Design of eye electroacupuncture massage instrument based on 3D printing technology

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Abstract. At present, the common eye massage instruments in the market is mainly used to relieve eye fatigue and cannot treat myopia. Traditional Chinese medicine electro-acupuncture has a good effect on the treatment of myopia, but its efficiency is low, and most adolescents have poor compliance, which is difficult to promote. This design combines electroacupuncture therapy with 3D printing technology to accurately locate the eye acupoints through three-dimensional scanning, therefore the massage effect is better. The design of the massage instrument not only fills the field blank of the electro-acupuncture massage instrument for myopia, but also is more easily accepted by the adolescents, meanwhile, it has the advantages of good effect and easy promotion.

1. Introduction
Practical medicine shows that Chinese medicine electro-acupuncture therapy has a better effect in treating myopia[1]. Electro-acupuncture therapy stimulates eye acupoints through micro-currents that are safe for the human body to promote eye blood circulation and dredge the eye meridians. Therefore, the effect of preventing and improving myopia is achieved. Three-dimensional scanning can convert the three-dimensional information of the object into digital signals that can be processed directly by the computer. Meanwhile the obtained data can be easily modified in the CAD system and processed in the CAM system. 3D printing technology can not only automatically, directly and accurately convert the design model in the computer into a physical object, but also simplify the manufacturing process, and most importantly, it can achieve personalized production.

2. Overall design
The design scheme is divided into the structural design of the massage instrument and the design of the control part of the massage instrument. The structural design of the massage instrument is further divided into the main body design of the massager, the design of the massage contact part, the wearing device and the design of the casing. The control part involves hardware design and circuit design.

3. Massager structural design
3.1 Main body design of the massager
The traditional eye massager is universal. In order to optimize the massage effect of the massage apparatus, it is necessary to match the positioned acupoint data to the eye massager. The hand-held white light grating 3D scanner can not only convert the stereo information into a digital signal that can be directly processed by the computer, but also has no harm to the human body. At the same time, it
has the advantages of fast speed, high accuracy, and high cost performance. The obtained three-dimensional data can process directly in CAD/CAM software[2].

The specific method is as follows: First, we need to locate the eye acupoint according to the eye acupoint map to. In order to show the eye acupuncture point more clearly, the eye area is painted white, and the position of the acupuncture points is marked with a black marker. Then we use the hand-held raster three-dimensional scanner to scan around the human eye to obtain the eye data. The eye data is shown in Figure 1.

![Figure 1. Scanned data](image)

Then we use Rhinoceros software to process the scanned data obtained from 3D scanning. By creating, editing, analyzing and converting NURBS curves, surfaces and solids, we can directly design the main body of the massager. The main body of the massager is shown in Figure 2 below.

![Figure 2. Left and right body of massager](image)

Because the main part of the massager is in direct contact with the human eye, we choose to use a liquid-curing three-dimensional forming (SLA) 3D printer to solidify the liquid photosensitive polymer to achieve the curing of the liquid material. The finished product that printed in this way has the advantages of high precision, great flexibility[3] and good comfort.

3.2 Massage contacts design
The massage contacts should be made of materials that are non-irritating, non-toxic, and non-allergic to human tissue, meanwhile have good physical and chemical properties and electrical conductivity. The conductive silicone has stable chemical properties, fine electrical conductivity, and can maintain its original elasticity and softness during contact with the human body[4]. Now it has been widely used in medical and military industries[5]. The design of the silicone massage contact is shown in Figure 3. After assembly, the silicone massage contact can be fixed on the main body of the massager. The function of the slot in the figure is to fix the electrode pad. In addition, this design designed a variety of sizes of massage contacts for myopia patients of different ages.
3.3 Massager shell design
The design of the massager shell is shown in Figure 4 below. The design is consistent with the main part of the massager. It consists of left and right parts, which are connected by a buckle. In addition, the position of the control elements such as the display screen, USB data interface and the connection position of the wearing device need to be reserved during the design.

In order to protect the internal circuit and other parts, the shell of the massager needs to be strong and resistant to falling, and it is better to have some elasticity. Therefore, we choose to use fused deposition molding (FDM) 3D printer to print the shell of the massager, which meets the design requirements and reduces the cost.

3.4 Wearing device
The wearing device should be made of lightweight, durable, flexible, comfortable to wear and low in cost. This massager is designed to wear the Velcro without glue, as shown in Figure 5. One end is fixed on the shell of the massager, and the other end can freely adjust the tightness of the buckle on the sticking surface and the hook surface according to the wearer's preference.

4. Control part design
4.1 Hardware design
The hardware design includes power module, display, microcontroller, data and charging interface, button and indicator design. As shown in Figure 6.
4.1.1 Power module design. In this design, we choose a lithium 5V ion battery as the power source of the massager. Lithium-ion batteries have a high average output voltage, low self-discharge, and a wide operating temperature range. Specially, it has superior cycle performance, fast charge and discharge, high output power, long service life, and no toxic or hazardous substances.

4.1.2 Display and data and charging interface selection. SAMKOON touch screen has the advantages of low power consumption, long life, small use space, and large amount of display information. Due to its low price, it is very suitable for use as a display screen in the massage device.

We choose USB as the data and charging interface. USB is a standard interface for PC. It is easy to carry and has a uniform standard. It can provide a single, easy-to-operate connection for all peripherals.

4.1.3 Buttons and Indicators. Since most operations are performed on the touch screen, this design only needs on-off key. The indicator light requires two indicators, the charging indicator and the working indicator. This design uses light-emitting diodes as indicators.

4.1.4 MCU Selection. The use of single-chip microcomputer can flexibly select the stimulation waveform and accurately control and adjust the size of the stimulation to suit different types of diseases and patients. The biggest feature of the 555 time-base circuit is that it can form an accurate timing circuit after adding a simple RC circuit. Its circuit structure is simple, strong stability. It’s counting time from microseconds to hours, and the output voltage is compatible with the TTL level, which satisfies the requirements of the product.

4.2 Circuit design

Using the 555 time-base circuit can design a variety of electrical acupuncture stimulation waveform circuit. The pulse sequence has multiple modes: equally spaced continuous pulses, intermittent wave pulses, amplitude modulated pulses, frequency modulation pulse. The equally spaced continuous wave pulse has the function of promoting blood gas circulation. The intermittent wave pulse is automatically appearing regularly and intermittently, which can improve the excitability of the eye muscle tissue. The frequency of amplitude modulated pulse is close to the breathing law of human body, and it can improve the excitability of ophthamlic nerve and muscle and adjust the meridians of eye. The frequency modulation pulse is a waveform in which the sparse wave and the dense wave alternately appear, which has the functions of promoting metabolism and eliminating inflammation and edema. By selecting different pulse sequences manually, we can meet the different needs of myopic patients and achieve the best treatment effect.
4.2.1 Basic waveform requirements. The output current amplitude of the basic waveform shall not exceed 80mA, which can be continuously adjusted by manually adjusting the knob on the touch screen. The width should be between 150 μs and 300 μs.

4.2.2 Pulse sequence mode. The pulse sequence has four modes. Mode 1 is continuous pulses at regular intervals, with a pulse frequency of 60Hz. Mode 2 is an intermittent wave pulse with a pulse frequency of 60Hz and a repetition period of 3S. Mode 3 is amplitude modulation pulse with a pulse frequency of 60Hz and a repetition period of 2S. Mode 4 is a frequency modulation pulse with a pulse frequency of 90-20Hz and a repetition period of 2S. The experimental circuit principle is shown in Figure 8 below.

Figure 8. Experimental circuit principle

5. Conclusion
Digital model and 3D printing technology make it possible to manufacture complex curved surfaces. This design combines 3D scanning technology with 3D printing to design a product that fully fits the
acupuncture points of the human eye, and achieves the effect of private customization. The treatment of myopia with traditional Chinese medicine electroacupuncture improves the traditional massage method of the eye massage instrument. It not only eliminates the rebellious heart of teenagers, but also improves the massage efficiency, making the treatment of myopia easier and feasible.

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