

Assisting autonomous precision medical rehabilitation through gesture recognition devices

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Abstract. With the aging of the population and the increase of various chronic diseases, there is a growing demand for effective and accessible medical rehab solutions. In order to overcome the above problems, this project innovatively adopts the gesture recognition technology to design and fabricate the realization of an autonomous accurate medical rehab gesture recognition assistance system. In terms of hardware, this paper uses Arduino as the main controller, Paj7620 as the gesture recognition device, and OLED 0.96 display as the system display. In terms of software, this paper utilizes Arduino IDE software to successfully write the code and realize all the functions. In terms of combining with actual medical rehab needs, the team chose elbow fracture rehab as a typical type of rehab, and designed a three-device obtuse triangle placement scheme for precise monitoring of rehab training. Initial simulation test results show that over 70% of participants reported an improvement in their rehabilitation outcomes, and about 90% found the system easy to use. The results of this project will directly benefit patients requiring long-term rehabilitation.

Keywords: Gesture Recognition, Medical Rehab, Arduino

1. Introduction

Treatment has been accessible to all thanks for the advanced technology. However, for a long time, medical rehabilitation is ignored. The aim of medical rehabilitation is to help people with behavioral difficulties to pull through [1]. It is true that the rehabilitation process will be less pressured than treatment, it is a vital part of body conditioning. Standard action can help patients a faster process and prevent them from further wound. So, the rehabilitation product should have the function to monitor and correct the actions. In the past, there were videos playing repeatedly on the displayer for the patients to follow. It was rather hidebound. They displayed videos they restored, and the patients followed them. The gesture was specified, so the actions were repeated and boring. Besides, incongruent gestures will possibly lead to deeper hurts and injury, which will definitely obey the initial aim of the project [2]. The most common medical instruments for private use are diagnostic kits. But the products in the past almost had no boundary to build connection or communication among the physicians and the patients. They tend to display standard actions through video and direct patients to follow. So, the project thinks of a piece of combined equipment to correct patients' actions timely.

For another, people now all have the requirement of healthcare. They earn enough money but suffer much pressure from work, so they care more about health than before. It is the same tendency and

situation with medical treatment. So far, there are also a great range of personal medical testing equipment. Lately, treatment instruments such as far infrared therapy instrument, magnetic therapy instrument; testing instruments such as blood pressure monitor, stethoscope; medical rehabilitation equipment such as oxygen concentrator, orthotics. There are a great many indications show that a complex piece of equipment can be built to satisfy the strict demand by the patients. The program aims at building a piece of combined equipment to build a connection in order to monitor, as well as to assist rehabilitation, a ‘three-device obtuse triangle place scheme ‘ to monitor and examine whether the action is standard.

2. System design scheme

2.1. General Scheme Design

The scheme generally combines electronic engineering and treatment. The subject will take Arduino as a core, working on programming with the software and the design of the hardware devices, and try to combine it with corresponding rehabilitation training, in order to improve the rehabilitation effect of patients. Arduino has the advantage of loading the experimental script on the board’s memory and let it run without interfacing with computers or external software, thus granting complete independence, portability, and accuracy [3]. The following figure 1 below is the main components and the function structure.

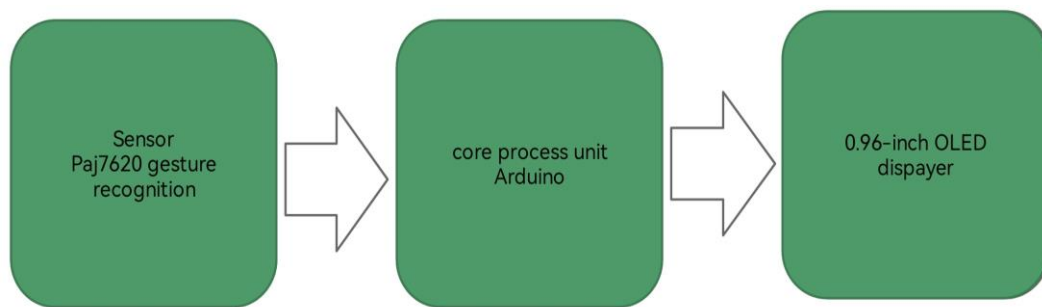


Figure 1. General scheme design (Photo/Picture credit: Original)

Gesture recognition system generally includes three parts: PAJ7620, digital processing unit and the output displayer. The scheme uses Arduino as the main control device. PAJ760 works as a gesture recognition device to monitor real-time human’s actions and moves, and provides timely feedback. 0.96-inch OLED displayer as display, real-time movement feedback, through Arduino programming, hardware soldering assembling and realize the new means of medical rehabilitation.

2.2. General hardware scheme design

2.2.1. Arduino- core process equipment. Arduino is a widely-used open-source microcontroller platform, which is based on simple IDE, making it easy to program, transfer and update the codes to the board [4]. Arduino has a great number of user community, offering abundant study resources, program cases and technique support.

Arduino serves as the hub of this project and is responsible for receiving data from the gesture recognition module Paj7620, processing this data, and driving other components (e.g., the display) based on this data. The Arduino runs the software written specifically for this project, which includes the algorithms for gesture recognition, the logic for processing the data, and the protocols for communicating with the external devices. Arduino The Arduino provides a variety of interfaces (e.g., digital I/O, analog I/O, PWM, I2C, SPI, etc.) for easy connection to various sensors and peripherals such as the Paj7620 and the OLED screen [5]. The Arduino is able to process the gesture data in real time and provide instant feedback through the connected display, which is crucial for patient rehabilitation.

2.2.2. PAJ7620- gesture recognition. Gesture recognition module plays an active part in the program, especially health treatment. In the scheme, PAJ7620 is selected as a gesture recognition mode. Paj7620 is a high-powered gesture recognition sensor, can recognize simple gestures. It is miniaturized designed, has high sensitivity, can respond quickly, and it is easy to integrate with microcontroller (eg. Arduino). The mode can recognize 9 various gestures, including moving upward, downward, forward, backward, clockwise, anti-clockwise, left, and right [6]. It takes advantage of infrared light to detect gestures, and capture dynamic changes of optical elements. Paj7620 is usually connected with the main controller (eg. Arduino) through I2C port, which makes data transform simple and efficient [7].

PAj7620, the core sensor, is used to capture the gestures of patients during the recovery. It can transfer the gesture it seizes to electric signal, and transform them to Arduino main controller. Paj7620 strengthens the combination of the patients and the recovery training, make it more perceptual and effective. With the help of Arduino and displayer, Paj7620 can provide timely feedback from the patients, helping their understanding as well as adjusting recovery training action.

2.2.3. 0.96OLED displayer. 0.96-inch OLED displayer is a kind of small display device. It displays clearly, low energy cost, tight dimension. The 0.96-inch OLED display is a small display device that has a clear display, low power consumption and compact size. In this project, the use of a 0.96-inch OLED display provides an effective visual feedback interface for rehabilitation training. OLED (Organic Light-Emitting Diode) technology enables displays to deliver high-contrast, high-resolution images. The display is typically 0.96 inches and has a resolution of around 128x64 pixels, which is enough to display a concise text and graphic information. Most 0.96-inch OLED displays communicate with the main controller (such as Arduino) through an I2C or SPI interface, facilitating data transmission and screen control [8, 9]. An important feature of OLED screens is high energy efficiency, that is, low energy consumption while providing a clear display effect.

During the recovery training process, OLED can display real-time gesture and training progress, and provide timely feedback. It can be used to display training direction (eg. standard gestures) to help patients execute action. Because of its small volume, the OLED displayer can make it easy to integrate into a variety of portable or stationary medical rehabilitation devices.

2.3. Software programming for gesture recognition system

The article makes use of Arduino IDE to program, which is developed by the Arduino. Arduino provides a cross-platform integrated development environment (IDE) based in Java and built to support different Arduino boards. It contains multiple code examples, a debug serial console, and is open source. With the IDE you can create your programs called sketches [10]. The general programming process analysis is shown as follows:

1. Initialize the entrance to the program, usually the setup () and loop () functions
2. Initialization and PIN set. Read the library function necessary, set PIN 2 and 3 as an output control.
3. Set Baud rate of the serial communication as 9600, in order to read and monitor the data.
4. Define the variables. Define variables Data, j, and array val[4] for storage and data processing.
5. Judge the input signal. Judge whether there is input signal using condition judgment and loop statements.
6. Read the signal code. If the input signal is detected, read the signal code; if not, continue the loop
7. Judge code and delay. Judge the code it read whether it is 0xaa, if, execute 2ms delay operation, go back to the circulation above.
8. Signal analysis. Read and analyze the following 4 signals, clear out the meaning they stand for.
9. Process the result. Operate on the basis of processed signal, eg. display information or control of some action.
10. Ending

2.4. Assisted precise medical rehabilitation scheme

In terms of combining with the actual medical rehabilitation needs, the team selected the typical and common rehabilitation type of elbow fracture after in-depth research and consideration. The rehabilitation process after elbow fracture requires precise movement control and moderate training intensity [11]. Therefore, it is important to ensure the correct rehabilitation movement for the rapid recovery of patients.

To satisfy the better medical rehabilitation, a special ‘three devices obtuse triangle place scheme. The core of the scheme is to place three complete gesture recognition devices in an obtuse triangle layout, as shown in figure 2 by the black, red and yellow modules in the image.

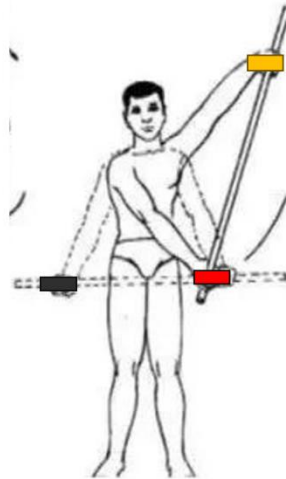


Figure 2. Precision medicine scheme (Photo/Picture credit: Original)

This layout not only facilitates the patient’s line of sight and range of motion during rehabilitation training, but also ensures that the gesture recognition module can capture the patient’s elbow movements in an all-round and seamless manner.

3. Results Analysis

3.1. Code Run Results

The software program part was written in Arduino and C language was used to implement the input of the code and finally burn the code into the Arduino hardware via USB cable. According to the main flow of the design, the code program of each part was completely inputted and compiled, corrected using its internal checking, and finally the executable target code was generated.

3.2. Hardware connection and test results

In accordance with the circuit wiring, the connection and operation of the hardware is utilized, and after completion, the hardware should be physically tested, and there is a failure of the PAJ7620 Gesture Sensor Module not working properly. First check the hardware to see if there is a problem with the line, whether the connection line internal fracture. If there is a problem, replace the line to reconnect, to see if it works properly. For similar problems, carry out continuous modification tests, and finally complete the testing of the physical hardware to achieve all the preset functions. The hardware connection diagram is shown in figure 3 below.

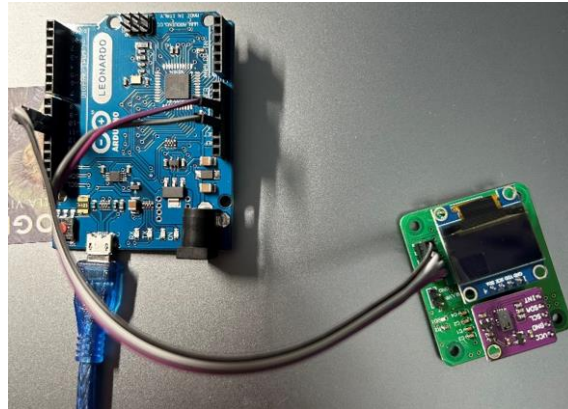


Figure 3. Hardware Connection Diagram (Photo/Picture credit: Original)

After successful testing, the preset functions were tested. The nine gestures of moving up, moving down, moving left, moving right, moving forward, moving backward, circular clockwise, circular counterclockwise and fluctuating are tested respectively. The test results are shown in the figure 4 below.

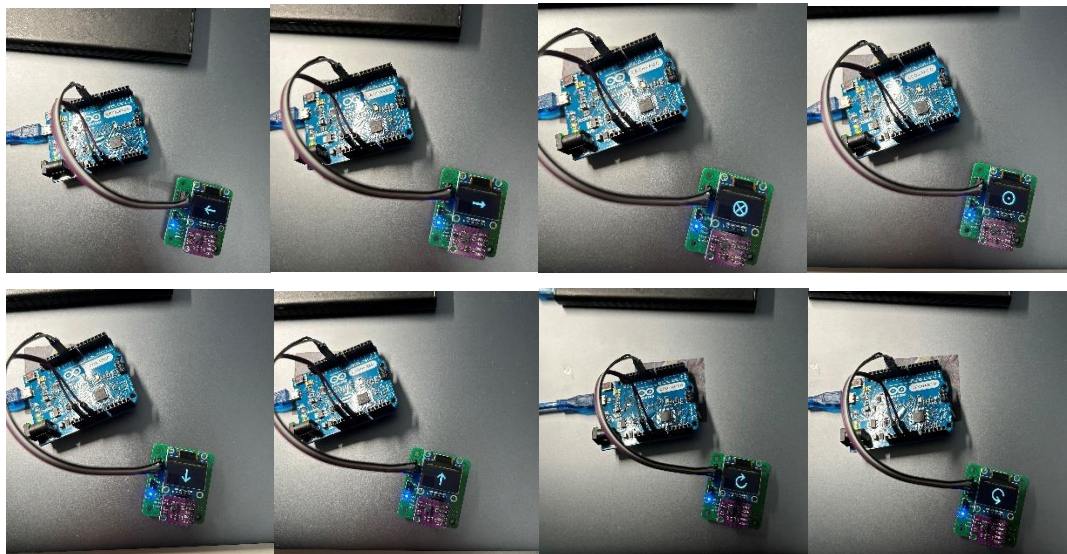


Figure 4. Functional test results (Photo/Picture credit: Original)

According to the results of the system function test, this design realizes the recognition of all gestures and all functions of can be realized and run well, which achieves the design goal.

3.3. Preliminary simulation test analysis

By working closely with the local community in Shanghai, our team conducted an initial simulation test of accurate monitoring of rehabilitation training in a real-world setting. In this test, we deliberately chose a diverse population of approximately 20 adults, ranging in age from 20 to 60 years old, to ensure the generalizability and reliability of the results. These participants included patients in the early stages of elbow fracture rehabilitation, patients in the middle stages of rehabilitation, and patients in the late stages of rehabilitation, who had direct experience and needs at different stages of the rehabilitation process.

Test results showed that over 70% of participants reported an improvement in their rehab results. Especially in terms of movement accuracy and participation, many participants reported that through our system, they were able to understand more clearly the requirements of each rehabilitation movement and receive immediate feedback during training, which helped them to complete the rehabilitation

movements more accurately. This not only enhances the effectiveness of the training, but also increases the participants' confidence and motivation in rehabilitation.

In addition, about 90% of the participants said they found the system easy to use. User-friendliness was a key consideration in our design. With a simple and intuitive user interface, as well as clear instructions and feedback, our system reduces the learning curve for participants, enabling them to operate and train on their own, even without the presence of a medical professional.

These initial test results provided us with valuable data and feedback that allowed us to further optimize the design in future iterations of the project.

4. Conclusions

The aim of this study is to explore the possibility of combining electronic engineering with the medical and healthcare fields, to assist autonomous and precise medical rehabilitation through gesture recognition devices, and to improve the effectiveness of patients' rehabilitation training. Through the integrated use of Arduino as the core processor, PAJ7620 gesture recognition module, and 0.96-inch OLED display, this system realizes the accurate capture and real-time feedback of patient's gestures and movements, thus providing an efficient and user-friendly rehabilitation training tool.

In terms of hardware design, the system fully considers ease of use and practicality. The flexibility and scalability of the Arduino platform allows the system to efficiently process and respond to gesture data. Meanwhile, the accuracy of the PAJ7620 gesture recognition module ensures the accuracy of motion capture. The addition of the OLED display not only provides clear visual feedback, but also enhances the user's interactive experience. For software programming, the programming and debugging of the system was accomplished through the Arduino IDE. The flow-based design and modularized construction of the programming process ensured the stability and maintainability of the code. In addition, the testing and debugging process of the system shows that the overall design has high reliability and efficiency. In terms of practical applications, preliminary simulation tests showed that the system performed well in real-world medical rehab scenarios. Most of the test participants reported a significant improvement in their rehab outcomes, especially in terms of movement accuracy and engagement. In addition, the user-friendliness of the system was highly rated, indicating that even individuals without a professional medical background can easily use the system.

Undoubtedly, this study has successfully applied electronic engineering technology to the medical and healthcare field, providing a new type of rehabilitation training tool for rehabilitation patients. In the future, the results of this study are expected to be further extended to other types of rehabilitation training, thus serving the healthcare industry more widely.

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