



Design of Foldable Automatic Massage Device

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Abstract: Designed for sedentary populations, middle-aged and elderly users, and sub-healthy groups, this foldable multimodal collaborative fully automatic massage device provides daily health solutions for ordinary households. Featuring an STM32 embedded microcontroller as the control unit, it operates a cam-based massage mechanism to deliver ankle massage therapy, achieving kneading effects. The scissor lifting mechanism enhances leg elevation and ankle mobility, effectively preventing leg-related issues caused by inactivity. Suitable for home use, community settings, and rehabilitation scenarios, this innovative device significantly improves quality of life.

Keywords: Mechanical Design, Massage Device, Scissor Lifting Mechanism, Electronic Control

I. Introduction

To address modern lifestyles' diverse needs for health management, convenience, and comfort, while considering varying levels of familiarity with smart devices among different user groups[1-2], this project designs an intelligent massage device. Key features include: 1. A brushless motor drives an improved elliptical cam, converting rotational motion into linear reciprocating strokes. This mechanism activates the foot support linkage rod to lift the four corners of the footplate, creating high-frequency ankle-shaking motions that effectively relieve foot fatigue for prolonged standing users, middle-aged/elderly individuals, and sub-healthy populations, while enhancing blood circulation. 2. A four-link scissor mechanism with electric push rods elevates the ankle massage unit from storage height to optimal massage position, ensuring ample working space. The foldable silicone gel basin design combines durability with space efficiency. 3. Bluetooth connectivity with mobile apps enables one-touch control of massage modes and temperature monitoring, significantly improving user experience. Suitable for home, community, and rehabilitation settings, this device substantially elevates quality of life.

II. Overall Design

The overall structure of this massage instrument can be divided into the following modules:

- (1) Cam Massage Module: The cam mechanism converts the motor's rotational motion into a reciprocating motion of the ankle, relaxing ligaments and enhancing joint blood circulation. Designed for calf muscle groups, this detachable massage module offers kneading, vibration, and heat therapy functions to alleviate leg soreness from prolonged standing or exercise. It extends foot care scenarios to the entire lower limb.
- (2) Scissor Lift and Folding Module: Before applying ankle massage, the footbed should be raised to a certain height to separate from the upper surface of the foot basin, creating space for the foot's back-and-forth rotation to ensure smooth operation of the massage module. The basin features a foldable silicone lid installed on its upper surface, which can be folded when not in use for convenient storage. This space-saving design aligns with the product's user-friendly concept of maximizing space efficiency.
- (3) Temperature measurement module: Equipped with an integrated temperature sensor, the system transmits real-time temperature data to the mobile app via Bluetooth, enabling precise temperature control through the app.

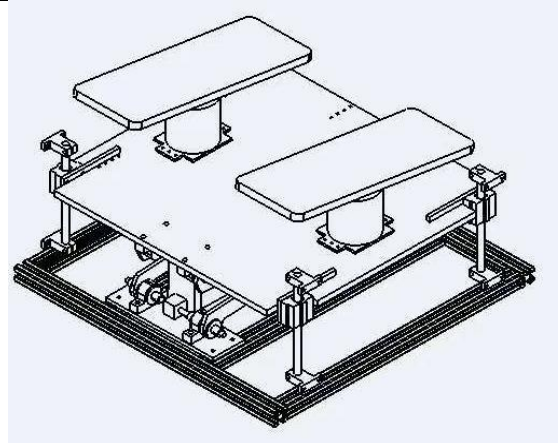


Fig. 1: Overall structure diagram

III. Mechanical Structure Design

3.1 Cam Massage Mechanism Design

The ankle massage mechanism employs a brushless DC motor (model JGA25-2418) as its power source [3], mounted beneath the cam. The cam features an internal groove for direct insertion and four smooth rods (as shown in Figure 2) topped with cylindrical rollers. A universal ball joint assembly is positioned between the upper footplate and the base.

When users need ankle massage, they can activate the system through a mobile app. The command triggers the brushless speed-reducing motor below, which drives the cam to rotate. The cam's slanted cylindrical design creates height variations that make four smooth rods extend and retract cyclically[4]. These rods alternately lift the four corners of the foot pad, creating an uneven distribution of pressure across the sole. This mechanism simulates natural foot movement, effectively massaging the ankles through controlled pressure distribution.

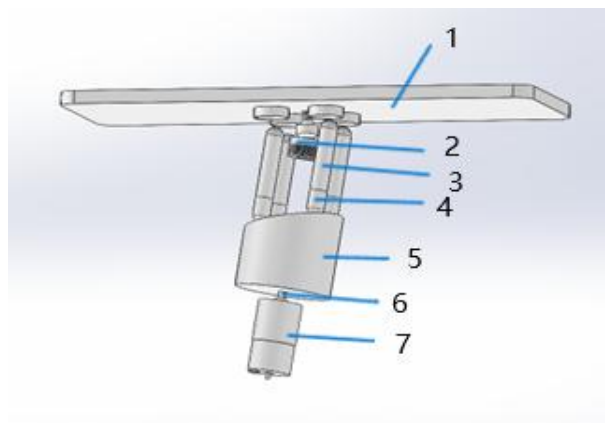


Fig. 2: Cam Massage Module Structure

3.2 Scissor Lift and Fold Module Design

This module consists of a scissor lifting mechanism and a silicone folding basin. To ensure smooth operation of the ankle massage mechanism, the entire assembly must be lifted.

The scissor lifting mechanism is designed to provide sufficient massage space for the ankle massage unit [5]. A brushless speed reduction motor will be installed on the lifting plate. The two screenshots in the figure demonstrate the scissor lifting mechanism (as shown in Figure 3).

The working process of the electric push rod-driven scissor mechanism is as follows: When the electric push rod receives a start signal, the motor drives the screw rod to rotate, causing the telescopic rod to perform linear extension and retraction. The telescopic rod is connected to the crossbars of the scissor mechanism. As the telescopic rod extends or retracts, it drives the crossbars to rotate around the hinge point. The interconnected crossbars of the scissor mechanism work in coordination, enabling gradual unfolding or folding to achieve lifting, sliding, and other movements for load-bearing and transportation purposes. Throughout this process, the electric push rod precisely controls the scissor mechanism's actions by regulating the telescopic rod's stroke and speed with precision.



Scissor mechanism: Four lifting linkages are used, where an electric push rod drives the rod, transmitting force through the linkages to lift the plane.

Lift the transmission path: electric push rod → 6mm smooth rod → transmission link → lift upper plane

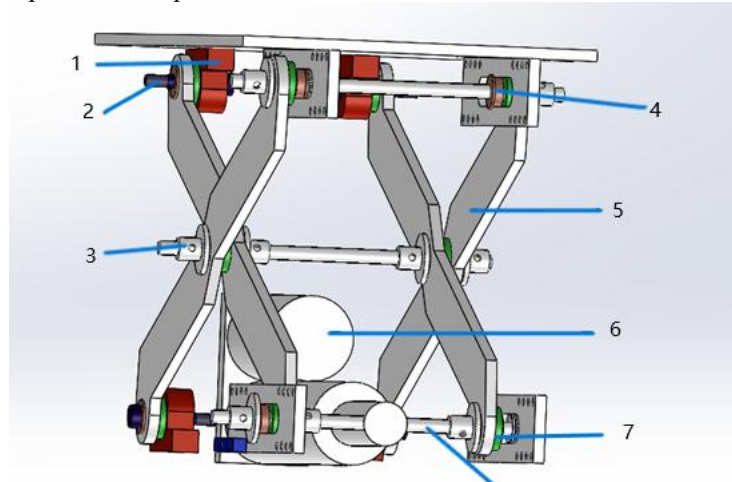


Fig. 3: Structure diagram of the scissor lifting mechanism

IV. Electronic Control Unit Design

The electronic control unit of this massage device is built around an STM32 embedded microcontroller.

4.1 Function Implementation Section

The device employs a DS18B20 digital temperature sensor to monitor the heating module in real time. When the water temperature drops below the preset level, the heating power gradually increases until reaching maximum capacity. Once the target temperature is achieved, the heating power is automatically reduced to maintain the water temperature around the set point. As shown in Figure 6, users can check the water temperature in advance through the mobile app while using the foot bath.

The motor drive system utilizes a JGA25-2418 brushless DC motor and an electric push rod with a 65kg thrust force, each driven by dedicated motor and push rod drivers respectively.

The electric heating unit features waterproof heating rods controlled by PLC, with mobile app-based remote operation for users.

4.2 Control section

The control system consists of five components: a power module, Bluetooth module (HC05), main chip (STM32F103), limit system, and elderly assistance button system. Upon power-on, the machine automatically initiates initialization procedures for all components, including motor, electric push rod, buttons, heating rod, and Bluetooth configuration.

When operating via buttons or the mobile app, the motor and electric push rod's corresponding pins detect electrical level changes. These changes trigger the motor's activation/deactivation, heating control of the electric heating rod, and extension/retraction of the electric push rod, thereby initiating or terminating massage sessions, heating cycles, and switching between storage mode and massage mode. Each time the trigger is activated, the digital status of the motor, electric push rod, and heating rod updates accordingly. The app displays real-time status updates to prevent program execution errors.

V. Conclusion

This design utilizes an STM32 micro-controller integrated with a mobile app to control the mechanical structure, enabling customized ankle massage therapy. Users can adjust functional modules through the app according to personal needs. During testing, after powering on the device, a 20-second reset period is required. Users select desired modules via the app interface: Pressing the "up" button activates the massage function, delivering noticeable kneading sensations in the ankle area. Selecting the heating module maintains water temperature at 35°C, which rises to 40°C after 2 minutes when heating is activated. Closing the massage function triggers the "down" button, lowering the massage mechanism to its storage compartment. The device effectively relaxes ankle joints and muscle groups through massage therapy. Featuring stable performance and reliable structure, it allows adjustable lifting height of the lower limbs and customized massage duration for the ankle joint. The compact storage design maximizes space utilization, combining intelligent functionality with user comfort while ensuring convenient maintenance.



VI. Acknowledgements

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References

- [1] Lu Lingyi, Cao Lei, Yang Ping. Design of a Smart Foot Care and Massage Device [J]. Examination Weekly, 2019 (02):191-192.
- [2] Zhou Chen, Xu Junbin, Qi Xin, et al. Research on an Intelligent Fumigation Foot Massager [J]. Heilongjiang Science. 2017, 8(20):172-173.
- [3] Xie Yun. Principles and Applications of Single-Chip Microcomputers [M]. Beijing: Beijing Institute of Technology Press, 2018.
- [4] Miao Yali, Yang Yuxia. Cam Profile Design Based on SolidWorks [J]. Science and Technology Innovation, 2025, (12):198-201.
- [5] Han Shukui, Jie Maoyan, Zhang Siwei, et al. Research on Structural Design of a Variable-Drive Scissor-type Auxiliary Station-Raising Device [J]. Mechanical Design and Manufacturing, 2025(02):103-108.