

Design and Implementation of an Eye Massager Simulating Finger Massage

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Abstract

Inspired by traditional Chinese eye exercises, an eye massager simulating finger motion was designed. The device primarily consists of a headband, connecting components, a dual-gear multi-link mechanism, massage heads, a control box, and three driving motors. The massage heads are designed to perform motions for massaging the upper and lower eye orbits and the Cuanzhu acupoints. This design facilitates more precise and efficient stimulation of ocular acupoints, thereby alleviating eye fatigue and demonstrating significant practical application potential.

Keywords: *Dual-gear multi-link mechanism; Eye massager; Chinese eye exercises.*

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I. INTRODUCTION

With the proliferation of electronic devices, excessive eye use has become extremely prevalent. Prolonged exposure to digital screens, such as computers and smartphones, induces a series of symptoms, including dry eyes, asthenopia, and headaches [1-3]. This phenomenon is particularly prevalent among populations requiring extended screen time, such as office workers, students, and gamers. Proper and moderate massage of the periocular acupoints and muscles can stimulate peripheral nerves, increase local blood circulation, and regulate ocular metabolism, thereby alleviating discomfort to some extent.

Currently, existing eye massagers are primarily categorized by their working principles into two types: airbag compression and contact-point vibration. Airbag compression models utilize an internal air pump to rhythmically and sequentially inflate and deflate airbags, generating dynamic pressure variations. From a mechanical perspective, this mechanism applies a flexible contact force via fluid pressure, simulating the kneading motion of human hands to apply pressure to the periocular skin. Contact-point vibration massagers typically incorporate one or more micro-vibration motors, often Eccentric Rotating Mass (ERM) motors. As the motor rotates, its eccentric mass generates centrifugal force, inducing high-frequency, low-amplitude mechanical vibrations in the device. These vibrations drive the massage heads, commonly made of materials such as silicone, to apply pressure to the periocular skin.

Chinese eye exercises are a classic ocular massage methodology integrating Traditional Chinese Medicine (TCM) theories of meridians and acupoints. They are widely implemented in primary and secondary schools across China, with the primary objective of relieving eye fatigue and protecting vision by stimulating specific periocular acupoints [4-5]. Compared to general ocular massage, the techniques of Chinese eye exercises are more systematic and targeted. Currently, no eye massagers on the market can effectively simulate the motions of Chinese eye exercises. Therefore, we propose to design an eye massager that simulates finger massage, referencing the motions of these exercises. The design is primarily based on the Chinese eye exercise motions for massaging the upper and lower eye orbits and pressing the Cuanzhu acupoints.

II. Design Scheme

The eye massager, which simulates finger massage, primarily consists of a headband (1), connecting components (2), a dual-gear multi-link mechanism (3), massage head components (4), a control box (5), and the driving motor. The overall structure of the eye massager is shown in Figure 1. A schematic diagram of the eye massager as worn on the head is shown in Figure 2. The headband secures the eye massager to the head via the connecting components. Two manual adjustment screws located in the connecting components allow for the adjustment of the position and orientation of the massage heads relative to the user's periocular skin.

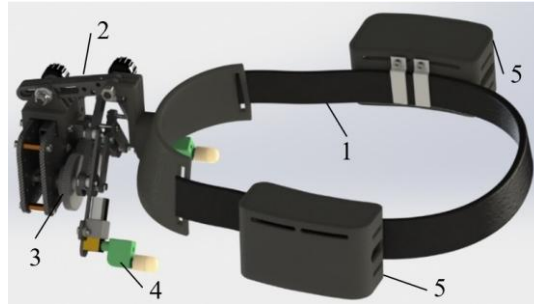


Figure1: The overall structure of the eye massager



Figure2: Schematic diagram of the eye massager as worn on the head

III. Working Principle

3.1 Dual-gear multi-link mechanism.

The kinematic diagram of the dual-gear multi-link mechanism is shown in Figure 3. Gear (301), the driving gear, is installed on the output shaft of the driving motor. The rotation of gear (301) drives gear (302), which in turn drives gear (303). Links (304), (307), and (309) are connected to gear (303) via revolute joints, while links (305), (306), and (308) are similarly connected to gear (302). All connection points are located at an equal distance e from the rotational center of their respective gears. Furthermore, revolute joints connect the following link pairs: (304) and (306), (306) and (310), (309) and (310), (305) and (307), (307) and (311), and (308) and (311). The front and side views of the dual-gear multi-link mechanism are presented in Figures 4 and 5, respectively. The gears are fabricated from nylon and the links from carbon fiber to reduce the overall weight of the device.

The massage head components (4) are mounted on the ends of links (310) and (311). The rotation of the driving gear (301) is converted by the dual-gear multi-link mechanism into an elliptical motion of the massage head components. This elliptical motion trajectory is illustrated in Figure 6.

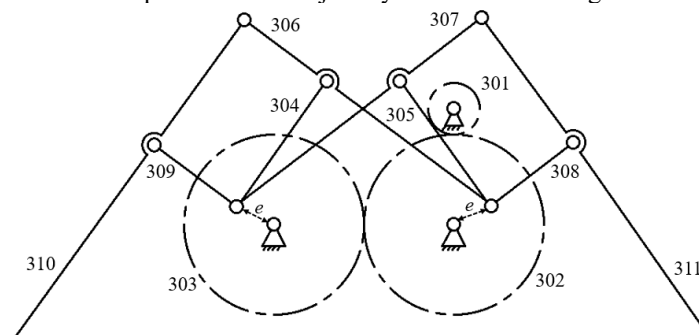


Figure3: The kinematic diagram of the dual-gear multi-link mechanism

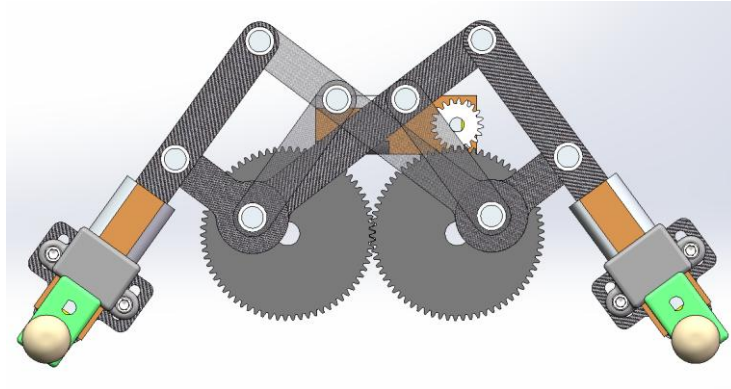


Figure4: The front views of the dual-gear multi-link mechanism

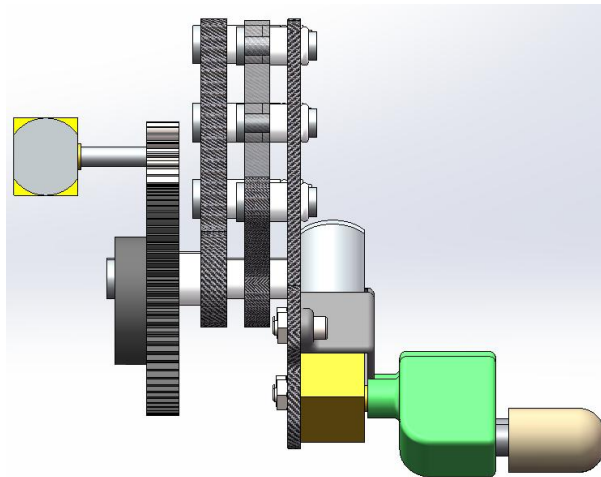


Figure5: The side views of the dual-gear multi-link mechanism

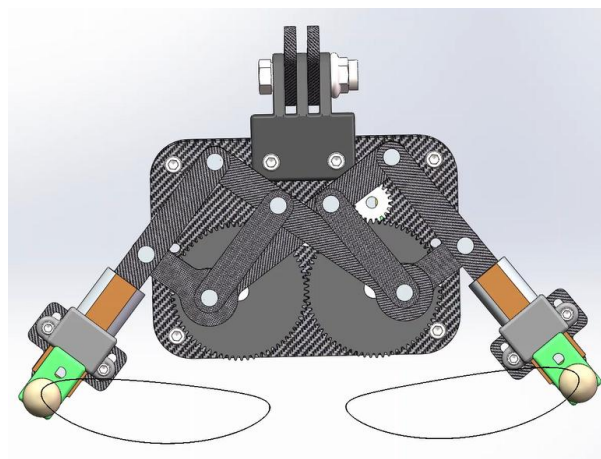


Figure6: Elliptical motion trajectory of the massage head components

The elliptical motion trajectory of the massage head components covers the periorcular skin, as shown in Figure 7. The massage performed along this elliptical trajectory achieves the specific motion for massaging the upper and lower eye orbits, which is characteristic of the Chinese eye exercises, as illustrated in Figure 8.

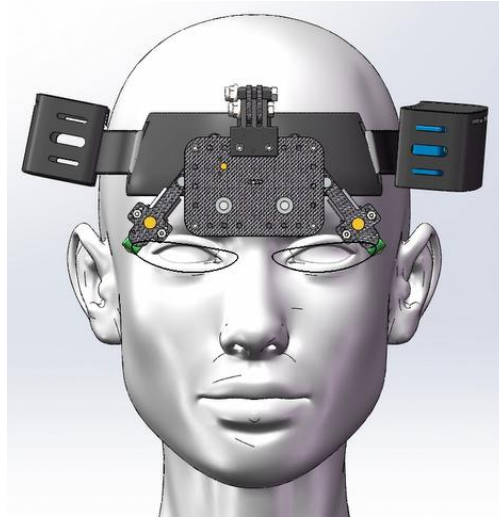


Figure7: Schematic diagram of the elliptical motion of the massage head components

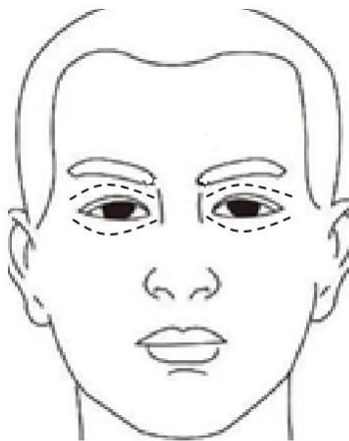


Figure8: Schematic diagram of massaging the upper and lower eye orbits in Chinese eye exercises

3.2 The massage head components

The massage head components include the driving motor (401), connecting block (402), spring pin (403), and massage head (404), as shown in Figure 9. The massage head (404) is fabricated from silicone material and designed with a rounded tip to simulate the shape of a finger. The connecting block (402) is fixed on the shaft of the driving motor (401). One end of the spring pin (403) is secured to the connecting block, and the other end is secured to the massage head (404). The rotation of the driving motor (401) drives the massage head (404) in a circular motion. This circular motion trajectory is illustrated in Figure 10.

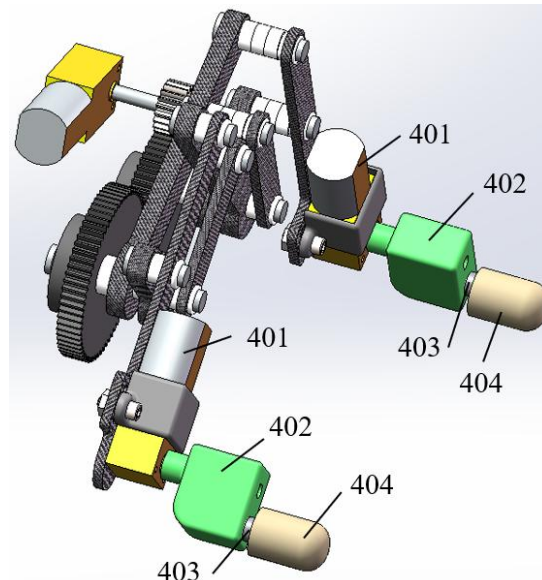


Figure9: Schematic of the massager head components

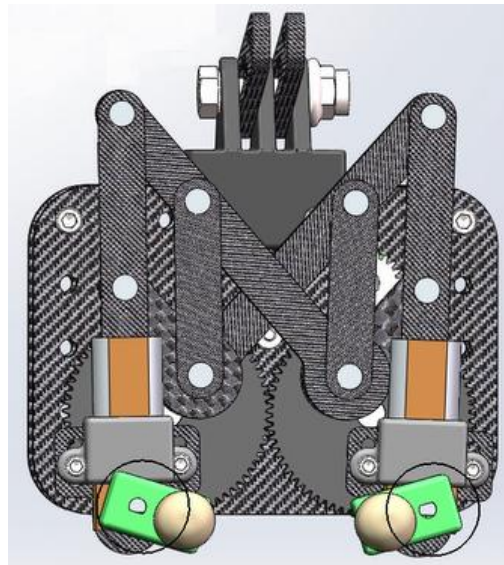


Figure10: Circular motion trajectory of the massager head

When links (310) and (311) are stationary, the circular motion trajectory of the massager head, as shown in Figure 10, can massage the Cuanzhu acupoint, as shown in Figure 11. This action achieves the massage of the Cuanzhu acupoint as performed in the Chinese eye exercises, as shown in Figure 12.

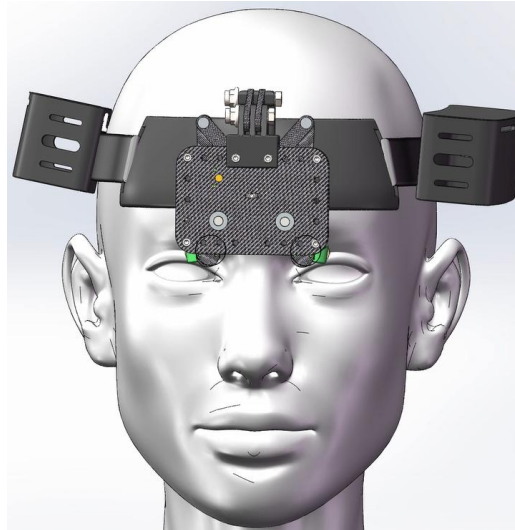


Figure11: Schematic diagram of the massage head's circular motion massaging the Cuanzhu acupoint

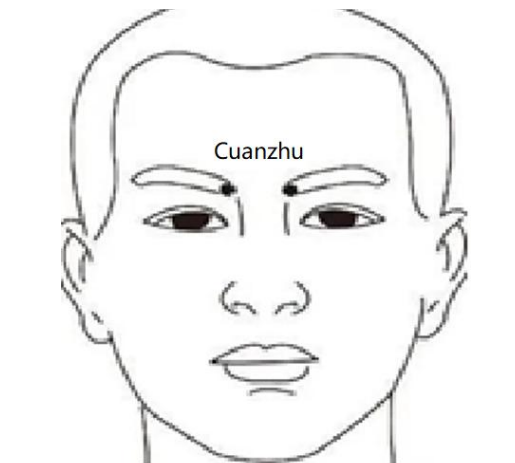


Figure12: Schematic diagram of the Cuanzhu acupoint location in Chinese eye exercises

As shown in Figure 13, the spring pin incorporates an internal spring, which makes its head (where the massage head is mounted) retractable. This design ensures the massage head remains in constant contact with the user's periocular skin under a consistent pressure, thereby achieving a reliable massage.



Figure13: The spring pin: physical object and internal structural diagram

3.3 Control box

The eye massager utilizes a compact ESP32 microcontroller as its main control board, as shown in Figure 14. A 12V 1800mAh lithium battery serves as the power supply, as shown in Figure 15. The ESP32 microcontroller and the lithium battery are both housed in the control box located on the headband. The Arduino IDE development environment and C++ programming are used to implement switch control for the encoded motor's start, stop, and forward/reverse rotation.

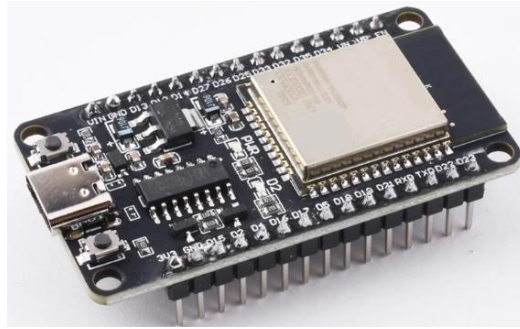


Figure14: ESP32 microcontroller used in the eye massager



figure15: 12V 1800mAh lithium battery used in the eye massager

IV. Application Prospects

Compared to general ocular massage, the techniques of Chinese eye exercises are more systematic and targeted. Massaging the Cuanzhu acupoint directly relaxes the corrugator supercilii and frontalis muscles, alleviating soreness in the brow ridge. Massaging the upper and lower eye orbits provides a comprehensive massage of the orbicularis oculi muscle, which surrounds the orbits. The orbicularis oculi is the muscle responsible for eye closure, and prolonged periods of open-eye work can cause it to remain in a state of sustained tension. Massaging the upper and lower eye orbits thoroughly relaxes this annular muscle, representing the step with the broadest relaxation range and the most comprehensive effect within the entire set of exercises. In contrast to common airbag compression and contact-point vibration eye massagers, the eye massager simulating finger motion can achieve more precise and efficient ocular massage to relieve eye fatigue, thus possessing broad application prospects. The assembled physical prototype of the eye massager is shown in Figure 16.



Figure16: The fabricated eye massager prototype

V. CONCLUSION

Referencing the motions of Chinese eye exercises, an eye massager capable of simulating finger massage was designed. The device utilizes a dual-gear multi-link mechanism to convert the rotation of the driving motor into an elliptical motion of the massage heads, achieving the action of massaging the upper and lower eye orbits. Concurrently, a driving motor integrated within the massage head components drives the massage head in a circular motion, implementing the massage of the Cuanzhu acupoint. The eye massager possesses a simple overall structure, is lightweight, and holds considerable application value.

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