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Design and implementation of multi-functional portable massager for office workers

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Abstract: *With the acceleration of the pace of modern social work, office workers generally face muscle tension and fatigue in the neck, shoulders, waist, back and other parts caused by maintaining a fixed posture for a long time (such as using a computer or sitting for a long time), which seriously affects their work efficiency and quality of life. However, traditional massage devices on the market often have shortcomings such as large size, single function, and limited usage scenarios, which cannot meet the immediate relief needs of office workers in fragmented scenarios such as offices and business trips. In order to solve the above problems, this study aims to develop a smart massager designed for office workers that integrates portability and versatility which effectively solves the problem that office workers cannot deeply relax and relieve fatigue in fragmented time through [4], modular design such as scissor structure and detachable massage head [2].*

Keywords: *office workers; Portable; Multifunctional massager; Smart app control*

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I. Introduction

In modern urban life and workplace environment, the continuous acceleration of the pace of work has made "sedentary office" and "long time at the desk" a daily state of office workers. According to statistics, more than 70% of the domestic working population maintains a fixed posture for more than 8 hours a day, and the incidence of muscle fatigue problems such as neck and shoulder stiffness and back pain is increasing year by year, which not only reduces work concentration and efficiency, but also affects physical health and life happiness in the long term.

The massage equipment in the current market is mostly designed with home scenarios as the core, and there are limitations such as bulky size and single function - large massage chairs cannot be adapted to office workstations, and small massagers can only achieve partial surface relaxation, which is difficult to meet the immediate and deep soothing needs of office workers in fragmented scenarios such as office breaks, business trips, and commuting. This "mismatch between demand and supply" has given rise to an urgent need for a workplace massage tool that is both portable and versatile.

Based on this, this study focuses on the actual pain points of office workers and proposes a multifunctional portable massager design scheme that integrates lightweight portable structure, modular massage components, and intelligent APP control [7]. By optimizing the product form to adapt to the office scene, combined with switchable massage mode and Bluetooth intelligent control, it aims to provide a "ready-to-use, efficient and soothing" fatigue relief solution for the workplace, and at the same time explore the application path of smart portable devices in the field of office health, providing a practical reference for the innovative design of workplace health products.

II. The overall structure and working principle of the multifunctional portable massager

2.1 Overall design

The multi-functional portable massager designed in this paper is mainly composed of lifting components, detachable massage heads, rotatable massage sets, screw slide devices, and intelligent control modules, which cooperate with each other to complete the work of relieving muscle fatigue, and its overall three-dimensional structure is shown in Figure 2-1.

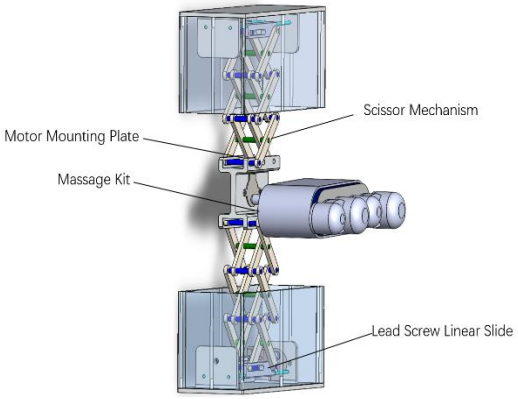

Figure 2-1 Overall three-dimensional structure

2.2 Working principle

The main functions of the multi-functional portable massager are massage set, multi-angle rotation, adjustable massage intensity, and lateral movement massage.

Before work, the lifting assembly is compressed, and the massage set is not yet assembled into the device. The steps for users to massage are as follows:

1): When the user needs to use the massager, stretch the upper shell and the lower shell longitudinally to the end, so that the lifting assembly is fully pulled open and then the massage set is installed.

2): When installing the massage set, first unscrew the lock handle, insert the massage set vertically into the port, and then tighten the handle to complete the installation.

3): Turn on the power and use the buttons on the belt to adjust the massage parameters; Or connect to Bluetooth, enter height and weight through the APP, the system algorithm generates the initial massage parameters, and the massage set and the massage head rotate at the same time to achieve multi-angle massage.

4): When the user feels that the massage head does not fit the body, the stepper pusher motor in the massage set can be started through the app, and the pusher motor can push out the massage head to make it more suitable for the user's body. [5]

5): At the same time, users can also start the screw module through the APP to make the lifting component and massage set move horizontally and reciprocatingly to expand the massage range.

6): After the massage, turn off the power, remove the massage set, and then compress the lifting assembly, just enough to close the upper and lower shells for easy storage.

III. Design and implementation of the main device of the multi-functional portable massager

3.1 Lifting assembly

The lifting assembly consists of a scissor mechanism, a motor fixing plate, and a stepper motor. The uppermost connecting rod is connected to the slide rail through a linear bearing connector, and the lowest connecting rod is connected to the linear bearing connector on the bearing. [3] The two pairs of connecting rods in the scissor mechanism are bolted to the motor fixing plate, and the stepper motor is installed behind the fixed plate. The scissor mechanism can realize height adjustment (height in the extended state 350 mm, compressed state height 150 mm) [1]. The stepper motor drives the massage set to rotate 360° around the central axis. As shown in Figure 3-1.

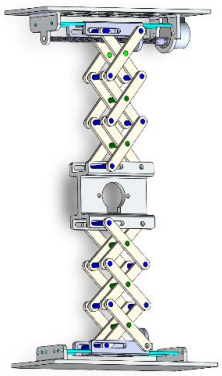

Figure 3-1 Lifting assembly

3.2 Detachable massage set

The massage set consists of 2 massage heads, 4 heating plates, two stepper motors, and a stepper actuator motor. The massage head is driven by a stepper motor. Stepper motor (connected to the push plate, the back side of the push plate is equipped with a stepper actuator motor, the stepper actuator motor drives the push plate to move forward and backward to adjust the massage intensity, the massage set displacement is 0-30mm.) The line between the massage set and the scissor mechanism is added with an easy-to-plug terminal block, which supports the convenient insertion and unplugging of the massage set, which is convenient for users to store and use. As shown in Figure 3-2, Figure 3-3

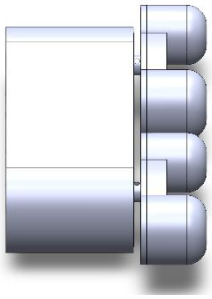

Figure 3-2 Massage set

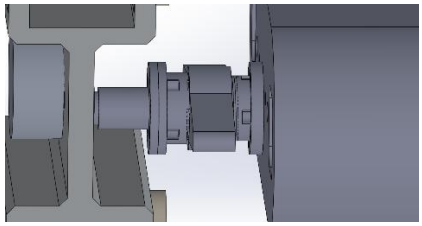

Fig.3-3 Pluggable mechanism

3.3 Screw slide device

It is composed of undertaking parts, screw screws, screw nuts, couplings, and stepper motors. The bearing is connected to the screw by a coupling, and the screw is connected to the stepper motor by a screw screw. Among them, the stepper motor (through the screw nut drives the wire to rotate, the screw rotates to drive the coupling to move left and right, and the coupling drives the scissor mechanism to move laterally, with a stroke of 50mm. As shown in Figure 3-4

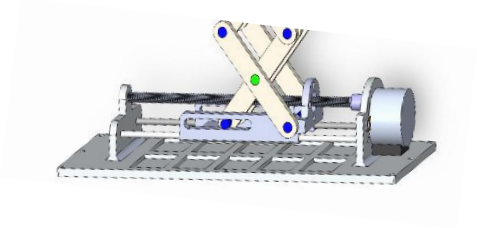

Figure 3-4 Screw slide device

3.4 Intelligent control device

The multi-functional portable massager designed in this paper is equipped with physical buttons and APP for control, and users can set functions according to different needs.

IV. Design and implementation of electronic control system

4.1 Software part design

The device uses the ESP32 development board as the main control unit, which is equipped with a high-performance 32-bit processor, which has the advantages of integrated Wi-Fi and Bluetooth dual-mode communication, multi-hardware timer, rich interfaces and support for multiple sleep modes, which can efficiently meet the needs of multi-motor collaborative control, wireless command transmission, real-time interrupt response and low power consumption. The development environment is Arduino-ESP32, and the core dependency libraries include Blinker library and esp32-hal-timer library, and the main program flowchart is shown in Figure 4-1.

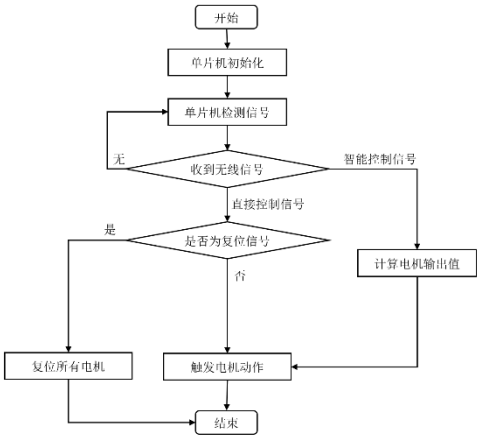

Figure 4-1 Flow chart of the main program

The device is controlled via the Blinker App on the mobile phone. The software adopts a Wi-Fi wireless communication architecture and builds a communication link between the mobile phone and the ESP32 based on the Blinker Internet of Things platform[7] to realize remote control of the mobile phone, and the signal transmission process is shown in Fig. 4-2 [8]. After powering on, the ESP32 connects to the LAN through a preset Wi-Fi account and password, installs the Blinker App on the mobile phone, and enters the corresponding key of the device to establish stable point-to-point communication [9]. Two control modes are provided in the Blinker App on the mobile phone: one is direct control, users can directly control the motor start-stop, speed, etc. in the App; The second is intelligent control, where users enter their height, weight and other data in the app, and send it to ESP32, which will automatically calculate the adapted pressure [10], automatically adjust the motor speed, etc.

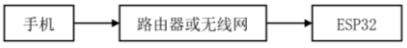

Figure 4-2 Block diagram of wireless signal transmission

The specific implementation steps are as follows: After the device is powered on, the ESP32 initializes and starts to detect the wireless signal acquisition. If the set conditions are not met, the microcontroller continues to monitor; If the set conditions are met, start the corresponding stepper motor and start massaging. After pressing the reset button, each motor resets and waits for the next working cycle.

4.2 Hardware part design

The input voltage of this device is DC 12V, which can directly meet the requirements of 4-wire bipolar stepper motor. The Mini560 DC-DC step-down module reduces DC from 12V to 5V DC to power the ESP32 and four 5-wire stepper motors. The circuit topology is shown in Figure 4-3.

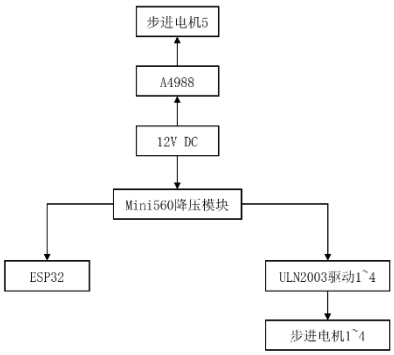

Figure 4-3 Hardware topology

V. Prototype experimental part

5.1 Purpose of the experiment

This experiment aims to systematically verify the structural rationality and functional effectiveness of the multi-functional portable massager for the core design objectives, focusing on the telescopic performance of the scissor mechanism, the disassembly and assembly efficiency of the detachable module, the response accuracy of the intelligent control system and the portability and comfort of the overall equipment. According to the design, the verification and development of the prototype is shown in Figure 5-1.

Fig. 5-1 Physical drawing of the prototype

5.2 Experimental subjects

The core structure includes scissor lifting assembly, detachable massage set, screw slide device and ESP32 intelligent control module, and the key design parameters are: scissor mechanism expansion range 150-350mm, screw slide table transverse stroke 50mm, massage head adjustment range 5-35N according to pressure.

5.3 Experimental process

During the prototype test, each module can operate normally, such as:
The lifting assembly can be easily stretched to a height of about 350 mm and can be compressed up to 150 mm when compressed. The prototype test process diagram is shown in Fig. 5-2 and 5-3.

Fig.5-2 Tensile diagram of lifting components

Fig.5-3 Compression diagram of lifting components

Detachable massage set, during the test, the massage set can be easily disassembled or assembled with the assistance of a pluggable mechanism. The test process diagram is shown in Figure 5-4.

Figure 5-4 Schematic diagram of detachable massage set

APP control system, press the turn button, the massager starts normally, the user enters his height and weight in the App, the massager can provide appropriate massage strength, for example: enter 3 sets of different height (160cm, 175cm, 190cm) and weight (50kg, 70kg, 80kg) data through the App, trigger the intelligent control mode, and use the pressure sensor to detect the output pressure of the massage head; 12.5N、18.4N、24.5N。 At the same time, observe the smoothness of the lateral movement of the components driven by the screw slide (stroke 50mm). Press the end button and the massager will automatically turn off, allowing the whole process to proceed smoothly. The APP interface diagram is shown in Figure 5-5.

Figure 5-5 APP interface diagram

To sum up, it has been tested that under the condition of suitable materials, the massager can undertake office workers to relax their muscles in fragmented time, and all functions can operate normally.

VI. Experimental conclusions

6.1 Structural innovation

The scissor mechanism achieves a height adjustment of about 150-350mm, adapts to the storage scene after compression, and has stable performance in 100 fatigue tests; The massage set is disassembled and assembled ≤ 20s to solve the pain points of traditional equipment; The precision of the screw slide table is 0.3mm, and the 360° massage head achieves curved part fit massage, and the modular design improves portability and maintenance.

6.2 Functional design is effective

The strength is adjustable from 5 to 35N, and the intelligent mode matching deviation is ≤3%, adapting to different muscle tolerances; The APP meets the preset requirements, and the performance guarantees convenient control.

6.3 Good system synergy

The ESP32 main control communicates stably with the Blinker platform, and the 12V/5V power supply system ensures that the motor and chip work together, and the multi-motor action is conflict-free and responds in a timely manner to ensure smooth and safe operation.

6.4 The application value is significant

The "small volume, quick disassembly and assembly, multi-mode" characteristics of the massager accurately match the needs of office workers, providing health solutions for fragmented scenarios. Modular and intelligent design provide technical reference for similar products, and can optimize algorithms and add physiological monitoring functions to improve the experience in the future.

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