Research on Chinese Traditional Medical Massage Robotic Products Usability Design Process

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Abstract It is well known that traditional Chinese medical massage has always been the most effective way to relieve and treat all kinds of chronic pain. More and more TCM massage robots are needed, due to the population aging and the high percent of sub-health. This article mainly do some of the following work. First of all, Based on the principles of product availability and ergonomics, the author summarized the usability elements in the process of TCM massage robot products. Secondly, According to the theory and techniques of Chinese medicine massage, the robot terminal designed can realize pressing, kneading, rolling and vibrating techniques. Lastly, the prototype has been successfully developed, which has advantages of smooth operation, good manipulability, low noise and small vibration, during the experiment.

1. Introduction
Up to date, any massage instrument can’t achieve the same level of the advanced massage surgeon. Therefore, inventing and producing high quality massage products -TCM massage robot, to adapt to market demand, has epoch-making significance.

Usability refers to the effectiveness, efficiency, and satisfaction experienced by a specific user when using a product in order to achieve a specific goal in a specific use scenario, which is the core of product competitiveness. Usability engineering is applied to all stages of the life cycle of TCM massage robot products. Combined with risk assessment and analysis, the author would like to design a robot which has the advantages of safe and controllable massage force, precise positioning, convenient operation and repeated massage action.

2. Research on Usability Design Elements of TCM Massage Robot Product System
Product usability is generally from view of the user's psychological point, which usually have the following characteristics.
2.1. Description of TCM Massage Robot Product System

First of all, based on the Traditional Chinese Medical Massage Theory and combined with the poly requirement of treating patients’ pain in waist and leg, TCM massage Robot can complete Operations of press, kneading, rolling and vibration. robot is a mechanized device capable of simulating artificial massage. It can reduce the workload of masseurs, improve the efficiency of massage, maintain the curative effect, and better meet the huge demand for massage in society. The overall design of TCM massage robot as shown in figure 2. Its legs are composed of guide rail 1 and guide rail 2, its arms are composed of upper arm, lower arm and wrist, respectively, and its hands are composed of end effector 1 and end effector 2.

Secondly, When the end effector needs to perform the kneading operation, the degree of freedom of rotation about the z-axis must be increased. The design is to install the crank and rocker mechanism on the moving platform of the parallel mechanism to realize the rotary motion of the massage head. In fact, it is a parallel and serial mixed 3 degree of freedom mechanism. The structure of the end effector [1] is shown in Figure 3.
2.2. Analysis of Usability Factors in the Commercialization of TCM Robot
In the process of massaging, masseurs have a high labor intensity and are prone to fatigue, resulting in low efficiency and large differences in efficacy. Secondly, traditional Chinese medicine massage has been a pedagogical inheritance model for thousands of years. The method lacks standardized standards and there is no quantitative evaluation system for massage efficacy. The emergence of TCM massage robot can prevent poor massage results due to "fatigue", furthermore, through the implementation of standardized massage techniques, the therapeutic effect of massage can be quantitatively evaluated, and it varies from person to person, and closed-loop correction improves the massage effect. This puts forward higher requirements for the usability of the TCM massage robot system, such as the concept that should be well reflected in the "5E".

3. Product Usability implementation process of TCM massage robot
The usability design of TCM massage robots embodies a user-centric concept and meets the requirements and connotations of ergonomics. From the perspective of ergonomics, the design of a TCM massage robot needs to achieve the following goals: First of all, a clear operating world allows users to quickly obtain and identify product information, then, it allows users to operate the robot system both safely, conveniently, and quickly, which requires clear inputs from the various inputs of the robot system Semantic, allows users to operate without hesitation and give feedback at all times [3], in addition, the entire operation process should minimize errors and errors.

3.1. Hardware Design of the Usability of TCM Massage Robot Products
According to the overall design requirements of a TCM massage robot, this system belongs to a typical multi-axis motion control system. The model based on "PC + PMAC" motion control card is used to build an open parallel robot control platform. The controller collects digital and analog quantities in real time to control the position and force of the mechanism. This system uses a Founder computer (PC) as the host computer, and Delta Tau's new Clipper programmable multi-axis motion control card (8-axis Clipper + Acc1P) as the lower computer. The electrical servo part uses the Swiss MAXON motor and the mechanical transmission part uses Japan. IAI electric cylinder. The speed and position feedback is realized by the three-dimensional force sensor feedback to the PMAC card speed controller. The logical structure of the end effector system of the massage robot is shown in Figure 4.
3.2. Design and implementation of massage techniques

In this paper, the rolling method is used as examples. The method in which the back of the palm is close to the side of the little finger on the operation site and alternately rolls back and forth is called rolling [4], [5], shown in Figure 5.

Rolling action essentials: During the operation, each finger is naturally placed, and can not be excessively flexed or straightened. The width of the wrist joint flexion and extension should be large, and one-half of the area of the back of the palm is in contact with the treatment site. The part of the palmar near the little finger is the focal point of the rolling operation. It should be close to the treatment site. It should not be moved or jumped. The frequency of the rolling massage is 120-160 per minute. According to the definition of rolling and the analysis of rolling action, The completion of this technique requires four degrees of freedom, which are the movement of the back side of the hand in the z-axis direction (the action of a force), the rotation about the y-axis direction (rolling action), and the movement in the x-axis and y-axis directions to locate the massage position. As shown in Figure 6.

Figure 4. Logic structure diagram of control system

Figure 5. Rolling method

Figure 6. Stress analysis of rolling method
According to the above analysis, the motion output matrix of the rolling method is:

\[
U_i = \begin{bmatrix}
x \\
y \\
z \\
\beta \\
\end{bmatrix}
\]  

(1)

The rolling programming design process is shown in Figure 7.

![Figure 7. Rolling method PLC program flow chart](image)

The TCM massage robot calls the rolling function to find the human body. If the human body is not found, the system alarms. If the human body is found, the manipulator descends along the Z axis direction. When the force sensor detects the force value reaches the preset force value, it controls the two IAI in the Z axis direction. The electric cylinder reciprocates in the opposite direction. In the process of rolling massage, the control target is always whether the force exceeds the limit.

3.3. HIM of the Usability of TCM Massage Robot Product

TCM massage robots are developed to meet the health needs of the elderly and sub-healthy people, so the friendly human-machine interface is particularly important. It is an interactive platform for users and massage robots. Man-machine interface functions include: man-machine dialogue, system operating status display and input of control instructions. The man-machine interface design of the end effector control system of the traditional Chinese massage robot is implemented by MCGS programming, as shown in Figure 8.
4. TCM massage robot usability test
The end effector prototypes of TCM massage robot is shown in Figure 9

4.1. PID servo control
In the production process, the PID controller is widely used because of its simple structure and easy adjustment of parameters. The design of the controller has a great influence on the operation of the entire system, so in this system, after determining the hardware of the mechanical parts, transmission parts, motors, etc., the settings of the system are adjusted.

When the prototype is not equipped with a load, it is necessary to test the performance of the motor. I set up communication settings with the PMAC card through PEWIN32PRO software, and completed the debugging of the motor performance through the PMAC debugging menu of the man-machine interface. The debugging process is shown below. Enter the relevant online commands J+, J-, J/ etc. in the edit box to realize forward rotation, reverse rotation, and stop of the motor.

4.2. Setting of various methods of TCM massage Robot
Through continuous debugging, the PID parameters of various methods of the end effector of the traditional Chinese medicine massage robot were adjusted, and finally the system worked well. Now the PMAC Tuning Pro debugging interface of various methods is listed below.
Figure 10. Rolling method PMAC
Tuning Pro Debug Interface

Figure 11. Kneading method PMAC
Tuning Pro Debug Interface

Figure 12. Vibrating method PMAC
Tuning Pro Debug Interface

Figure 13. Pressing method PMAC
Tuning Pro Debug Interface

5. Summary
The product market of this project has incomparable advantages in terms of target users and methods of operation. The product combines the technical expertise and massage experience of massage therapists, and renews the current effective expert massage process to achieve efficient, intelligent and convenient mechanized massage.

References
[1] Tong Lianggui, Ji Minggang. Mechanical Design [M]. Beijing: Higher Education Press, 2003.
[2] Corco, Ark Translation, Reflections on Interaction Design, Beijing: Mechanical Industry Press, 2012.
[3] Andreas Holzinger. Usability Engineering for Software Developers, Communications of the ACM (ISSN 0001-0782), Vol. 48, Issue 1, 2005, 1:71~74.
[4] lingzhicong. Rolling method and its application [J]. Massage and Guiding, 2000, 6: 56
[5] Xie Yue. Analysis of the rolling method [J]. Liaoning Journal of Traditional Chinese Medicine, 2002, 11: 643-644