Development and design of an intelligent guide stick for the blind

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Abstract: China has the largest group of disabled people in the world, and blind people account for a large part. However, we pay less attention to the blind, especially to the infrastructure for their daily life. In this paper, a guide stick was designed based on STM32F103C8T6 microcontroller to improve the safety for the blind. An ultrasonic module completed the distance measurement and GPS module located the blind. When the distance to obstacles was not more than 100cm, the guide stick gave a voice alarm and vibrated to warn the blind. The guide stick broadcasted the distance from its current location to the nearest obstacle when the broadcasting button was pressed. The current location was sent to the guardian by pressing the message button, which was useful especially when the blind user needed help. For experiments, ten blind people walked with guide sticks at different starting distances and speeds according to their own walking habits. 540 groups of data were obtained, among which 498 groups avoided obstacles successfully. The average success rate was 93%. It shows that under the normal walking speed (≤30cm/ s), the guide stick can effectively help the blind avoid obstacles and improve their safety.

1. Introduction
In the 1st National Sample Survey of Persons with Disabilities(NSSPD) in 1987, 6826 (0.4%) were blind. In 2006, the 2nd NSSPD showed that there were 12.33 million patients with visual disabilities, accounting for 14.9% of the total number of disabled people[1]. Blind people are not only a member of our ordinary people, but also a special group. Due to congenital or acquired physiological defects, they will encounter many inconveniences in their daily life. One of the biggest obstacles for blind people is that they can't find and avoid obstacles accurately and timely.

At present, most of the assistive devices for guiding the blind at home and abroad are guide dogs and guiding instruments. As we all know, guide dogs have high cost and time-consuming to train, and can't accompany their owners all their lives. The blind guiding instruments on the market have single function and large size. The CTT blind guide made by Xu Xiangyu's team [2] can determine the position of obstacles from 3D perspective, which is accurate and clear. However, its practicability and operability are limited, and it still cannot be put into practical use. Huang Hongzhi's intelligent travel navigation helmet for blind people [3] uses visual processing to judge obstacles and traffic lights, which has comprehensive functions but high cost and is not easy to carry. Lin Chen's intelligent blind walker [4] uses infrared detection to automatically avoid obstacles and exchange information with head-mounted sensors, but the accuracy of infrared rays is not high, which is greatly affected by the environment and is inconvenient to carry. The multi-directional infrared ranging intelligent bracelet made by Wu Xue et al. [5] uses infrared ranging depending on the intensity of reflected
light, and the system tests its obstacle avoidance function accurately through black, white and gray obstacles. Its function is limited due to the limited items that the bracelet can detect. The public environment designed by Karen Duarte team provides blind assistance system, which limits the scope to the relatively narrow environment of shopping center and cannot be widely used [6]. The blind guide rod designed by Sulaxorn Budilaksono team uses Arduino master controller to control ultrasonic sensor HC-SR04[7], which is small but has single function, and cannot bring better experience to blind people.

In order to make up for the problems of inaccurate infrared ray, slow real-time detection and timely feedback in the above system, this paper designs a blind guide stick with STM32 single chip microcomputer as the core, which can accurately measure the distance by ultrasonic, and feed back to the blind in time through voice broadcast. In dangerous situations, the vibration of the vibration motor causes the blind to be alert, and can also notify their guardians by SMS. The application of the system can greatly reduce the potential safety hazard of blind people walking, and reduce the accidents caused by blind people's inability to judge obstacles.

2. System hardware design
The guide stick consists of an STM32F103C8T6 main control controller, GPS sensor, ultrasonic ranging sensor, key detection, vibration motor, remote transmission module and voice module. The system design block diagram is shown in figure 1.

Fig. 1 The block diagram of the guide stick system

The minimum system of single-chip microcomputer: the STM32F103C8T6 single-chip microcomputer is the core, with peripheral circuits (clock circuit, reset circuit, power supply circuit). It Mainly completes the data collection and conversion. The STM32F103 microcontroller [8] integrates the ARM Cortex-M3 core of embedded Flash and SRAM. Compared with 8/16-bit devices, ARM Cortex-M3 32-bit RISC processor provides higher code efficiency.

The voice playing circuit design: the MP3-TF-16P voice module is controlled by STM32F103C8T6 single chip micro-computer. This MP3 module is small and cheap. It can be used alone or controlled through serial port. The module itself perfectly integrates the hard decoding of MP3, WAV and WMA. It is easy to use, stable and reliable without complicated bottom operation.

Ultrasonic ranging circuit design: HC-SR04 ultrasonic transceiver module can generate 40kHz square wave, which is driven by the amplifier circuit to transmit ultrasonic waves. The transmitted ultrasonic waves are reflected by obstacles and then received by the ultrasonic receiving probe. Two IO ports of single chip microcomputer are respectively connected with TRIG and ECHO interfaces on ultrasonic module to realize trigger control to send out detection signals and receive return signals. The distance is calculated according to time difference and transmission speed of sound waves in the air.

GPS module design: ATGM336H module takes UART serial port as the main output channel, and outputs according to NMEA0183. It can be transferred from USB to TTL line or directly connected to MCU, with accuracy of 2.5m. The module has the advantages of high sensitivity, low power consumption and low cost, and is suitable for vehicle navigation, handheld positioning and wearable devices.

Remote transmission module: The SIM900A module is directly connected with the MCU through TTL serial port with GSM module, which supports the global four-frequency network.
Vibration module circuit design: The vibration motor is controlled by high-power MOS FET, and the vibration motor is controlled by PWM.

3. System software design
The software flow chart of the guide stick system is shown in figure 2. After the initialization, the current distance from the stick to the nearest obstacle is measured by ultrasonic ranging. Then GPS data is obtained, and the current location is analysed. After that, the system determines whether the measured current distance exceeds the threshold value. If yes, a voice alarm is given with the vibration motor starting, and the current distance is broadcasted. Otherwise, the voice broadcasting button detection is carried out. If the voice broadcasting button is pressed, the current distance is broadcasted to the user. If not, the message button detection is followed. If it is pressed, the current location data is sent to the guardian. Otherwise, the system returns.

![Software Flow Chart](image)

Fig. 2 The software flow chart of the guide stick system

4. Experimental results
In the experiment, a straight road was chosen as the experimental route, and the wall with a height of 2 meters and a length of 1 meter and three stationary human bodies were taken as obstacles. In this paper, the distance from the blind man's starting position to the nearest obstacle is taken as the starting distance, and the distance between the blind man's stop position and the nearest obstacle is taken as the actual stop distance. When the guide stick is 100cm away from the obstacle, a voice alarm will be given, and the blind will stop moving
forward. If the actual stopping distance is not less than 50cm, it is considered that obstacle avoidance is successful. Otherwise, obstacle avoidance fails.

For experiments, the starting distance varied from 150 cm to 15 meters, and was tested every 25cm. Ten blind people having different walking habits used the guide stick to help them walk at different starting distances and speeds. Finally, 540 groups of data were obtained, among which 498 groups were the data of successful obstacle avoidance. According to formula (1), the successful obstacle avoidance rate was 93%.

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\text{Successful obstacle avoidance rate} = \frac{\text{the number of successful obstacle avoidance times}}{\text{the number of failure avoidance times}} \times 100\% \quad (1)
\]

Table 1 shows some data obtained by one blind person walking with a guide stick. At the starting distance of 3 meters, 5 meters and 6 meters respectively, the blind man walked at his fastest speed. For the rest, he walked at his daily habit speed. It can be seen that obstacle avoidance fails more often when the blind user walk too fast (> 30cm/s). At the normal walking speed (≤30cm/s), the blind walking with the aid of the guide stick can effectively avoid obstacles and improve the safety of the blind during the journey.

| Starting distance | Speed of Blind people | Reaction time of blind people | Actual stopping distance | Is it successful to avoid obstacles? |
|-------------------|-----------------------|-------------------------------|--------------------------|-------------------------------------|
| 150cm             | 15cm/s                | 0.5s                          | 46cm                     | No                                  |
| 175cm             | 13cm/s                | 1s                            | 50cm                     | Yes                                 |
| 200cm             | 12.5cm/s              | 1s                            | 52cm                     | Yes                                 |
| 225cm             | 18cm/s                | 2s                            | 55cm                     | Yes                                 |
| 250cm             | 15cm/s                | 1s                            | 53cm                     | Yes                                 |
| 275cm             | 14cm/s                | 2s                            | 56cm                     | Yes                                 |
| 300cm             | 35cm/s                | 1s                            | 32cm                     | No                                  |
| 325cm             | 12cm/s                | 1s                            | 54cm                     | Yes                                 |
| 350cm             | 15cm/s                | 1s                            | 52cm                     | Yes                                 |
| 375cm             | 14cm/s                | 1s                            | 53cm                     | Yes                                 |
| 400cm             | 12.5cm/s              | 2s                            | 55cm                     | Yes                                 |
| 500cm             | 32cm/s                | 1s                            | 38cm                     | No                                  |
| 600cm             | 32cm/s                | 2s                            | 55cm                     | Yes                                 |
| 700cm             | 14cm/s                | 1s                            | 51cm                     | Yes                                 |
| 800cm             | 15cm/s                | 1s                            | 53cm                     | Yes                                 |
| 900cm             | 16cm/s                | 2s                            | 50cm                     | Yes                                 |
| 1000cm            | 18cm/s                | 2s                            | 54cm                     | Yes                                 |
| 1200cm            | 20cm/s                | 1s                            | 52cm                     | Yes                                 |
| 1500cm            | 20cm/s                | 2s                            | 58cm                     | Yes                                 |

5. Conclusions
In this paper, an intelligent guide stick with STM32F103C8T6 as the main control chip is designed, which provides a convenient, safe and efficient travel aid for the visually impaired. When the guide stick is 100cm away from the obstacle, it gives a voice alarm and vibrates to remind the blind to avoid the obstacle. At the same time, the system has voice broadcasting and positioning functions, which can broadcast the current distance according to the needs of blind people. Blind people can also send position messages to guardians.
through the system to seek help in time. The experimental results show that, at normal walking speed, the blind walking rod can effectively avoid obstacles and improve the travel safety of the blind.

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