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# Smart Guide Stick based on Multi-Sensing Technology

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## Abstract

**The number of blind people has increased dramatically in recent years due to congenital or various accidental causes. The visual impairment brings inconvenience to life, especially when going out, and can also lead to safety accidents. Therefore, it is necessary to solve the daily travel problems of blind people. The design of a multi-sensor-based human-computer interactive smart guide aims to help blind people travel safely. The guide is equipped with a GPS positioning system, ultrasonic sensors and a voice announcement system to help blind people perceive the parameters of their surroundings and issue warning and alert messages according to the state of the surroundings.**

## Keywords

**GPS positioning system, ultrasonic sensor, voice announcement system, software system design, human-computer interaction system.**

## 1. Introduction

According to the WHO, there were approximately 5 million blind people in China in 2006. By 2010, that number had climbed to 8.248 million. Another six years later, the number of blind people had increased to 17.31 million. Today, the number of blind people in China has surpassed 20 million. And at the same time, blind people are unable to communicate with others using normal body language and lack the necessary social skills due to their lack of vision, plus the mobility restrictions that prevent them from having a colourful life like normal people. With the continuous development of technology, there are many smart canes available in the market, but these canes do not solve their travel problems. The system is based on the 89C52 microcontroller, which incorporates a variety of sensors to analyse and process the environmental parameters around the cane and optimise the algorithm to make the information processing faster and more sensitive. This is followed by a language announcement system and a navigation system to make travel easier.

## 2. General system design and research objectives

### 2.1. Overall system design

The system consists of an 89C52 as the control core, a water accumulation sensor, a voice alarm module, an ultrasonic distance measurement module, a GPS/GSN module and a battery module. The overall structure is shown in Figure 1.

### 2.2. Research Objective

(1) The corresponding sensors are selected to help blind people travel smoothly by sensing the environmental parameters around them, using GPS to provide precise location for journey navigation, changing destination information and route enquiry in time according to the journey.

(2) Push road conditions, such as traffic light signals, water on the road, and information about the blind pavement ahead, based on the environmental information sensed by the sensors, using voice prompts.

(3) Safety alarm, when the sensor attached to the guide detects an unknown object (car or obstacle) greater than 1m in diameter 3m away from the user it will send an alarm and quickly identify the target object and send an alarm based on the echo signal, when the signal is less than 3m the guide will enter emergency safety mode. Night light warning to alert pedestrians in darker environments.

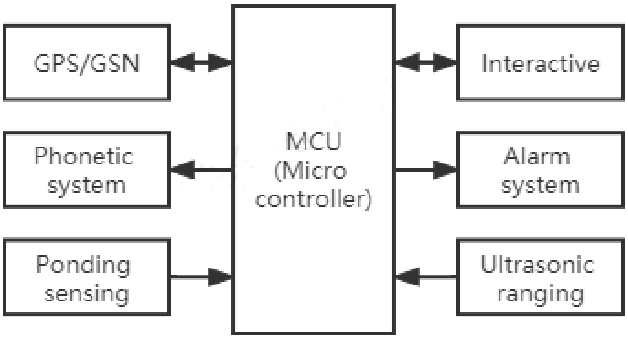


Figure 1: Overall Structure Diagram

## 3. Software and hardware design

### 3.1. Microprocessor

In order to realize the system functions, this design uses the microcontroller 89C52 as the central processor. 89C52 is the basic product of INTEL's MCS-51 series microcontroller, which is a high-performance 8-bit microcontroller manufactured by ATMEL's reliable CMOS process technology and belongs to the standard MCS-51 HCMOS product. It combines the high speed and high density technology of CMOS with the low power consumption characteristics of CMOS, it is based on the standard MCS-51 microcontroller architecture and instruction system, and belongs to the 89C51 enhanced microcontroller version with more functions such as integrated clock output and up or down counter. It can be used for both byte and bit processing, making it easy to use. The I/O ports are simple to set up, and after decades of development, all types of sensors and sensor source code are available, which greatly simplifies the design process.

### 3.2. Ultrasonic distance measurement module

As shown in Figure 2, according to the principle of ultrasonic sensor distance measurement, by sending and receiving ultrasonic waves, using the time difference and the speed of sound propagation in the medium, the distance from the module to the obstacle in front is calculated and transmitted to the control center, so as to achieve the function of detecting the surrounding environmental parameters.

The system uses the HC-SR04 ultrasonic distance measurement module, the circuit schematic diagram is shown in Figure 3. HC-SR04 ultrasonic distance measurement module can provide a non-contact distance sensing function of 2cm-400cm, the distance measurement accuracy can be as high as the non-contact distance sensing function, the distance measurement accuracy can be as high as 3mm; the module includes ultrasonic transmitter, receiver and control circuit. The module uses the IO port TRIG to trigger the distance measurement, giving a minimum of 10us of high level signal presentation. The module automatically sends eight 40khz square waves and automatically detects if a signal is returned; if a signal is returned, a high level is output through the IO port ECHO and the duration of the high level is the time from the launch to the return of the ultrasonic wave. Finally, the distance from the obstacle in front can be calculated through the formula. The calculation formula is

Test distance = (high level time * speed of sound (340m/s))/2. (1)

The calculated distance enables a judgement to be made by detecting obstacles or pits etc. ahead.

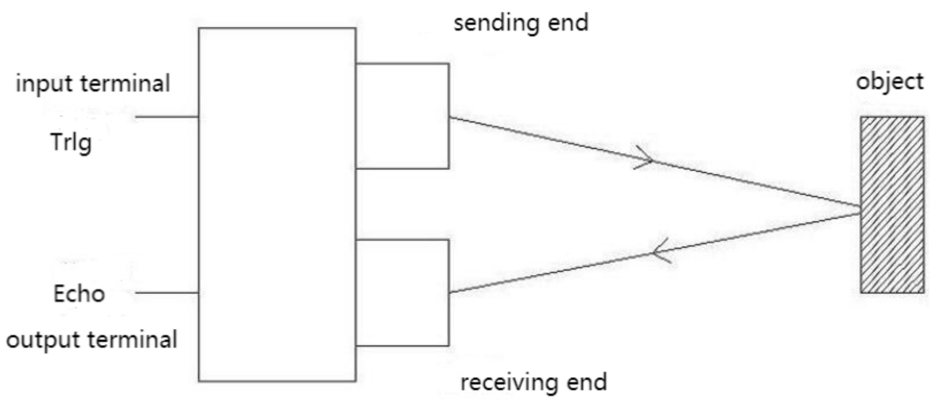


Figure 2: Schematic Diagram of Ultrasound Operation

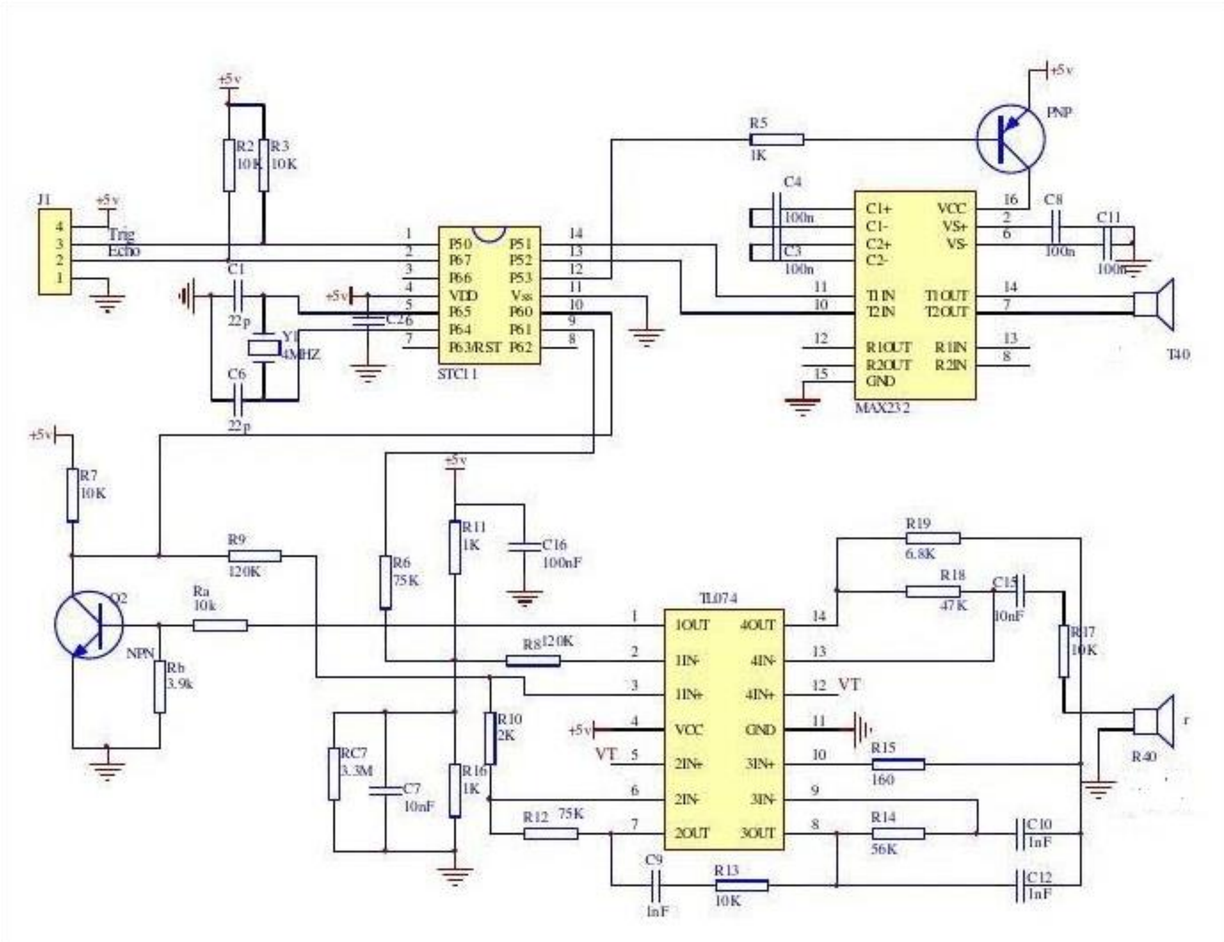


Figure 3: HC-SR04 Ultrasonic Circuit Schematic

## 3.3. GPS/GSM module

The GPS module inside the cane can locate the current location in real time and analyse the route to navigate through the location information. The main function of the positioning module is to track and record the activities of visually impaired people in real time and, in case of

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emergency, to send information about their current location to a smart home system such as a mobile phone and to inform their family members by means of a text message in order to seek their help. This will enable them to be rescued in the first instance and avoid secondary harm.

## 3.4. Voice Alarm System

The voice system uses the XFS5152CE, which is a highly integrated voice synthesis chip for Chinese and English speech synthesis; it also integrates speech encoding and decoding functions to support recording and playback by the user; in addition to this, it also innovatively integrates a lightweight speech recognition function, supporting the recognition of 30 command words. I2C interface and SPI interface. The XFS5152CE can receive commands and data sent by the host computer through the UART interface, I2C or SPI interface, and the maximum length of data allowed to be sent is 4K bytes. The voice system together with the vibration sensor and the buzzer module form the voice alarm system. The voice module circuit principle is shown in Figure 4.

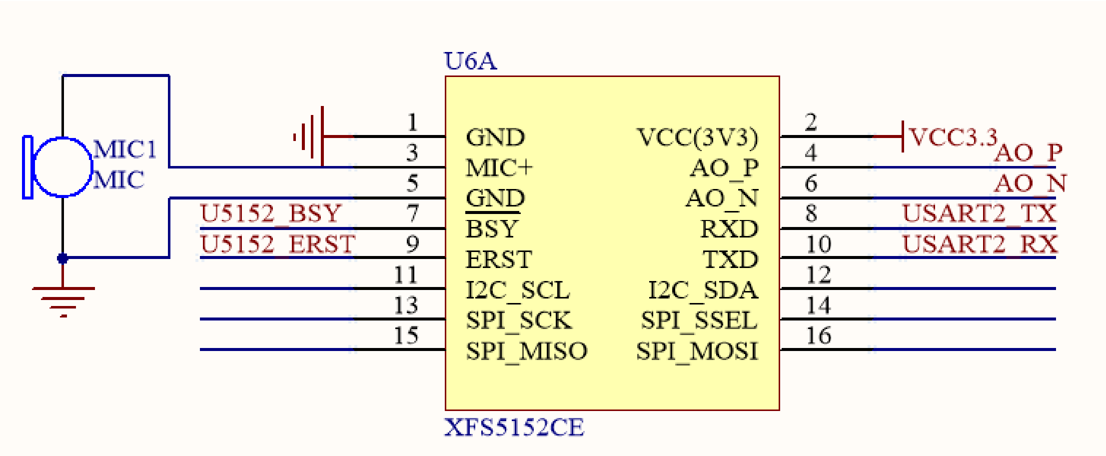


Figure 4: XFS5152CE Voice Module Circuit Schematic

## 3.5. Standing Water Sensor

Generally after the rain, the road surface will be more or less waterlogged, and the waterlogging will cause some inconvenience and sometimes even danger to the blind people walking.

The capacitance measurement method is used here. The flat capacitance is selected to measure the depth of water and other parameters through the change in capacitance, using the principle that the dielectric constant of water is much greater than that of air. The flat plate capacitance is calculated by the formula

$$C=\varepsilon*S/d \quad (2)$$

The circuit uses a NE555 time base oscillation circuit. When the depth of the accumulated water changes, the capacitance C changes, resulting in a change in the output frequency of the circuit, and the depth of the accumulated water is calculated from the amount of change.

## 3.6. Power supply module

The cane uses two 8.9V batteries in series to form the power supply, as each module does not require a high voltage, so 8.9V is sufficient, and then the voltage is converted to the voltage required by each module through the voltage conversion module.

## 3.7. Software Module

The software is programmed using the Keil uVision4 software development tool, written in C. Keil uVision4 provides a complete range of development solutions including library management, macro assembly, linker, C compiler and simulation debugging, which are combined together in an integrated development environment, making the target code very

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efficient. The system program mainly includes the main program, the language alarm subroutine, the ultrasonic distance measurement subroutine and the GPS navigation subroutine.

After initialisation of the system, the destination is set via the human-machine interface, the path is planned and the system is started to work. Judging the road condition such as whether there are obstacles, steps, standing water, etc., if there are, make voice prompt and alarm, if not, judge whether the destination is reached, if yes, you can send a safe arrival SMS to your family and end the system work. The flow chart is shown in Figure 5.

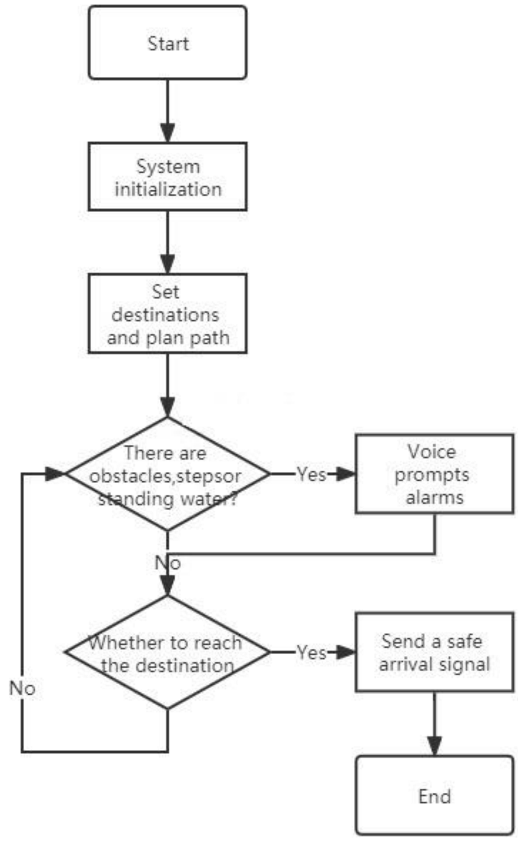


Figure 5: Software Flow Chart

## 4. Sensor test results

In order to get a general idea of the accuracy and error of the sensors, accumulation tests and distance tests were carried out on the accumulation sensor and ultrasonic sensor respectively. The specific results are shown in Table 1 and Table 2.

Table 1: Clean water and Chaotic Water Testing Results

| Actual depth /mm | Clean water Measuring depth/mm | Error /% | Actual depth /mm | Chaotic water Measuring depth/mm | Error /% |
|---|---|---|---|---|---|
| 10 | 10.3 | 3.0 | 10 | 10.7 | 7.0 |
| 20 | 20.5 | 2.5 | 20 | 18.9 | -5.51 |
| 50 | 48.8 | 2.4 | 50 | 48.0 | -4 |

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Table 2: Ultrasonic Sensor Test Results

| Order number | Timer value | Measuring distance/cm | Actual distance /cm | Error /% |
|---|---|---|---|---|
| 1 | 32 | 54.4 | 50 | 8.088 |
| 2 | 63 | 107.1 | 100 | 6.629 |
| 3 | 93 | 158.1 | 150 | 5.123 |
| 4 | 122 | 207.4 | 200 | 3.568 |
| 5 | 158 | 268.6 | 250 | 6.925 |
| 6 | 196 | 333.2 | 300 | 9.964 |

## 5. Conclusion

This design uses microcontroller-based GPS navigation and ultrasonic distance measurement principles to complete the design of an intelligent guide cane to achieve the positioning function of the blind, and can detect obstacles within 3 meters around as well as standing water, puddles and such on, then issue an alarm or vibration prompt according to the situation.

In addition, the design can only test the situation in front, and the detection of obstacles in the left and right directions is still under consideration.

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