Appendix 1-1: System Overview Document

No.:

Chinese Topic Title:Robert hand—Remote Wireless Synchronization Smart Phone English Title:Robert Hand—Remote Wireless Synchronized Smart Hand

1. Introduction

In the past few years, the COVID-19 pandemic has had a severe impact on the global medical system, especially for medical personnel, who have increased the risk of infection by coming into close contact with patients for rapid screening or treatment. At the same time, we have been paying attention to the news and found that in recent years, there have been many cases of firefighters dying in the line of duty, as well as injuries or accidental deaths caused by police officers while performing arrests and other duties, which shows that in emergency work environments, the risk of injury or accidents cannot be ignored. Therefore, we began to explore how to reduce direct contact and use technology to improve work safety and efficiency.

2. Creative Description

This system aims to achieve precise remote control of robot movements through image recognition technology and wireless transmission technology. The user scans his hand movements through the camera, and the system calculates the finger joint angles in real time and transmits the data wirelessly toArduinoWe believe that this technology can be widely used in medical, high-risk environments, industrial automation, etc. It can improve work quality and work environment by remotely operating through image recognition.

3. System Function Introduction

The functions of this system can be divided into four categories: user interface, image recognition real-time data processing, remote control and robot synchronization. The system flow is shown in Figure 1.

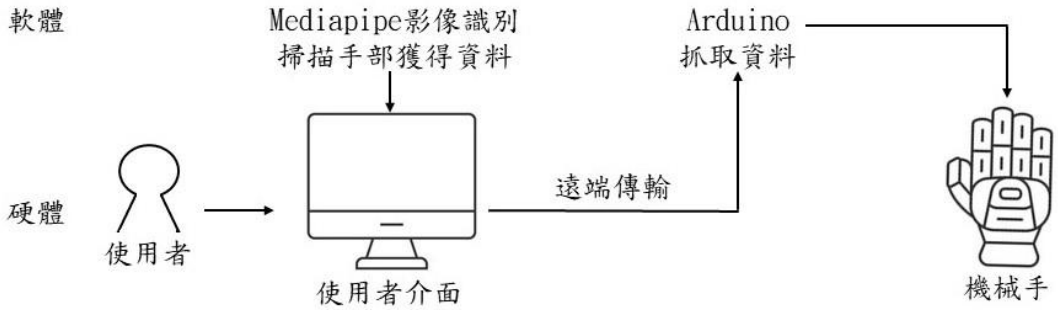

Figure 1. System flow chart

The following is a detailed description of each function.

- User interface: Users can operate through the interface and scan their hands through the camera. When not in use, the user can cancel the operation through the interface button, as shown in Figure 2.

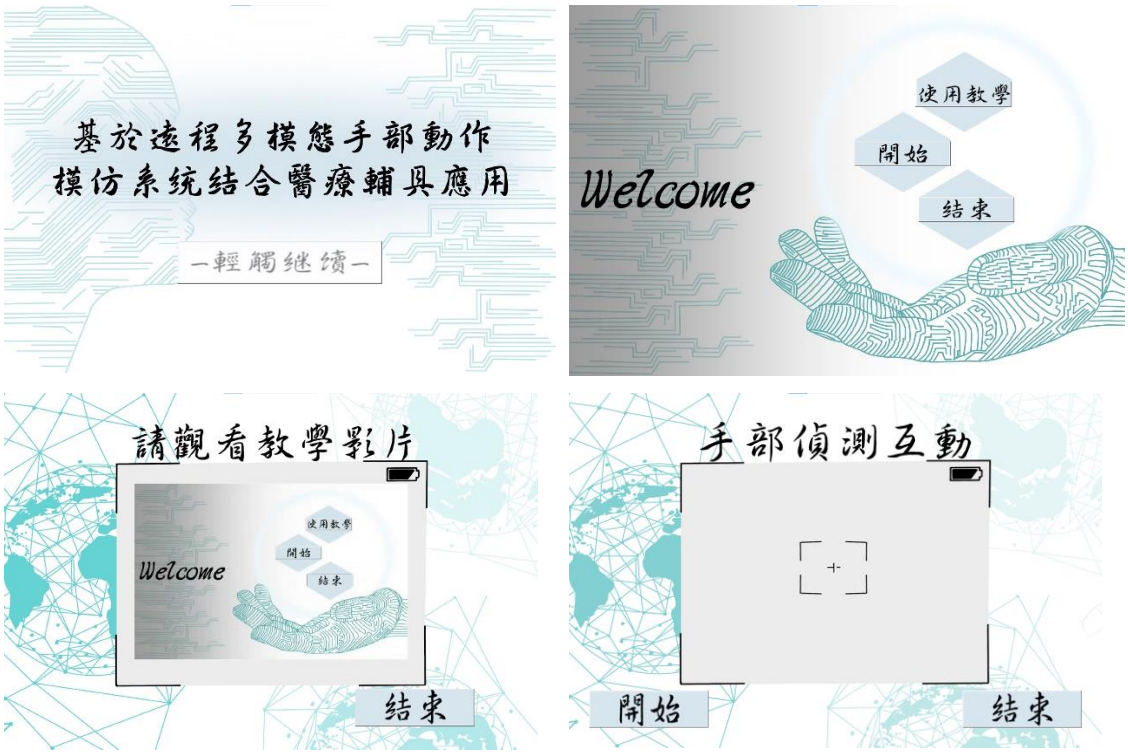

Figure 2: User Interface

- Image recognition real-time data processing: The images generated by the scan are processed by the system MediapipeImage recognition analyzes the palm, identifies the points at the finger joints and connects the two points into a line, calculates the joint angles and generates data, as shown in Figure 3.

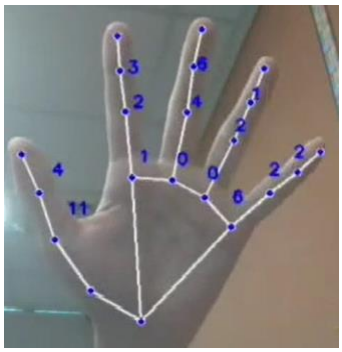

Figure 3MediapipeImage recognition (the numbers in the figure are the bending angles)

- Remote control: Utilizing data generated by image recognitionWi-FiBy performing wireless remote transmission, users can perform contactless operations regardless of the distance, as shown in Figure 4.

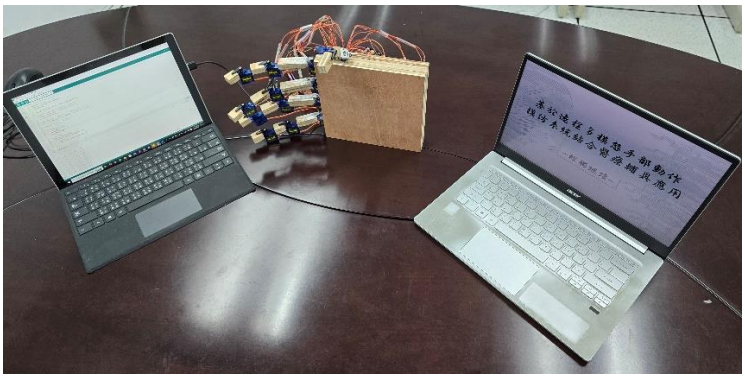

Figure 4: Remote control example (right isMediapipe, leftArduinoConnector Chip)

- Robot synchronization: The received data is used to control the robot so that it can accurately imitate the user's hand and synchronize its movements, as shown in Figure 5.

Figure 5. Robot synchronization example

In general, the system covers four core functions: user interface, image recognition real-time data processing, remote control and robot synchronization. Users can scan their hands through the interface, and the system uses MediapipeIt performs image recognition, calculates joint angles, and transmits data wirelessly to a remote location, controlling the robot to synchronize the user's hand movements. This system enables contactless remote control, perfectly combining image processing technology with mechanical movements.

4. System Features

The feature of this system is that the data generated by image recognition is transmitted to the remote end through wireless transmission. The user can ignore the distance limit and can control the robot by simply showing the action in front of the camera. Remote operation can reduce the risk of infection and injury to the operator and improve work safety. Wireless transmission brings real-time performance to this system. The system has low latency and can reflect hand movements to the robot in real time. Therefore, this system can accurately synchronize the user's hand movements. Through hand movement capture technology, image analysis can calculate the bending angle of each finger joint in a very short time, achieving accuracy. Coupled with the low latency of the system, it ensures that the robot can accurately imitate the user's hand movements.

5. System Development Tools and Technologies

This system can be divided into three parts according to the development tools: software, hardware, and communication.

- Software:Mediapipe,Arduino IDE Hardware:ArduinoChip,
- hardware equipment, robot communication:Wi-FiWireless
- network transmission

We choosePythonAs a development language for image recognition technology,PythonThe flexibility of the platform allows us to quickly develop and program computations.MediapipeThe suite analyzes image data. MediapipeAs a powerful image recognition framework, it can help us process the image data of hand movements in real time. This system uses the hand tracking module to accurately obtain the finger joint angles and store the angles in an array for encryption and simplified processing. The encrypted data is then sent to the socketTransfer toArduino, simplifying the data transmission and processing process.

existArduino IDEIn this tutorial, we write a program to control the robot.ArduinoAs the control core, it is responsible for receivingMediapipe's data and decrypt the encrypted data.

The decrypted angle data is then output to the motor to accurately control the robot's movements. This reduces the burden on the hardware to process complex data and also makes it easier for developers to quickly locate and solve problems by simplifying data during the inspection process.

To achieve contactless remote operation, we useWi-FiWireless transmission technology to ensure that data can be transmitted stably and quickly toArduinoPlatform, this system usesTCP During the data transmission process, the image recognition system transmits the joint angle data to theArduino, ensuring that the robot can complete action instructions accurately and in a timely manner.

In terms of hardware selection, we chose to useArduino Uno R4 wifiAs the main chip development, the chip has built-inWi-Fimodule, which facilitates wireless data transmission.Arduino PWM servo shieldAdd a motor connection socket and use a wire to connect the motor and the control board.SG90Servo metal motors are used to drive the joints, and wood is used as the structural material for the palm and knuckles, as shown in the table below.

	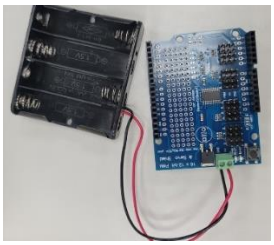
Arduino Uno R4 wifi	Arduino PWM servo shield
	
SG90Servo Metal Motor	Robot design

Table 1. Hardware equipment

6. Target users of the system

The users of this system can cover many fields, especially when precise remote operation or avoiding direct contact with dangerous environments is required. For example, in the medical field, medical staff can use this system to perform medical auxiliary operations without direct contact with patients, especially when dealing with infectious diseases, which can effectively reduce the risk of infection. In addition, emergency personnel such as police and firefighters can also use this system to perform high-risk tasks without having to enter dangerous scenes in person, thereby ensuring their own safety. At the same time, this system is also suitable for scientific researchers, especially when remote experimental operations or high-precision research are required, which can improve experimental efficiency and safety. Engineering and technical personnel in the field of industrial automation can also use this system to operate to ensure efficiency and safety in dangerous working environments.

7. System Usage Environment

This system is suitable for a variety of environments with remote operation requirements. Medical environments are important application scenarios for this system, especially medical institutions that require contactless diagnosis or operation, such as infectious disease prevention and control centers, isolation wards, etc. In these environments, the system can effectively reduce the risk of cross-infection and improve the accuracy of operations. Secondly, the system also has important applications in high-risk application scenarios, such as police enforcement, firefighter rescue, or handling chemical leaks. These environments are usually full of uncertainties, and the system's remote control function can reduce personnel's direct exposure to danger and ensure the mission is carried out. In addition, industrial environments and scientific research teaching environments are also potential application environments for this system. It is required to handle high temperature, high pressure or toxic substances in laboratories or simulate the teaching needs of experimental processes, and can realize scientific research operations and efficient learning outside the laboratory.

8. Conclusion

This system successfully combines image recognition, wireless transmission and robot simulation technology to achieve innovative applications of remote hand manipulation simulation. Through the system, users can accurately simulate and control robots in a remote environment. The system has the characteristics of low latency and high precision, which can improve the safety and efficiency of operations in different fields. Whether in the fields of medical care, emergency rescue, industrial automation or scientific research and teaching, this system can effectively reduce contact risks. We believe that this system can play an important role in various fields in the future and bring substantial help and changes to users.