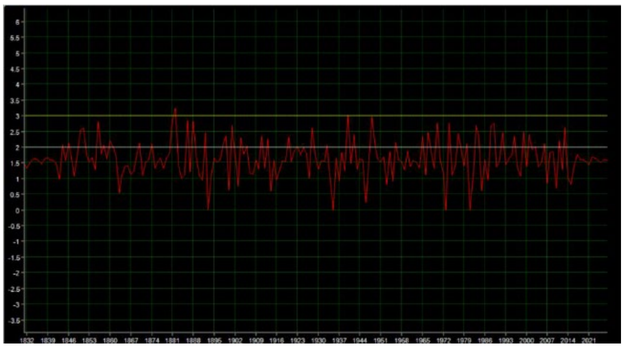

Figure 5 The output waveform in the honking environment after connecting the filter circuit

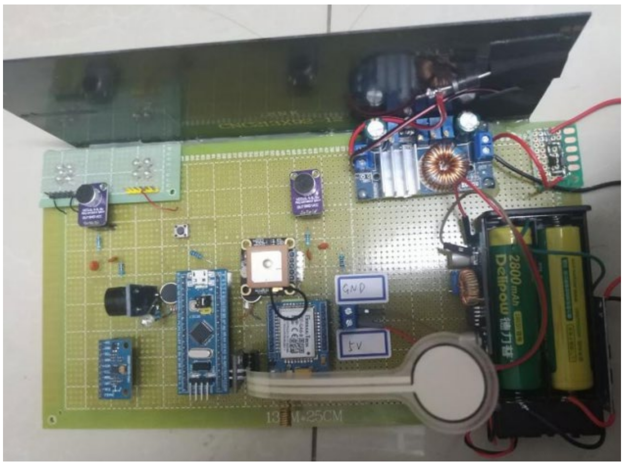

Figure 6 System physical image (front)

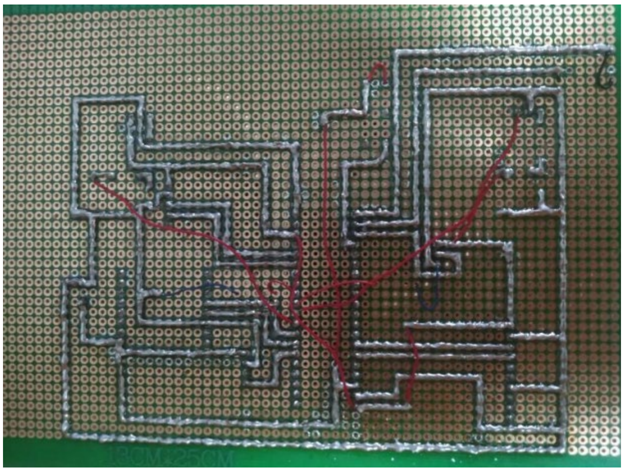

Figure 7 System physical image (back)

Finally, by pressing the cancel alarm button, we can observe that the GSM module has sent a message to the contact person reporting safety, while the sound and light alarm is turned off.

B. Conclusion

This paper first tests the microphone module with data cope software and gives the test steps and Tests effect. By using the computer port to power, when using the power supply module in this document, whether there is test effect diagram of filter circuit in silent or Whistle environment, and it can be proved that the power module designed in this paper has small ripple and good stability. Then, it introduces the steps of distress alarm function test and the test effect diagram is given. Through system testing and analysis, it can be proved that, the system effectively realizes the functions of solar power supply, horn prompt, distress alarm, steering prompt and so on. And it meets the design requirement.

With the rapid development of technology, intelligent living has become popular worldwide, and smart helmets have also been widely used in security, military, fire protection, mining, transportation and other fields. This article makes improvements to the shortcomings of existing smart helmets, proposes and designs smart helmets for safe travel for deaf people, and mainly completes the following research work:

(1) By reviewing and analyzing the current research status of smart helmets both domestically and internationally, and addressing their shortcomings, the research objective of this article is determined to achieve functions such as horn warning, distress alarm, and steering warning.

(2) Determine the performance requirements, overall architecture, and workflow of the system based on research objectives.

(3) Complete the system hardware design, perform circuit design and construction according to different functions. The main control adopts the STM32F103C8T6 minimum system, and the solar power supply function includes a power module; The horn prompt function includes a microphone module and a vibration module, the distress alarm function includes a pressure detection module, GSM module, GPS module, sound and light alarm module, and button module, and the steering prompt function includes an MPU9250 attitude detection module and LED lights.

(4) Complete the system software design, use Keil uVision5 software programming, and write programs based on STM32F103C8T6 sub functional modules to achieve whistle prompt, distress alarm, and steering prompt functions. The main performance is to collect the sound of vehicle horns and indicate the direction of the horns; If the collection pressure exceeds the threshold, send a location distress message, activate the sound and light alarm, press the button to cancel the alarm, send a safety message, and collect the head movement posture through MPU9250. When the cyclist turns, the direction will be displayed on the LED to remind the vehicles and pedestrians behind. After research, it was found that the program design for the horn prompt function described in the proposal report is not feasible. The original plan was to use a microphone array to estimate the sound source position through time delay estimation based sound source localization (TDOA), controllable beamforming based sound source localization, or high-resolution spectral estimation based sound source localization algorithms.

(5) Complete the overall debugging and functional testing of the system, and use DataScope software to observe the output waveform of the microphone module under different conditions; Test the distress alarm function and provide a test effect diagram. Through system testing and analysis, it can be proven that the system has effectively implemented functions such as horn warning, distress alarm, and steering warning, meeting the design requirements.

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