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Digital Analysis and Application of Operator's Action Based on Inertia Motion Capture

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ABSTRACT: The incorrect working posture of equipment operators is one of the important reasons leading to the work musculoskeletal disease WMSDs. It is very important to evaluate the posture load because the experimenter of testing machine or the operator of large equipment will keep a certain wrong posture for a long time, which will lead to low back pain and back pain. However, the traditional posture load assessment method has some problems, such as difficult data acquisition and complicated scoring process. In order to solve this problem, this paper uses lightweight inertial motion capture system to collect real-time human posture data, and quantitatively describes the rationality of human operation behavior with posture load evaluation model, and finally builds a digital analysis platform for visual display. In this paper, firstly, the layout of sensors is designed, and a set of motion capture system embedded with wearable sensors is developed to obtain the human body data of operators. Secondly, according to the real scene, 3ds Max is used to build digital mannequins and other objects, and integrate them into a system. Finally, Unity3D is used to design a visual digital analysis platform to display human data information for load assessment, and the parameters of the model can be changed independently through the controllable components of Unity3D to achieve the purpose of human-computer interaction.
KEYWORDS: Posture load assessment; Motion capture; Inertial sensor.

I. INTRODUCTION

WMSDs is a chronic and gradually accumulated disease caused by many factors, mainly manifested in the injury and dysfunction of muscles, bones and nervous system[1]. It is a common health problem of occupational population, especially in labor-intensive industries, such as manufacturing, construction and agriculture. In developed countries, WMSDs is the main cause of operators' absence from work due to illness and the decline of working ability, which brings serious economic burden to society and individuals and reduces the quality of life[2]. In the factory and other operating situation, incorrect working posture is one of the most important reasons for the operators to suffer from WMSDs. Keeping the wrong working posture for a long time will not only affect the work efficiency of operators, but also cause back pain and back pain after long-term accumulation[3][4]. Although there are some standardized work instructions, operators often can't immediately find out whether their posture is correct, and working in the wrong posture will inevitably cause diseases[5]. Recently, with the rise of motion capture and somatosensory technology, human-computer interaction is paid more attention, and the technology is becoming more and more mature. It can not only capture human data in real-time, but also display it digitally[6][7]. Therefore, this paper intends to design a visual posture load assessment system by combining digital twin technology and motion capture, so as to help operators find problems in their working posture and reduce the risk of illness.

The concept of digital twin was first put forward by Michael Grieves, which can be understood as creating a digital version of the "clone" for the complex system studied, and reproducing the actual situation of real objects on the digital body[8]. The development of digital twin of human body provides an excellent platform. Multi-scene virtual human construction and efficient human-computer interaction can not only be applied to various commercial and strategic scenes, but also provide a good technical platform for scientific research[9-11]. This paper intends to use the human digital twin technology to analyze the captured human digital method, and observe and change the parameters in real time through the software platform to achieve the result of human-computer interaction.

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Human motion capture refers to the use of motion capture system to measure the data of key parts of the human body, and transmit the data to the computer, and then get the three-dimensional coordinate data of the human body after processing. When the data is recognized by the computer, it can be processed to reproduce the human motion[12]. Commonly used motion capture technologies mainly include optical and inertial motion capture devices. Devices with different principles have their own advantages and disadvantages[13]. Inertial motion capture is measured by geomagnetic field and gravity. Compared with the optical type, the inertial dynamic capture does not require high working environment and is not disturbed by obstacles. At present, the application of inertial motion capture system in operator posture load evaluation has the following shortcomings: (1) High cost. Although the equipment is simple to operate, convenient to wear and high in transmission accuracy, the price of the equipment is high; (2) The secondary development is difficult. Many devices are encrypted when they are manufactured. Although some products are open source, it is difficult to find the source code, and some key data collection processes are difficult for individuals to reproduce; (3) The sensors are large in number and volume, which is troublesome to wear and may interfere with people's normal activities. Therefore, low-cost, high-precision, lightweight inertial motion equipment is in great demand in scientific research and market. Reducing the volume, the number of sensors, and rationally designing various components are the key to designing motion capture equipment at present, and will also be the research direction of this paper[14-16].

This paper is divided into four parts. The first part introduces the research background and chapter arrangement of this paper.

In the second part, firstly, the software and hardware of the motion capture system are developed, and the hardware facilities of the inertial motion capture system are selected. The IMU sensor of the whole body is connected with the ESP32 development board by using flexible printed circuit board (FPC), and the multi-channel human joint posture data is summarized by programming, and finally sent to the upper computer through WIFI. The communication between the PC software and the client program is realized, and the data is reprocessed, so as to obtain usable data. Secondly, the experimental scene is selected and a digital model based on 3ds Max and Unity3D is established to complete the real-time presentation of the operator's actions, and a digital analysis platform is designed to judge the operator's posture load according to its real-time data.

In the third part, the experimental flow of the software and hardware design of inertial motion capture system is introduced, including the hardware and software selected in the experiment, and the results of using this software to capture motion data. According to the contrast test, the reliability and efficiency of the designed inertial motion capture system are judged.

The fourth part summarizes the main research contents and results of this paper, and points out the shortcomings of this paper.

II. METHODOLOGY

2.1 Software and hardware development of inertial motion capture system

To achieve accurate and real-time human motion reproduction requires an efficient motion capture system. In order to achieve this goal, it is necessary to design a hardware system with low cost and high performance and a software system with high real-time and accuracy. This chapter will start from the hardware design and software development of the motion capture system, in order to create a low-cost, high-real-time motion capture system suite. The overall design framework is shown in Figure 1.

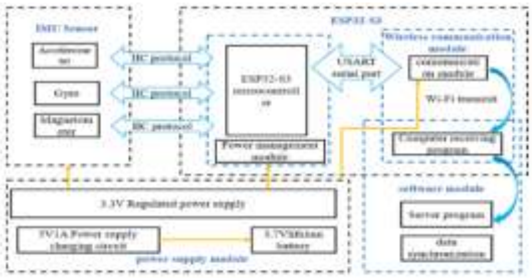

Figure1 Overall Design Framework of Inertial Dynamic Capture System

The hardware design of wearable inertial motion capture device includes three parts: data acquisition, data aggregation and data transmission. In order to realize these functions, the required components include: data acquisition unit, nine-axis inertial measurement unit (IMU), which is composed of accelerometer, gyroscope and magnetometer, and can collect acceleration, angular velocity and magnetic flux data of human bones. Data aggregation unit microcontroller ESP32. Integrated control module The battery management module and the Wi-Fi module can receive instructions from the PC to control the sending and receiving of sensor data, and send the data back to the PC through Wi-Fi. The software part includes how the PC terminal receives the data sent by the sensor, how to synchronize the sensor data and how to realize real-time reproduction of human movements through these data.

2.1.1 Hardware development

① IMU sensor

The hardware and electrical components required for inertial motion capture system include IMU sensor, ESP32-S2 single-chip controller and rechargeable battery.

The IMU data acquisition unit is an IMU product of Victor, which can acquire 3-axis acceleration, 3-axis angular velocity and 3-axis magnetic field. The product model is WT901CM, as shown in Figure 2. This product is characterized by high data transmission speed and high data transmission accuracy, and the data update rate of a single sensor can reach 200HZ. At the same time, because it adopts the high dynamic Kalman filter fusion algorithm, the transmitted data has the advantages of high accuracy, high dynamic and real-time compensation. In addition, due to the use of MEMS microelectronics technology, the size of the sensor is only 20 × 20 ×8.2mm, and the volume is very small.

Figure 2 WT901CM dimension drawing

② ESP32 single chip microcomputer

ESP32 is a series of low-cost, low-power microcontroller, and includes Wi-Fi and Bluetooth modules. The ESP32-S3 series used in this paper can support various peripheral interfaces such as IIC, SPI, IIS, etc., and has a large storage space, which can satisfy the simultaneous data transmission of multiple sensors.

Figure 3 ESP32 Physical Diagram

On the controller side, ESP32 is equipped with Xtensa32-bit LX7 dual-core processor, with a main frequency of up to 240 HZ, which can efficiently process multiple data at the same time. ESP32 communicates with the sensor through IIC protocol, and only one FPC cable is needed to control the sensor and receive data. When the ESP32 receives the command from the PC, it will send the command to the sensor and wait for the data to be sent back, and then send it back to the PC. If the PC is disconnected, it will stop sending instructions.

In this paper, IIC protocol is used to realize the data transmission between IMU sensor and data aggregation unit ESP32-S3 to ensure the timing and integrity of data.

2.1.2 Software development

① Sensor data acquisition

In this paper, ESP32 development board is used to collect the data of each sensor through IIC bus protocol. The information needed for IIC bus to collect data is sensor address and sensor register address. The data acquisition program consists of data acquisition and processing programs for sensors, TCP client sending programs and IIC data acquisition programs. When the main function starts running, the IP address and port number of the server will be bound first to connect with the host server. Then there are some settings for IIC data collection, including sensor address, sensor register address, etc. Finally, the while loop is used to read the acceleration data and angular velocity data of IMU sensor continuously, and the collected data is sent to the host server through TCP. The specific flow chart is as follows:

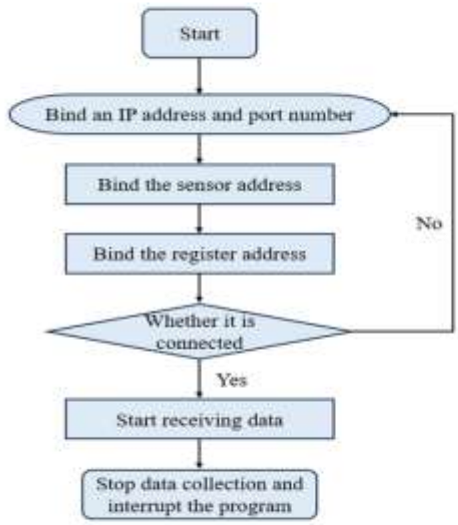

Figure 4 Flow chart of data acquisition at computer terminal

② Design of network server based on Socket class

The original data directly received by PC is unprocessed, the number of data in each frame is uncertain, and the data of each port is transmitted independently, and the data is not synchronized, so it can not be used directly, which requires subsequent processing of the data. In order to achieve our goal, we need to establish a server to receive and process the original data sent from the upper computer and transmit data between PC terminals. Socket is a way of data transmission on the computer side. It is an interface for controlling data transmission, and creates a channel for transmitting data through network connection.

When creating a network connection, you need to choose the appropriate transport protocol first. The most common are TCP transmission control and UDP user datagram protocol. Compared with UDP protocol, TCP has slower transmission and reading speed, but it is better in controllability, especially when data is lost. When data loss occurs, TCP has a self-checking and recovery mechanism, which can recover the correct transmission within a reasonable time range and avoid the loss of a collected frame of data. After comprehensive consideration, this paper chooses TCP transmission protocol to ensure the integrity and fluency of the predicted human movements.

Socket is a programming interface that encapsulates TCP/IP. As an interface between application layer programs and network protocol stack, it allows applications to interact with network protocols. After the computer is connected to the network, it can distinguish different computers and different programs of the same computer through IP+ port. Socket is the entrance of the program. Figure 5 shows the basic flow of communication between server and client through Socket.

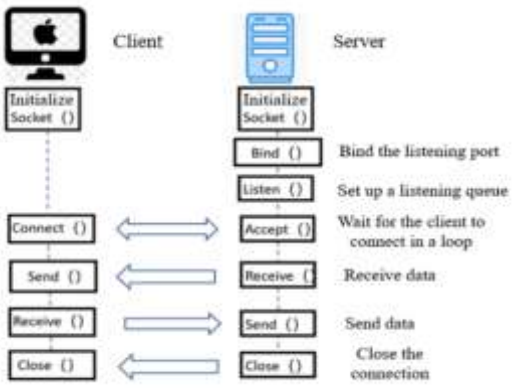

Figure 5 Basic communication flow between server and client.

In Socket programming, multithreading is usually used to handle the connection requests of multiple clients. That is to say, whenever a new client initiates a connection request, a new thread needs to be created for data communication with the client. The consequence of this is that when there are too many client nodes, a large number of threads will be created or destroyed, which will occupy the resources and time of the operating system, bring a great burden to the operating system, and increase the processing time of the CPU, thus greatly reducing the performance and response speed of the client application. At the same time, the delay and congestion between asynchronous threads will also cause synchronization and management problems of multi-client nodes. It can be seen that the simple Socket model can not meet the requirements of sensor data synchronization and high efficiency. It is very important to design a high-performance server application to reduce the scheduling of threads and ensure the synchronization and stability of each node.

③ Design of high-performance network server

The high-performance server in this paper is based on the SocketAsyncEventArgs class, which is an important class for asynchronous Socket programming provided by the. NET Framework. It encapsulates the parameters and events related to Socket operation, so that asynchronous operation can be managed and handled more efficiently in asynchronous network communication. By using this class, the following advantages can be achieved: reducing the frequent creation of connection objects, reducing memory fragmentation and improving the stability and reliability of the system; Thread pool and other mechanisms can be used to realize the concurrent processing of asynchronous Socket operations, thus improving the concurrent performance of the server; Simplify asynchronous programming model: SocketAsyncEventArgs class provides a simple and intuitive programming model, which handles asynchronous Socket operations in an event-driven way, making the code more readable and easy to maintain. Therefore, this paper designs a high-performance server application based on the SocketAsyncEventArgs class, and the specific communication flow is as follows:

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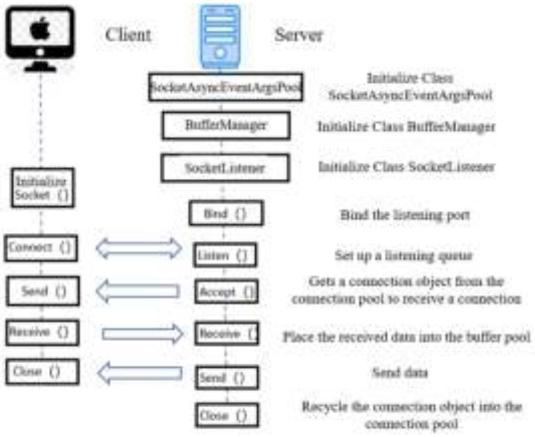

Figure 6 Network Communication Process Design Based on SocketAsyncEventArgs Class

Based on the above communication mode, data is obtained from each node through asynchronous threads, which are independent of each other. However, human motion recognition needs the data of all nodes at the same time, so it is necessary to complete the conversion of data from asynchronous to synchronous.

The strategy of realizing multi-node synchronization in this paper is as follows: First, a linear queue is created for each node, which follows the principle of first-in first-out (FIFO), that is, the data put in the queue first is taken out first. Then, an asynchronous thread is created, which is responsible for reading message data from the buffer pool and putting it into the corresponding queue according to the source node of the data. Next, create an asynchronous thread, which is responsible for looping through all queues and checking whether they all have data. If all queues are not empty, then take out an inertial data from each queue and splice the data from different nodes into a frame of data according to certain rules. Finally, add the generated frame of data to the data list. In this way, the synchronization of multi-node data is realized.

2.2 Workspace Digital Twin Modeling of Human-computer Interaction Scenes

After the operator's data is obtained by inertial motion capture system, it needs to be imported into the computer to digitally reproduce the human body. Before that, we should choose the posture load evaluation method to determine the required human body data. Posture load evaluation refers to the process of evaluating the load borne by human body in a specific posture. Its purpose is to evaluate whether the load borne by human body in work, sports, life and other activities is reasonable, so as to avoid the injury and fatigue caused by posture. There are four commonly used posture load assessment models, namely RULA model, OWAS model, NIOSH model and REBA model. The four posture load assessment methods all have their own advantages and disadvantages and applicable scenarios, and should be selected reasonably according to the real situation when using them. The following are the evaluation processes and evaluation criteria of the four methods.

2.2.1 Decomposition of operator posture and action

In order to evaluate the operator's posture load, it is necessary to first decompose the actions in the operation process into several key actions, then score each key action, and finally get a comprehensive score. Action disassembly refers to the decomposition of actions in the operation process into several key actions for evaluation and analysis. The steps of action disassembly mainly include the following aspects: first, carefully observe the whole operation process, understand the purpose, content and requirements of the operation, grasp the key points and difficulties of the operation, roughly describe the flow and characteristics of the whole operation process, and decompose it into several key actions according to the amplitude, speed, direction and stress of the action; Secondly, these key actions are recorded in sequence and described in the evaluation form, including the name, start time, end time, duration, angle, intensity and other information of the actions; Finally, compare the disassembly results with the actual actions, check whether there are any mistakes or omissions, and modify or delete unreasonable or unnecessary actions. Action decomposition is the premise of posture load evaluation, and reasonable action decomposition can make us have a deeper understanding of actions and divide key actions.

2.2.2 Establish the handling scene.

Based on the existing experimental conditions, it is planned to establish a scene of material handling in the process of car assembly in chapter 4, as shown in the figure. The handling process is as follows: first, take out the box containing the car parts from the shelf and put it on the shelf of the workbench. Because the shelf has three floors and different heights, there may be actions such as bending over or tiptoeing in the process of taking materials. However, the shelf is close to the workbench (less than 1m), so the footsteps move less; Then take one out of the box at the beginning of assembly.

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Figure 7 Experimental Scene Diagram

This paper analyzes the scene in the process of car assembly, and mainly studies the load influence of human arms and waist. Because of the small activity space, the movements of legs are less and single. For this scene, NIOSH lifting formula is rough, ignoring the influence of human joint and bone angle, and OWAS has too much analysis of legs, and the scoring focus is inconsistent. Compared with RULA, REBA scores faster and scores upper limbs more accurately. Therefore, considering comprehensively, this paper chooses to ignore the influence of leg joint angle and choose the RULA rapid human upper limb scoring method with stronger pertinence and fastest scoring speed.

2.2.3 Digital Modeling of Workspace

With the real scene, this paper is going to establish a digital analysis platform based on Unity3D, which can directly and real-timely display the data of the operator in the trolley handling scene, and can analyze the posture load according to the data.

Virtual scene modeling of trolley assembly line includes human modeling and object modeling. Object modeling mainly includes material, workbench and shelf modeling. The modeling steps of the virtual assembly line are mainly four steps: measurement → 3D solid modeling → integration → rendering. The measuring tools are more traditional. The two measuring tools, tape measure and vernier caliper, are mainly selected. After recording the measured data on a paper table, the model is built according to the size. The tool of 3D solid modeling and integrated selection is 3ds Max. The reason for choosing this tool is that the max file type saved by this software can be directly imported into Unity3D. As shown in Figure 8 and Figure 9, the interface between the shelf and the workbench is established respectively. The manikin is the existing Unity3D model package and model found through the browser, as shown in Figure 10.

After importing these models into Unity3D, rendering makes them closer to the real scene, and the final virtual scene is shown in Figure 11.

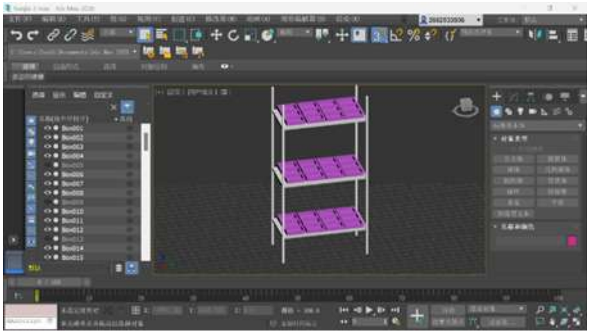

Figure 8 3ds Max Establishing Shelf Interface

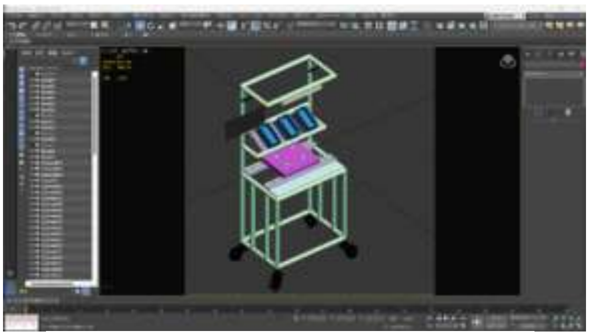

Figure 9 3ds Max Establishing Workbench Interface

Figure 10 Unity3D mannequin

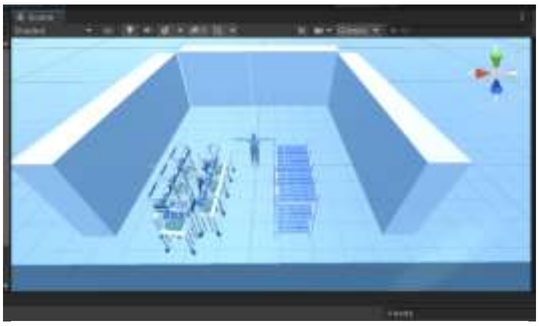

Figure 11 Unity3D car assembly virtual scene

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2.2.4 Design of Digital Twin Analysis Platform

After the design of the work space is completed, in order to obtain the information such as attitude angle and load score directly, it is necessary to insert an information visualization chart and associate it with the human body. At the same time, in order to realize human-computer interaction, control elements such as buttons and sliders are added. In this way, not only experts can give suggestions for improvement according to the operators' action scores, but also virtual experiments can be realized. Through experiments, it is verified whether the parameters of the workbench, shelves and so on are unreasonable, and reasonable parameters that can improve the operators' posture load can be obtained. The interface of digital visualization platform is shown in Figure 12.

Figure 12 Digital Twin Platform Based on Unity3D

III. CASE STUDY

3.1 Design of experimental software and hardware and introduction of overall process.

The purpose of this experiment is to verify the feasibility of high-performance server based on SocketAsyncEventArgs. The inertial measurement unit module used in this experiment includes Vitter's 901Wi-Fi finished equipment, Vitter's IMU data acquisition unit WT901CM and data aggregation unit ESP32. Software modules include witmotion-Udp(V3.0.12), Thonny development environment, Visual Studio2022 and netassist. The hardware part is mainly used to collect data and send data to the server, among which 901Wi-Fi of Weite is a purchased inertial motion capture product, and its transmission rate can only reach 10HZ when using TCP protocol, which is slow but stable, and is mainly used to test server programs. The remaining two parts are integrated into a set of equipment designed independently, and the specific functions and composition have been introduced in the second part. The software part is used to receive and process data. Witmotion-Udp(V3.0.12) is an upper computer program which is matched with Wit's 901Wi-Fi product, and is used to receive data and send it to the server application.

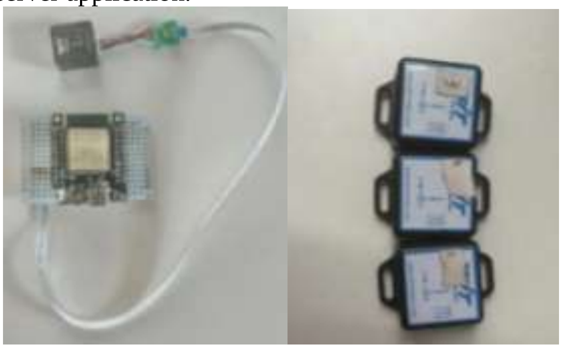

Figure 13 Hardware Physical Diagram

Figure 14 Thonny Software Interface

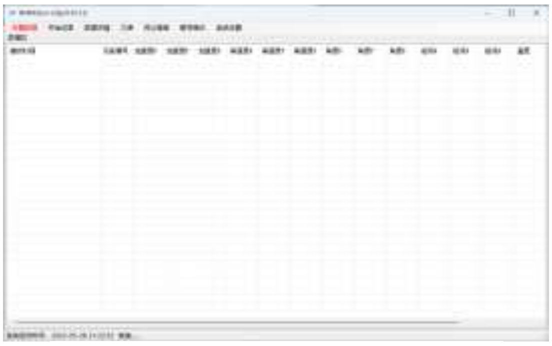

Figure 15 Witter PC Software Interface

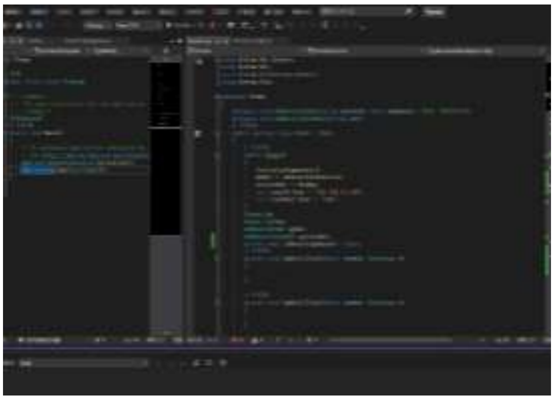

Figure 16 Visual Studio2022 Software Interface

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Figure 17 Netassist Software Interface

The flow of this experiment is as follows: (1) Visual Studio2022 is used to write the server program of a single sensor based on Socket and SocketAsyncEventArgs, and the experimental equipment chooses 901Wi-Fi of Vitter to realize stable data transmission. (2) Visual Studio2022 is used to write server programs based on Socket and SocketAsyncEventArgs for multiple sensors, and a comparative experiment is made. The experimental equipment chooses 901 Wi-Fi of Witt to verify the high concurrency of high-performance server programs based on SocketAsyncEventArgs. (3) The self-designed measuring unit consisting of WT901CM and ESP32 is verified by the server program of SocketAsyncEventArgs. (4) After successful verification, write the server application window to facilitate data collection and visualization.

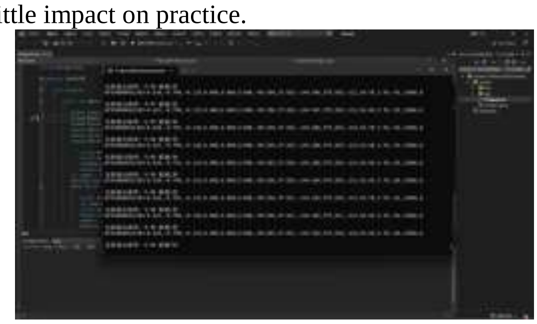
3.2 based on WT901Wi-Fi but single sensor communication programming

When using WT901Wi-Fi to communicate, it is necessary to use WitMotion-Udp host computer (PC software for short) to complete the network distribution work, that is, bind the sensor with IP address and port number. As shown in figure 18. First, connect the IMU with the host computer, then open the upper computer software, select the corresponding communication serial port, select the TCP protocol, and set the IP address and port number. The port number can be selected by yourself. After success, the bound IP and port number will be displayed, as shown in Figure 19.

Figure18 Interface for Binding IP and Port Number

Figure 19 Interface after successful distribution network

After the distribution network is successful, the server program based on Socket and SocketAsyncEventArgs is written according to the communication flow between the client and the server. As shown in Figure 20 and Figure 21. After a period of operation, the data output frequency based on Socket is basically stable at around 9.98HZ. The data output frequency based on SocketAsyncEventArgs class is basically stable at around 9.64HZ. Both of them are basically stable around 10HZ and can receive data smoothly. However, the lower program rate based on SocketAsyncEventArgs may be caused by more program methods and classes, and the loss rate of received data rate is not higher than 4%, which has little impact on practice.



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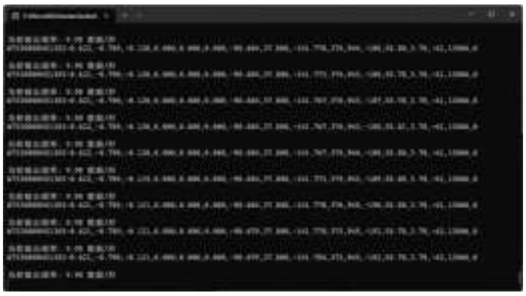

Figure 20 Interface for Receiving Data Based on Simple Socket Program

Figure 21 Interface for Receiving Data Based on High Performance SocketAsyncEventArgs Program

To sum up, the above experiments prove the reliability of receiving single sensor data based on Socket and SocketAsyncEventArgs program. Next, you will write a program to receive multiple sensors to verify their performance.

3.3 Programming of Multi-sensor Communication Based on WT901Wi-Fi

When using multiple sensors, it is necessary to distribute the network for each sensor and set different port numbers, and then use asynchronous threads to run data receiving and outputting programs of different ports on the basis of a single sensor, so as to ensure the orderly output of data. In order to facilitate the experiment, we use two sensors to carry out the experiment.

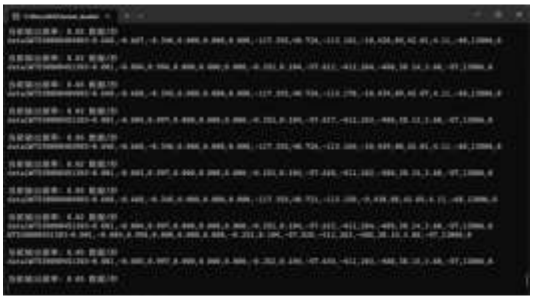

Figure 22 Data output interface of simple receiver

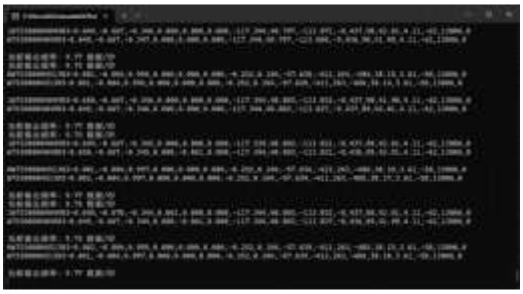

Figure 23 Output interface of high-performance receiver

It can be seen that when two sensors are used, the output rate of the program based on simple Socket drops to about 8HZ, while the sampling rate of the high-performance server program based on SocketAsyncEventArgs is stable at about 9.77HZ. This phenomenon may be caused by temperature and sensor hardware itself. However, it can be seen that the performance of the Socket program established by using the SocketAsyncEventArgs class is obviously better than that of the simple Socket program when collecting multiple sensors.

3.4 High-performance server programming based on WT901CM

After verifying the feasibility of the high-performance server based on SocketAsyncEventArgs class, we intend to use the self-designed integrated device to verify its data concurrency performance at high speed.

First of all, we can receive the data from the sensor to the PC through Thonny software, and send it to other server applications through the port. We make a virtual server through netassist to observe the effect of data transmission. As shown in the figure, Thonny software receives data from data sensors and sends it to the code interface of the server. Figure 24 establishes the interface for netassist to receive data on the virtual server.

Figure 24 Netaassist Receiving Data

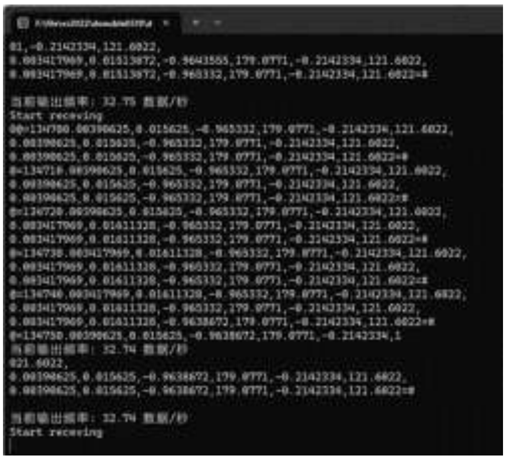

Figure 25 Receiving 120HZ Data Output Interface

The client program written by Thonny can successfully receive the sensor data and send it to the server of the specified port. The frequency reaches 120HZ. The high-performance server application based on SocketAsyncEventArgs class is shown in Figure 25. It can be seen that the rate of receiving and outputting data in real time is stable at about 32.75 frames/second, ranging from 1 to 5 data per frame. Although the number of data in each frame is uncertain, it can ensure the stable output rate of each frame. Therefore, we will focus on the stability of the number of data outputs in the future.

From this, we can draw the experimental conclusion:

(1) Reliable data acquisition can be achieved even with low-cost hardware equipment.

(2) The high-performance data acquisition system based on wireless somatosensory sensor network (WBSN) realized in this paper has good performance in practical application scenarios, and provides the network function of real-time communication.

(3) The server-side application of SocketAsyncEventArgs has strong scalability, and the data acquisition is stable when the number of wearable inertial sensors or the transmission rate of nodes increases.

(4) The server-side application of SocketAsyncEventArgs class has excellent performance, no stress in high concurrent application scenarios and stable node connection.

(5) The server-side application of 5) SocketAsyncEventArgs has strong scalability, and the data acquisition is stable when the number of wearable inertial sensors or the transmission rate of nodes increases.

After getting the feasibility conclusion of high-performance server program based on SocketAsyncEventArgs, in order to better show the real-time data acquisition process, this paper designs a window program, which can display the collected data value, number and time in real time, and control the start and end time. The window program interface is shown in Figure 26.

Figure 26 High Performance Server Program Window Interface Based on Socket Async Event Args

IV. CONCLUSION

With the proposal of "Made in China 2025", the scale of China's manufacturing industry is constantly expanding, and there are more and more manufacturing operators, which has become a manufacturing power. At the same time, however, the safety and health problems of operators have also been exposed, among which the work musculoskeletal disease WMSDs is the most important one. Incorrect working posture is one of the main causes of WMSDs. Objective that research on posture load assessment at home and abroad is mostly in the form of questionnaire, which has a long sampling period and is easy to hurt operators. In order to help operators evaluate posture load conveniently and quickly without damaging them. In this paper, an inertial motion capture system is designed to collect the original data of operators, and a digital analysis platform for operators is built. This paper mainly studies:

(1) Motion capture and digital twinning are combined to evaluate human posture load. Firstly, the composition and motion characteristics of human skeleton joints are introduced. Secondly, how to identify the posture angles of human bones through the data collected by sensors is explained, so as to reproduce human movements. It solves the problems of difficulty in obtaining original data and complicated evaluation process.

(2) Hardware design of lightweight inertial capture package. Including the selection of hardware facilities and connecting them together to realize the stable output of data. Firstly, IMU sensor with high transmission rate and small volume is selected. Secondly, ESP32 is selected as the development board of single chip microcomputer. Then, the hardware connection and communication mode between them are determined. Finally, how to transfer data from hardware to PC through Wi-Fi. The motion capture device has the characteristics of small volume, high speed and low delay.

(3) Write a high-performance server program based on SocketAsyncEventArgs class. Through comparative experiments, the transmission rate of high-performance server under single sensor and multiple sensors is verified, and its transmission performance can still be guaranteed under the high-speed of multiple sensors. At the same time, a window program is designed to drive the server program to receive and display data, which improves the convenience.

This paper only makes a preliminary study on inertial capture equipment, and there are still many unsolved problems, which will be carried out in the following aspects in the future:

(1) Repeated debugging and experimental records are made for the program, so as to improve the server application and make it a stable, efficient and multifunctional application.

(2) Improve the digital analysis platform. At present, the platform can display human body data, but it can't change human body size, action angle and so on.

(3) Optimize the hardware facilities. At present, the designed and integrated motion capture device is not stable enough for data transmission, and its stability and transmission rate need to be further improved.

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