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Article

Design and Development of Intelligent Assistive Glasses for the Visually Impaired

Corwin Ellery
University of Northern Iowa, Cedar Falls, USA
corwin.ellery659@uni.edu

Abstract: *This paper presents the design and implementation of intelligent navigation and emergency rescue glasses for visually impaired individuals, integrating multiple sensing and feedback modules based on the STM32F103RCT6 microcontroller. The system combines a camera module utilizing the OV2640 sensor, an ultrasonic ranging module (HC-SR04), and a BDS navigation and positioning unit to achieve accurate environmental perception, real-time obstacle detection, and location tracking. The vibration output and fault alarm modules are designed to provide intuitive feedback and ensure equipment reliability, supported by lightweight and ergonomic humanized design principles. Experimental testing under various indoor and outdoor conditions demonstrates that the system achieves navigation accuracy within 5 meters and obstacle detection error within 5 centimeters. The glasses effectively support safe mobility and emergency assistance for the blind, offering a practical, low-cost, and user-friendly solution for intelligent navigation and safety enhancement.*

Keywords: *Smart glasses for the blind; STM32 microcontroller; obstacle avoidance; ultrasonic ranging; BDS navigation; human – computer interaction; emergency rescue system*

1. Introduction

According to data released by the China Association of the Blind, the number of blind people in China has exceeded 17.3 million by 2022, and the number is still growing. What is more shocking is that more than 300,000 people in China have become blind due to high myopia. At present, the commonly used auxiliary means for the blind in China are mostly blind poles, guide dogs and so on[1]. However, traditional auxiliary means for the blind are inadequate in achieving accurate navigation and emergency rescue, which limits the independence and quality of life of the visually impaired. Therefore, the development of "Intelligent navigation and Emergency rescue - Smart glasses for the blind" is particularly important. This technology will provide the blind with more reliable and intelligent navigation and emergency rescue methods, which help them live more autonomously and participate in social activities, and provide timely support in emergency situations, adding security and convenience to their lives.

2. The design of System overall scheme

This product uses STM32F103RCT6 as the control core, integrates the camera, ultrasonic ranging module, navigation and location module, vibration output module and fault alarm integrated system, with a humanized design. The system captures images of the surrounding environment through the camera and identifies environmental information. And the ultrasonic ranging module measures the distance between the user and obstacles. Meanwhile, the STM32F103RCT6 main control chip conducts data processing and decision-making. The navigation and positioning module further provides path planning and rescue. The vibration output module outputs motion signals, and the fault alarm ensures the maintainability of the equipment. Human-computer interaction realizes the humanized design of the device, and the battery uses a small and lightweight polymer lithium-ion battery to jointly provide intelligent navigation, safe obstacle avoidance and emergency rescue services for the blind. The overall scheme design of the system is shown in Figure1.

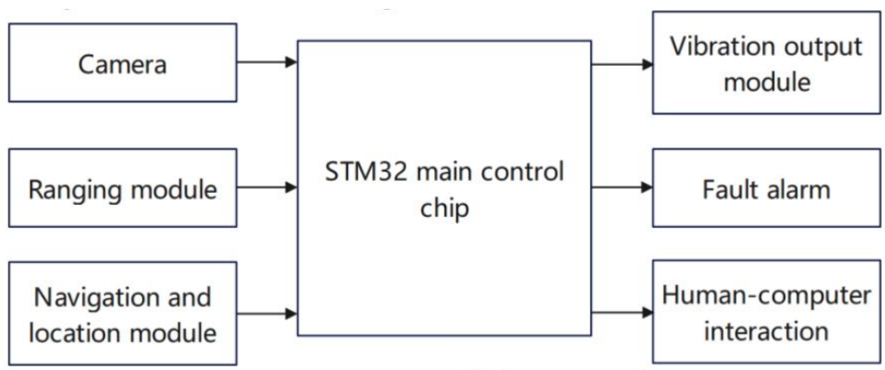

Figure 1. System overall design scheme

3. The design of Obstacle avoidance module

Accurate environmental perception and real-time data processing are the key to ensure the safe travel of blind users. This part focuses on the design of the obstacle avoidance module, including the camera module based on the OV2640 sensor, the HC-SR04 ultrasonic ranging module and the BDS navigation and positioning module.

3.1 Camera

In order to realize the accurate obstacle avoidance function of the blind smart glasses, the camera module integrated with the OV2640 sensor is selected as the image acquisition component. OV2640 as a mature CMOS image sensor, with high resolution, low power consumption and good image processing capabilities, through the conFigureuration of camera resolution, frame rate and other parameters, to ensure that real-time while ensuring clear and accurate image data can be obtained. According to the actual needs of the blind, the lens can adjust the appropriate focal length to provide a suitable field of view. The built-in autofocus mechanism ensures clear images at different distances. The OV2640 camera collects the image data of the front environment in real time. After the image acquired by the camera is pre- processed by denoising and brightness adjustment, the image data is transmitted to the STM32F103RCT6 microcontroller for further analysis and processing. With the support of STM32F103RCT6 microcontroller, an obstacle recognition algorithm based on image processing is implemented[2]. The algorithm uses color, texture, shape and other feature information in the image to identify and locate obstacles in the front environment. By comparing the differences in the continuous frame images, the key information such as the position and size of obstacles can be detected in real time.

3.2 Ultrasonic ranging module

HC-SR04 is used as ultrasonic ranging module, the working principle of this module is based on the propagation and reflection of sound waves, by transmitting ultrasonic pulses, and receiving the echo reflected back from obstacles.

When the STM32F103RCT6 sends a high level signal of at least 10 μ s to the Trig pin of the HC-SR04 through its GPIO interface, the control circuit of the HC-SR04 triggers the ultrasonic transmitter to emit a 40kHz ultrasonic signal; The ultrasonic signal propagates in the air and is reflected back after it encounters an object. The reflected ultrasonic signal is received by the receiver of the HC-SR04 module. Once the receiver detects the reflected wave, the Echo pin will output a high level signal, and the duration of the high level signal is proportional to the time difference between the ultrasonic wave from transmission to reception. At this point, the STM32F103RCT6 immediately starts the timer to start the time until the Echo pin's high level ends. The STM32 microcontroller calculates the distance between the module and the obstacle by detecting the high level duration t on the Echo pin, combined with the speed at which the sound waves travel through the air (about 340m/s). The calculation formula is: distance = (high level time t x sound speed) / 2[3].

3.3 Navigation and location module

The BDS module receives the satellite signal and calculates the position information, which is then sent to the STM32F103RCT6 via the UART interface. STM32F103RCT6 receives and analyzes these data, including extracting key information such as longitude, latitude and height from the original data, verifying and correcting it, and then feeding the results back to the blind user through the output module[4].

In the event of an emergency, users can send their location information through the BDS system to a preset emergency contact or rescue agency. After the user triggers the emergency help function, the system automatically obtains the current location information and sends it to the specified receiver through Bluetooth.

4. The design of the Output module

The output module transforms the system processing results into information that can be perceived by users. This part focuses on the design of output module, including vibration output module, buzzer fault alarm module and convenient humanized design..

4.1 Vibration output module

The STM32F103RCT6 receives data from BDS modules, cameras, ultrasonic sensors and other devices. The data is processed and analyzed using the built-in processor. Generate corresponding control instructions according to processing results and user settings[5], then the control command is transmitted to the vibration output module via GPIO.

When the vibration output module receives the control command, the internal vibration element is driven to produce physical vibration. The vibration frequency, duration, mode and other parameters are determined by the control instruction of STM32F103RCT6. Four modes of operation of the vibration output module are shown in Table 1 below.

Table 1. Four modes of operation vibration output module

Left turn	The left mirror holder is used to support short and continuous triple shocks

Right turn	Similar to the left turn, the right mirror holder is used to support a short and continuous triple shock
Go straight	Mirror holder on both side is used to support short and continuous trible shocks
Back to back	Continuous vibration with mirror holder on both side

4.2 Fault alarm module

When STM32F103RCT6 detects abnormal situations such as insufficient power and equipment failure, STM32F103RCT6 will deal with them according to the preset logic judgment rules. Once it is determined that an alarm signal is needed, the STM32F103RCT6 will output a square wave signal with a certain frequency and duty cycle through its GPIO pin. The frequency and duty cycle of the square wave signal determine the sound frequency and volume of the buzzer. By adjusting these parameters, the alarm sound can be controlled accurately. When the passive piezoelectric buzzer receives the square wave signal output by STM32F103RCT6, the piezoelectric ceramic chip inside the buzzer will be deformed and produce mechanical vibration driven by the electrical signal. These mechanical vibrations are amplified through the metal sheet or diaphragm of the buzzer and transmitted to the air to form an alarm sound.

The duration and frequency variation of the alarm sound is achieved by the control of the counterwave signal by the STM32F103RCT6. For example, the alarm sound can be set to a continuous long sound or a discontinuous short sound.

4.3 Humanized design

Lightweight design: The use of lightweight material plastic titanium as the glasses frame of the main material, these materials have sufficient strength and durability, relatively light weight. In the design process, unnecessary components and structures are minimized to achieve the best lightweight effect.

Ergonomic design: The arc and nose rest of the glasses are designed according to the ergonomic principle to ensure that the glasses are comfortable and stable and not easy to slip off.

Battery: The battery uses a small polymer lithium-ion battery (Li-Po), which has a higher energy density than the traditional lithium-ion battery and can store more power.

Convenient charging method: At the glasses charging interface, the easy-to-identify Braille sign is designed to help blind users accurately find the charging interface location. The widely compatible USB interface is selected as the charging method to facilitate users to charge at any time and anywhere.

5. Test and running result

In order to ensure that the blind smart glasses can operate stably in different environments and lighting conditions, the test environment includes indoor and outdoor scenarios. The indoor environment includes corridors, rooms, stairs and other internal environment, while the outdoor environment includes the selection of open areas such as roads, parks and squares.

5.1 The test of Navigation function

By simulating multiple routes from the starting point to the end point in the outdoor square, it is tested whether the glasses can plan a reasonable and safe walking path according to the current position and destination. By comparing the position information provided by the BDS module with the known coordinate points, the positioning accuracy of the navigation system is verified. In the test process, it is checked whether the user can be prompted by vibration in advance at the turning point.

5.2 The test of Obstacle avoidance

Obstacles such as tables, chairs and people are set indoors, and the HC-SR04 ultrasonic ranging module is used to measure whether the actual distance and the displayed distance are consistent with the actual distance of the obstacles at different distances. The image capture ability of the camera and the ranging stability of the ultrasonic sensor were tested under the environment of dark view and obstacle occlusion at night in the park.

5.3 The test of Emergency rescue function

Simulate the user to trigger the emergency help function to check whether the glasses can accurately obtain the current location information and send it to the emergency contact person or rescue agency preset in advance through Bluetooth.

Test the response of the fault alarm module in the case of insufficient power and equipment failure, and detect whether the buzzer can emit a clear and loud alarm sound.

5.4 The running result

In the open area, the positioning error is less than 5 meters, which can accurately plan the route and advance the vibration output at the turning point. In the range of 0.2 meters to 4 meters, the ultrasonic ranging error is less than 5 cm, and the camera can accurately capture the environmental information. In the case of good signal, emergency help information can be sent immediately, and the buzzer can emit a clear and loud alarm sound. Figures 2 and 3 below show the corresponding test results of BDS positioning test and ultrasonic ranging.

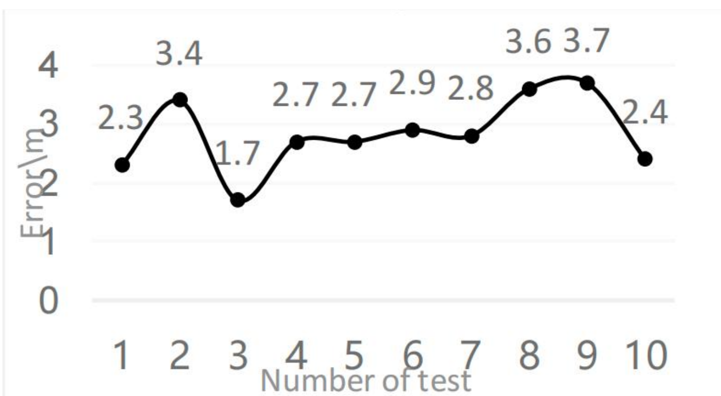

Figure 2. BDS positioning test results

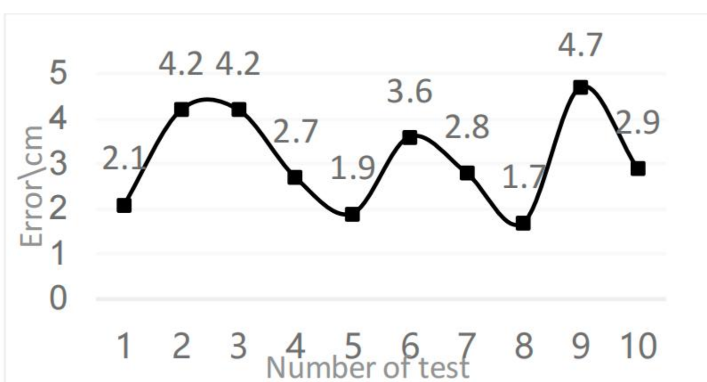

Figure 3. Ultrasonic ranging test results

6. Conclusion

After discussing the smart glasses for the blind in the field of intelligent navigation and emergency rescue, we found that this innovative technology can bring unprecedented convenience and security to the blind. Through intelligent navigation, obstacle avoidance, voice interaction and fault alarm modules, glasses help the blind to independently navigate and improve their ability to avoid obstacles safely, and improve the user experience through humanized design. This technology is not only the embodiment of scientific and technological progress, but also the concern and support of the society for the vulnerable groups. Looking forward to the future, with the progress of science and technology, smart glasses for the blind are expected to play their value in more fields and create a better life for the blind.

References

[1] Y.F. Dan, K.K. Shi, W.R. Li, et al. Design and Development of Intelligent Obstacle Avoidance Glasses for the Blind [J]. Fujian Computer, Vol. 37 (2021) No. 4, p. 99 – 101. (In Chinese)

[2] W.B. Wang, H.Y. Zhang, X.F. Li. Technology Optimization of Smart Glasses for the Blind Based on GPS Positioning System [J]. Modern Information Technology, Vol. 4 (2020) No. 12, p. 57 – 59. (In Chinese)

[3] Y.Y. He, M.Y. Ou, X.R. Duan, et al. Design of Intelligent Blind Glasses for Obstacle Avoidance Based on STMC89C51 [J]. Science and Technology Innovation, Vol. 31 (2020), p. 152 – 153. (In Chinese)

[4] Y.H. Yan. Design of Ultrasonic Ranging System Based on Single Chip Microcomputer [J]. Science and Technology Innovation, Vol. 12 (2024), p. 82 – 85. (In Chinese)

[5] F. Tong, S.Y. Xu, T.Z. Xu. A Processing Method of High Precision Ultrasonic Ranging [J]. Journal of Xiamen University (Natural Science Edition), Vol. 4 (1998), p. 43 – 48. (In Chinese)