Research and Discovery of Smart Dumb Gloves

Xiaoshuang Yu, Suying Liu*, Weiyi Fang, Yankun Zhang
School of Software, Zhengzhou University, Zhengzhou 450000, China

*Corresponding author email: liu_suying@zzu.edu.cn

Abstract. According to the statistics of China's health organization, there are a large number of deaf-mute people in the whole country. Sign language is used to communicate between deaf and dumb people. When they communicate with people who don't know sign language, it will bring a lot of inconvenience. Based on the above problems, we propose a sign language gesture recognition system based on data glove. The overall architecture is composed of stm32 MCU, flex4.5 bending sensor, mpu6050 six axis sensor, Bluetooth transmission module and mobile phone voice app. It collects the user's hand movement information through flex4.5 bending sensor and mpu6050 six axis sensor, Then the STM32 microcontroller processes the data and compares it with the action data in the database. Then the action voice command is sent to the mobile phone through the Bluetooth transmission module, and finally the voice playback and text display are carried out through the mobile phone app. The software of sign language gesture recognition system is developed by using processing software based on Java language, which is connected with it to complete the recognition of sign language actions, and then output the words to be said through the intelligent voice system.

Keywords: Intelligence, dumb, glove, sign language, deaf-mute.

1. Introduction
With the rapid development of computer technology, intelligence has become one of the main directions of development [1]. It is always the research purpose of computer intelligence to make machines think and make judgments like human beings. At present, deep learning technology has made significant development in image recognition and speech recognition. Sign language gesture recognition is closely related to speech recognition. Similar to speech, gesture in sign language has the characteristics of large amount of data and strong timing, so it can inherit and use the frontier research results in speech recognition.

Although predecessors have done a lot of research on gesture recognition based on data glove, there is still no product widely used by deaf people in the market. One possible reason is the high cost of data gloves. The data gloves on the market are mainly used for VR, so the price is generally high. Take the product of dataglove Inc., which is mainly engaged in data glove, as an example, the cheapest data glove also costs $585.00, about 3800 yuan. If we want to promote this technology, whether we can use lower cost data gloves to achieve the same recognition effect is a key. To sum up, whether in the improvement of people's quality of life and happiness or the improvement of social productivity, intelligent dumb glove has its huge development space and immeasurable significance.
In view of the shortcomings of intelligent devices for the deaf and dumb in the current market, we designed intelligent dumb gloves. Intelligent dumb gloves belong to a part of intelligent wearable devices [2]. At present, various markets have begun to pay attention to the application of intelligent control technology, but there is still a great lack in intelligent devices for deaf and dumb people. The traditional common sign language communication cannot meet the needs of the times, and the intelligent sign language communication is the inevitable requirement of the development of the times. Compared with traditional sign language, intelligent dumb glove has more powerful function and "consciousness", which brings convenience to people's life and improves the quality of life. In this paper, Bluetooth technology, intelligent recognition and embedded technology [3] are combined to realize a kind of intelligent dumb glove which is convenient for wireless control. Based on the mobile phone which is widely used at present, the intelligent system is designed, and the wireless Internet of things is applied to the intelligent wearable device, so that the intelligent dumb glove has wireless characteristics and becomes an independent form. The design of the whole system is comfortable and low power consumption, which has a broad application prospect in the future communication of deaf and dumb people.

1.1. Project overview
Sign language is a bridge between deaf and dumb people and the world. With the development of computer technology and the popularization of intelligence, the research on sign language recognition is endless [4]. Nowadays, the main research methods are based on machine vision and wearable input device. Compared with sign language recognition based on machine vision, sign language recognition based on wearable input device has the advantages of real-time finger bending, abduction and hand shape information [5]. Based on this, we envisage that the Internet of things technology will be applied here, which is expected to improve the scientificity, real-time and accuracy of equipment use. The main features of this project can be summarized as follows:

1. Design of data acquisition and identification system
   The design objectives of the system are mainly in three aspects: in order to monitor the connection and data of Bluetooth in real time, the Bluetooth data receiving and storage module is needed; in order to determine the validity of the data and ensure the timely detection of abnormal gloves (such as broken wire), the data processing and analysis module is needed [6]; in order to record samples and understand self-learning conveniently The recorded sample content needs sample recording and corpus annotation display module.

2. Decide and arrange help information
   The content of help information and error information, organization of query methods and error information, help information display format design.

3. Software interface design
   Our mobile app interface is designed according to the following steps to make the interface humanized and practical, so that every user can have the best experience.

4. Comprehensive test and evaluation
   The key task of this stage is to make the system meet the predetermined requirements through various types of testing and evaluation. It can take a variety of methods, such as test method, user feedback, expert analysis, software testing, etc., to evaluate many factors of the software interface, such as functionality, reliability, efficiency, aesthetics, etc., so as to obtain the user's satisfaction with the interface, so as to find errors or errors as soon as possible In order to improve and perfect the system design.
2. product introduction

2.1. project introduction
The intelligent dumb glove can get the information of finger bending, abduction and hand shape change in real time, and the 3D tracking device can give the spatial position of the object in real time. According to this feature, by combining gloves with 3D tracking device, with the help of appropriate algorithm, the position and posture information of palm and arm in space can be obtained. App transmits a series of sign language actions used by glove users to mobile app through Bluetooth module, and the mobile app matches with the existing dumb gesture database. It carries out real-time dumb gesture translation and text display to users through voice, so that users can translate dumb language according to their own needs, so that the deaf and dumb people can overcome their physical defects and have a better life Communicate with others and express inner thoughts.

2.2. project technology implementation

2.2.1. Software implementation. In order to achieve the goal of sign language recognition, sign language gloves need to collect at least two aspects of finger and gesture data. The finger data is used to judge the hand posture, the bending sensor is used, the gesture data is used to judge the hand trajectory, and the three-axis gyroscope sensor is used. In order to receive and preprocess the above two groups of data, the MCU is needed. In order to transmit the data to the intelligent terminal wirelessly, the Bluetooth module is needed.

(1) Design of data acquisition and identification system
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(2) Software interface design
Our mobile app interface is designed according to the following steps to make the interface humanized and practical, so that every user can have the best experience.

1. User research: draw up the requirements, and get a general picture of the use of the product through comprehensive analysis.
2. Product analysis: according to the complexity and difficulty of the product, the task action is decomposed in detail, the reasonable division of labor is carried out, and the interaction mode suitable for users is determined;
3. Product positioning: after understanding the users and related products, the positioning of products will be clearer.
4. Environment analysis: determine the hardware and software support environment and interface of the system, and provide users with various document requirements, etc;
5. Screen display and layout design: formulate the content of screen display information and the order of interface display, and then design the overall layout and display structure of the screen.
6. Help and error information design: determine and arrange the content of help information and error information, organize query methods, and design the display format of error information and help information;
7. Determine the interface: according to the user's own characteristics, product analysis and positioning, determine the development environment and product layout, get the product interface design structure diagram, and establish the product interface prototype.
8. Prototype trial: after the preliminary system requirements analysis, develop a simple and operational system to meet the requirements of the system copy for users to try, let users evaluate and
put forward suggestions for improvement, and further improve the system requirements specification and system design.

9. Comprehensive testing and evaluation: the key task of this stage is to make the system meet the predetermined requirements through various types of testing and evaluation. It can take a variety of methods, such as test method, user feedback, expert analysis, software testing, etc., to evaluate many factors of the software interface, such as functionality, reliability, efficiency, aesthetics, etc., in order to obtain user satisfaction with the interface in order to find out the error or dissatisfaction as soon as possible, so as to improve and perfect the system design.

Maintenance phase: the key task of maintenance phase is to make the system meet the needs of users persistently through various necessary maintenance activities.

![Figure 1 Interface diagram of data acquisition and identification system](image1)

**Figure. 1** Interface diagram of data acquisition and identification system

(3) Data receiving and storage

The program receives Bluetooth data through cbcentral manager delegate protocol, and the block diagram is shown in Figure 1.2.1.

![Figure 2 Bluetooth data receiving block](image2)

**Figure. 2** Bluetooth data receiving block
When cbccentral manager calls any function, the program will update the state of the system and display it in the user interface. The specific process is: peripheral discovered → peripheral connected → services discovered → characteristic discovered.

The outgoing parameter of diddiscoverperipheral function contains (RSSI *) RSSI. When calling this function, the signal strength value at this time will be recorded and displayed in the user interface.

The outgoing parameter of the didupdatevalueforcharacteristic function contains (cbcharacteristic *) characteristic, which is the Bluetooth data packaged as cbcharacteristic object.

In fact, we use the data in the data characteristic.value.description As received Bluetooth data for subsequent processing. Each time the function is called, the number of frames will be + 1 and displayed on the user interface.

Because the communication mode between Bluetooth and Arduino promini is asynchronous communication, a packet from Arduino may be split into two packets by Bluetooth. If the data is directly stored without processing, the data will be lost and misplaced in the subsequent recognition, which will affect the overall recognition effect. The program uses a custom databuffer class to handle this situation.

The external interface provided by databuffer is
- (void)writeBuffer:(NSString*) incomingStr;
- (NSString*) readBuffer

Function through the ring array structure to achieve the initial storage of Bluetooth data, readbuffer function through the regular expression search method to extract the complete data packet in the ring array, and send out in the way of nsstring *.

(4) Data processing and analysis

In the actual test, it is found that the data transmission rate of the left-hand Bluetooth module is faster than that of the right hand. Therefore, in the data reception, the left hand may have sent three packets of data while the right hand only sends one packet. If the left-hand and right-hand data are simply spliced packet by packet, the left-hand data may overflow. The program uses a custom message buffer class to deal with this problem.

The external interface provided by message buffer is
- (MessageBuffer*) ini
- (NSString*) getFullMessage:
  (NSSString*) message forHand:( NSString*) hand;

The ini function is used to generate a circular array of counters and caches. The function of getfullmessage is to cache the data of left and right hands and splice them together. When the left-hand data overflows, the real-time right-hand data is no longer used, but the latest data from the right hand is used for splicing. The result after splicing is sent out in the form of nsstring *.

After the completion of the data splicing, the data is unpacked. The program defines a structure called glovedata, the definition statement is as follows:

typedef struct {
  double acceleration [6];
  double angular Velocity [6];
  double angle [6];
  int flex [10];} GloveData;

The structure consists of four arrays, which store acceleration, angular velocity, angle and bending sensor values respectively. Unpacking is completed in viewcontroller. The process is to separate acceleration, angular velocity, angle and bending sensor data from the data processed by message buffer, and store them in the defined structure. After separating the data, the given algorithm is used to solve the data, and the actual value of the data is obtained.

The drawing of line graph is completed by datashowview class. DataShowView does not provide external interfaces. It only contains the drawRect function automatically invoked by the system. Its function is to extract data from the gloveData structure and draw a broken line graph, which is displayed on the user's interface. As shown in Figure 1.3.1.
2.2.2. Hardware implementation. The hardware design of our project mainly includes bending sensor, gyroscope, power supply design, resistance to voltage conversion, the use of serial port, Arduino data transmission.

(1) **Bending sensor**

The popular products on the market are spectrum symbol. The size used in the paper is 2.2 "and 4.5", 2.2 "for thumb and little finger, 4.5" for index finger, middle finger and ring finger.

In the selection of gyroscope, mpu6050 three-axis gyroscope sensor is used in this paper. The data types provided are acceleration, angular velocity and angle.

(2) **Gyroscope**

In the selection of gyroscope, mpu6050 three-axis gyroscope sensor is used in this paper. The data types provided are acceleration, angular velocity and angle. The coordinate system of this kind of gyroscope takes itself as the origin at all times, and the measured acceleration is the combination of gravity acceleration and external acceleration. Therefore, the direction of motion can be judged by the projection of acceleration on the coordinate axis. On the other hand, the process of motion can be judged by angular velocity. The data of both are not affected by the orientation, so they can be described more effectively. Draw the trajectory. The data sent by gyroscope is three sequential output
data packets, each packet has 11 bytes, which are acceleration, angular velocity and angular packet respectively.

| Data number | Data content     | Meaning                      |
|-------------|------------------|------------------------------|
| 0           | 0x55             | Bactou                       |
| 1           | 0x51             | Identification              |
| 2           | AxL              | X-axis acceleration low byte |
| 3           | AxH              | X-axis acceleration high byte|
| 4           | AyL              | Y-axis acceleration low byte |
| 5           | AyH              | Y-axis acceleration high byte|
| 6           | AzL              | Z-axis acceleration low byte |
| 7           | AzH              | Z-axis acceleration high byte|
| 8           | TL               | Temperature low byte         |
| 9           | TH               | High temperature byte        |
| 10          | Sum              | Checksums                   |

Data number | Data content     | Meaning                      |
|-------------|------------------|------------------------------|
| 0           | 0x55             | Bactou                       |
| 1           | 0x52             | Identification              |
| 2           | wxL              | X-axis angular velocity low byte |
| 3           | wxH              | X-axis angular velocity high byte|
| 4           | wyL              | Y-axis angular velocity low byte |
| 5           | wyH              | Y-axis angular velocity high byte|
| 6           | wzL              | Z-axis angular velocity low byte |
| 7           | wzH              | Z-axis angular velocity high byte|
| 8           | TL               | Temperature low byte         |
| 9           | TH               | High temperature byte        |
| 10          | Sum              | Checksums                   |

Figure 5 Acceleration data and angular velocity

(3) Conversion of resistance to voltage
The bending sensor is equivalent to the resistance which can change the resistance value with the bending degree. Because the processing core is the single chip microcomputer, it is necessary to convert the resistance value into the voltage value and connect it to the analog port for measurement. The change range of bending sensor is 7-20 (4.5 °) and 20-40 (2.2°). There are two common conversion methods, using simple voltage divider circuit conversion or using operational amplifier conversion.

(4) Use of serial port
Two single chip microcomputers are used as master and slave respectively. The master is connected with gyroscope and the slave is connected with Bluetooth module. Because Arduino promini has no USB interface, direct debugging is more troublesome [7], so Arduino uno with USB interface is used for debugging. Arduino uno is superior to Arduino promini in processing speed and main frequency crystal oscillator, and is competent in feasibility test. When using Arduino uno for feasibility test, the data packet loss caused by SPI connection is serious. The possible reason is that Arduino itself does not support the protocol well, which leads to the inconsistency of clock frequency in asynchronous communication. In view of the above reasons, the paper can only give up SPI connection and use other methods. After analyzing the actual situation, it can be found that the serial ports of gyroscope and Bluetooth module are divided into two interfaces: TX (transmission) and Rx (reception), but in fact, the gyroscope only needs to transmit data, and the Bluetooth module only needs to receive data, which is only half of the serial port. Therefore, we can consider dividing the serial port into two, connecting the TX of gyroscope to the RX of Arduino, and connecting the TX of Arduino to the RX of Arduino Connect to RX of Bluetooth module. The feasibility test using Arduino uno shows that this transmission method can achieve normal data transmission, and the packet loss rate is zero. The experimental results show that this connection method can realize the independent use of serial port.
Figure. 6 Gyroscope and Bluetooth module are independently connected to the Arduino ProMini through the serial port.

(5) Arduino data transmission

After the feasibility study of serial port usage, Arduino Promini is used for practical test. In the test, the transmission rate is normal, but there is still some loss or dislocation in the received data. After reading the chip data for many times, it is found that the problem may be caused by the baud rate error. In the process of transmission, the program will first check the check sum of each packet of data. Because the gyroscope data itself has been packaged, in order to reduce the amount of data, the gyroscope data is unpacked and further processed. The data of each bending sensor is a hexadecimal integer of one byte. After collecting all the three packets of gyroscope data, the data of gyroscope and bending sensor will be sent to Bluetooth module in two packets.

Figure. 7 Data receiving and preprocessing block

(6) Power supply design

The main power consumption components in the circuit are MCU, Bluetooth module, gyroscope and operational amplifier. According to the parameters of the components selected before, the main current is less than 22.2ma when the power output voltage is 3.3V. In order to ensure the design requirements of continuous working for 10 hours and the size limit of no more than 30 * 30MM, the final battery selected in this paper is 300mAh lithium battery with the size of 30 * 25MM, nominal voltage 3.7V. In order to charge the battery more conveniently, the circuit board is equipped with a
micro-USB interface, which is installed on the outside of the circuit board. In order to control the battery charging or power supply, the circuit board is also equipped with a switch. In order to ensure the wearability of the whole system, the size of the switch is required to be less than 1 mm in height, less than 2 mm in stroke and less than 4 mm in width, and the package is surface mount. The final size of the label switch is 0.7 mm in height, 1.4 mm in stroke and 3.1 mm in width, which meets the design requirements.

2.3. Project advantages
1. In the sign language recognition method based on wearable input device, the commonly used input devices are data glove and 3D tracking device. The data glove can get the information of finger bending, abduction and hand shape change in real time, and the 3D tracking device can give the spatial position of the object in real time. According to this feature, by combining the data glove with the 3D tracking device, with the help of the appropriate algorithm, the position and posture information of the palm and arm in space can be obtained. The sign language recognition system based on wearable input device can be further divided into finger language recognition, sign language word recognition and continuous sign language recognition according to the recognized objects.
2. Using simple and common components (Bluetooth module, gyroscope, etc.) to design and make a pair of low-cost sign language gloves. The test shows that it can complete the data acquisition function and achieve high recognition.
3. Using the new technology of speech recognition, the deep neural network hidden Markov hybrid model is established for sign language recognition.
4. The training and real-time recognition system based on dynamic time warping, single Gaussian hidden Markov model and deep neural network hidden Markov mixture model is established, and the time complexity and accuracy of three different recognition methods are compared. Real time recognition of sign language is completed on the intelligent terminal.

3. Epilogue
Intelligent has become one of the main directions of development, intelligent wear has gradually entered people's vision, intelligent dumb gloves just conform to the trend of the times, so that more deaf people can express their feelings without discrimination from others. The development prospect of intelligent dumb gloves is immeasurable.

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