The design of an improved intelligent guide stick for the blind

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Abstract: There are about 17 million blind people in China, which means that one out of every 80 people is blind. However, due to the lack of facilities and policies to help the blind, many blind people can't enter some normal places, which brings lots of inconveniences to the blind. In order to make blind people travel more conveniently and safely, this paper designs an improved intelligent guide stick to provide security guide for the blind's daily travel and their precise location for their guardians. The location data and the images of surroundings were sent to the guardian's smart phone to help them find the blind especially in a multistory building. In this paper, 10 blind people walked with the help of the improved guide stick in a 3-story building that was divided into 12 different areas. The guardians received text messages and real-time images sent by the guide stick to determine where the blinds were. Finally, 300 groups of data were obtained, among which 282 groups were got when the blind people were successfully located and found, with the successful finding rate of 94%. The experimental results show that with the help of the improved guide stick, the blind can be located more precisely and effectively.

1. Introduction
There are 85 million disabled people and 44 million disabled and semi-disabled elderly people in China[1]. Many of them need assistive devices. Assistive devices are products that compensate and replace human functions[2], and are means of helping the disabled and the elderly to improve their life quality and enhance their ability to participate in society. China is the country with the largest demand and the fastest growth of assistive devices in the world.

According to the estimation of the World Health Organization, more than 1 billion people in the world need one or more kinds of assistive devices, of which only about 10% are satisfied. By 2050, the population in need of assistive devices is expected to reach more than 2 billion. At present, both the number and the scale of domestic assistive devices enterprises are small, and they still focus on processing middle and low-end products. More than 70% of the middle and high-end products, such as electric wheelchairs and scooters, that can be produced on a large scale are OEM (Original Equipment Manufacturer) products[3], and the middle and high-end prostheses, orthoses, low-vision assistive devices and cochlea mainly rely on imports.

The blind obstacle avoidance glasses designed by Dan Yufang's team [4] collected images through open-cv and measured distance with binocular vision, but the detection area was limited, which still had a great impact on the blind's actions. The blind guide rod [5] based on Arduino designed by Yuan Shifeng's team had LED display to prompt passers-by at night, but it lacked accurate positioning of obstacle distance. The navigation rod of the Internet of Things designed [6] by Li Kai team effectively transmitted the road information to the blind through headphones, and used video recognition technology and
temperature and humidity sensors to identify road obstacles, but there was no accurate positioning and emergency alarm for the blind, and there were still many problems in the safety of the blind. In order to help blind people to travel safely and make their daily life more easily, an intelligent guide stick was designed by our team. Using the ultrasonic module, voice module and GSM module to cooperate with each other, it can effectively avoid obstacles and improve the safety of the blind during the journey. However, in multistory buildings, it was hard to determine what floor the blind people were in, which brought lots of difficulties to the guardians who were eager to find the blind, especially when the blind was in danger and seeking help.

In view of the above problems and the actual situation, this paper further optimizes the guide stick designed in [7]. The optimized design is constituted of STM32F103C8T6 as the master control module, GSM module, WIFI module, camera and mobile APP, etc. The location of the multistory building the blind is in can be sent as a short message to the guardian’s mobile phone. When the guardian arrives at the building, his mobile phone can communicate with the camera built in the optimized stick through the 2.4GHz wireless signal sent by WIFI. The real-time images of the current surroundings around the blind are captured and sent to the guardian’s mobile phone. The blind can be quickly and exactly located by the guardian according to the images. The improved guide stick can ensure the safety of the blind more comprehensively, especially when the blind gets lost in densely populated or confined space.

2. System hardware design
The improved blind guide stick system includes STM32F103C8T6 main controller, ultrasonic distance sensor module, GSM module, voice module, vibration module, key detection module, WIFI module, camera module and mobile APP. The system block diagram is shown in Figure 1.

![Fig.1 The block diagram of the guide stick system](image)

The main controller STM32: the STM32F103C8T6 single chip microcomputer is used as the main control chip. The microcontroller works in the temperature range of -40°C to +85°C, and the power supply voltage is 2.4-3.6V. A comprehensive power-saving mode allows the design of low-power applications.

Ultrasonic distance sensor module: HC-SR04 ultrasonic ranging module can provide 2cm-400cm non-contact distance sensing function, and the ranging accuracy can reach as high as 3 mm. The module includes ultrasonic transmitter, receiver and control circuit.

GSM module: ATGM336H module[8] supports single-system positioning of BDS/GPS/GLONASS satellite navigation system and multi-system joint positioning of any combination with its excellent positioning and navigation functions, and supports QZSS and SBAS systems to support A-GNSS and D-GNSS.

Voice module: MP3-TF-16P is a voice module providing serial port, which perfectly integrates the hard decoding of MP3, WAV and WMA. At the same time, the software supports TF card driver and FAT16 and FAT32 file systems. When the distance measured by the ultrasonic is less than the threshold, the voice module will remind the blind to avoid the obstacles.
Vibration module: Uchuang SW-1801P module, comparator output, clean signal, good waveform, strong driving ability, LM 393 comparator used for over 15MA. This module makes the blind have a feeling of vibration as a real-time warning.

WIFI module: ATK-ESP8266\(^9\) uses AP mode and default WIFI module as hot spot to realize direct communication between mobile phone or computer and the module, and realize wireless control of local area network.

Camera module\(^{10}\): After turning on the power supply, it sends a 2.4GHz transmission signal\(^{11}\), which is widely used in network products and quite stable. 2.4GHz can be transmitted farther, so it can cover a larger range, and it is easier for signals to pass through walls.

Mobile APP platform: After receiving the signal, decode the signal and convert it into an image for output.

3. System software design

The software of the improved blind guide stick system includes two parts, one for the blind user and the other one for the guardian. The software flow chart is shown in Figure 2.

In the blind user’s part, the system is started and initialized. After the ultrasonic ranging and GPS data analysis, the distance value to the nearest obstacle and the location data of the blind is read. The distance value is compared with the threshold. If it is less than the threshold, the voice broadcast will be started, the vibration module will be enabled, and then the voice alarm will be played. Otherwise, key detection is performed. When the voice broadcast key is pressed, the current distance to the obstacle will be broadcasted by the speaker. Then the state of the short message button is detected. If it is pressed, the location data of the blind will be sent as a short message to the guardian’s mobile phone. If not, the system will return back to the beginning to do the ultrasonic ranging again.

In the guardian’s part, the WIFI module is powered on to provide a hot spot signal to the guardian’s mobile phone through AP mode. The wireless camera module sends out a transmission signal of 2.4 GHz. After the successful communication of the mobile phone and the camera through the hot spot, the application in the mobile phone is launched to decode the transmission signal, and then the real-time images captured by the camera are obtained on the guardian’s mobile phone.

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

In the experiment, a three-story building was selected as the experimental site. Each floor covered an area of about 20*20 (unit: meters). The whole building was divided into 12 different areas, which were marked by different patterns including triangles, circles, squares and numbers, and four different colors: red, green, blue and white. The sketch map of the three-story building with 12 different areas was shown in Figure 3. The improved blind guide stick we designed in this paper and the original one designed in [7] were used separately by the blind who walked in the building and stopped at random.

![Fig.3. The sketch map of the three-story building with 12 different areas](image)

At the beginning of the experiment, with the assistance of the original guide stick, 10 blind people who had their own walking habits entered the experimental site in turn. They went up or down the stairs. As they pressed the message button, the GPS location data was sent to their guardian’s mobile phone. The guardian then went to find the blind only according to the GPS location data. 200 groups of finding time were recorded, some of which were shown in Table 1. The average finding time was 6 minutes 3 seconds.

Then the improved guide stick was used by the same 10 blind people who entered the experimental site in turn again. In addition to the GPS location data, the guardian’s mobile phone communicated with the camera built in the guide stick, and the real-time surrounding images of the blind was obtained to help the guardian to quickly locate which area the blind was in. The time cost in each finding was recorded, and some was shown in Table 2. The average finding time is 3 minutes 49 seconds. It can be seen that the average finding time was significantly shortened.

It was considered as a successful finding when the blind was found by the guardian within 5 minutes. There were 282 groups of successful findings in the total 300 findings when the improved guide stick was used in the experiments. According to Formula (1), the successful finding rate is 94%.

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\text{Successful finding rate} = \frac{\text{the number of Successful Findings}}{\text{the total number of Findings}} \times 100\% \quad (1)
\]

Table 1 Experimental data obtained when the original guide stick was used

| The NO. of the guardian | The NO. of the blind person | Time cost in finding (min) | Is it a successful finding? |
|-------------------------|-----------------------------|-----------------------------|----------------------------|
| ①                       | Number 1                    | 04:43                       | Yes                        |
| ①                       | Number 3                    | 08:15                       | No                         |
Table 2: Experimental data obtained when the improved guide stick was used

| Guardian | blind person | Looking for time (min) | Is it successful to find? |
|----------|--------------|------------------------|--------------------------|
| ①        | Number 1     | 03:32                  | Yes                      |
| ①        | Number 8     | 04:45                  | Yes                      |
| ②        | Number 3     | 03:55                  | Yes                      |
| ②        | Number 4     | 04:25                  | Yes                      |
| ②        | Number 2     | 03:18                  | Yes                      |
| ③        | Number 5     | 03:58                  | Yes                      |
| ④        | Number 9     | 06:18                  | No                       |
| ④        | Number 6     | 04:51                  | Yes                      |
| ⑤        | Number 10    | 01:46                  | Yes                      |
| ⑥        | Number 10    | 04:21                  | Yes                      |
| ⑦        | Number 10    | 03:43                  | Yes                      |
| ⑧        | Number 10    | 07:33                  | No                       |

5. Conclusions
In this paper, an improved guide stick is designed for helping guardians to find the blind quickly especially in a multi-story building. In addition to detecting and broadcasting the road condition in front of the blind in time, it can send location information and real-time surrounding images to guardian’s mobile phone. The experimental results showed that the time consumption in finding the blind was obviously shortened, which greatly improved the travel safety of the blind.
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References
[1] Yang Lixiong, Li Xi. Research on AIDS Policy for Disabled Persons in China [J]. Research on Disabled Persons, 2018(01):43-51.
[2] Wang Hong, Xu Xiaoming. Aids for the disabled and their services [J]. Chinese Rehabilitation Theory and Practice, 2007(04):321-323.
[3] Yang Wei, Lu Jianlong, liuhong, Xu Luomin. Discussion on the Development of Rehabilitation Aids Industrial Park [J]. China Engineering Consulting, 2018(09):87-91.
[4] Dan Yufang, Shi Kaikai, Li Weiren, Wang Tianfeng, Zhu Heng. Design and development of intelligent obstacle-avoidance glasses for blind people [J]. Fujian Computer, 2021,37(04):99-101.
[5] Yuan Shifeng, Zhang Ruoyu, Liu Chun, Wang Yuping. Design of intelligent blind rod based on Arduino [J]. Science and Technology and Innovation, 2021(05):61-62+65.
[6] Li Kai, Xi Mengjiao, Chen Deyong, Duan Jincai, Wu Yan. Design of multi-functional blind navigation rod based on Internet technology [J]. Journal of Liaoning University of Science and Technology, 2021,23(01):11-13.
[7] Ren Yunan,Huang Junzhe,He Hui,Wang Yixuan,Zhu Haohan,Li Zhiyu,He Jin. Development and design of an intelligent guide stick for the blind[J]. Journal of Physics: Conference Series,2021,1748(6).
[8] Shu Xiulan, Zheng Xubin, Li Zesen, Ma Changyun, Liu Shi. Design of indoor positioning system based on ATGM336H+ESP01S [J]. Electronic World, 2021(02):184-185.
[9] Zhang Hushi, Lin Weilong, Yang Fazhu, Huang Xiangjun, Jin Xingyi, Jie Chen, Luo Xiaochun, Zhang Yingying, Gan Xin. Internet of Things Temperature Monitoring System Based on ESP8266 WiFi Module [J]. Internet of Things Technology, 2020,10(12):32-35.
[10] A. C. Gheorghe. Raspberry Pi Based Microscope Camera with Wireless Functionality[J]. The Scientific Bulletin of Electrical Engineering Faculty,2018,18(2).
[11] Qi Qiping, Yuan Weidong, Bian Xiaojun, Lu Zhiwu, Zhang Kaifeng. Key technology and application of 2.4G RFID intelligent IoT regional positioning [J]. Electronic Technology and Software Engineering, 2020(01):66-67.