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Learning and Training with Force Feedback for an Acupuncture Education System

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Abstract: It is mostly important in acupuncture to become highly skilled by training with repeated practice. However, such practice can hardly be done on a real human body, which may always be accompanied with pain and misery. In this study, a computer training system with force feedback for acupuncture was proposed. A human acu-points model with acu-point name, position, meridians, stinging techniques and healing functions was created within the computer, and devices with force feedback functions for skill training were used in the system. A trainee gets acupuncture experience not only by visual information, but also from sensing the force information with a true-false judgment of his movement being real-timely given during the exercise.

Keywords: Acupuncture, Computer Learning and Training System, Force-feedback, Training Environments for Skills, Quantification of Technique

Introduction

Acupuncture is an ancient Chinese healing method in which stimulations are applied to the acupoints (defined position on the human body), leading to an increase of the healing power of the human himself and the recovery of the sickness [1]. Recently, acupuncture has been paid more attention worldwide, so the Acupuncture of Chinese Medicine has been registered in the humanity national intangible cultural heritage list by UNESCO in November 2010. Although the miraculous ancient Chinese healing method has still some parts not yet being explained scientifically, it is used with increased worldwide interests, and even an Acupuncture Universities has been established in Japan [2].

It is important in acupuncture, similar as most of the oriental medical treatments, to use fully the human 5 senses, and to become skillful mainly by repeated exercises [3]-[5]. However, there are problems in learning and training for acupuncture, such as the lack of clarity in the textbook, the difficulties for a judgment of the accuracy when stinging an acu-point, and so on. Thus, the development of an acupuncture training system using the advanced computer technology can be of great help [6].

We have been doing researches on the development of a computer-assisted acupuncture training system for quite a long time. In this study, we reported an improvement on such system. An acu-point human body model was created within a computer, with which the study of recognition of correct 3D acu-point position, and the sting action on them was done with a true-false judgment. When building up the system, we paid more attention to the representation, teaching and training of the tiny operation force applied in the sting action.

The teaching of the insertion angle and insertion speed for a sting operation on an acu-point using a mechanical force feedback system was proposed [7]-[11].
As one of the series researches for the training system, this study reported an improvement on the system by introducing a haptic device PHANTOM. The teaching of the tiny force adjustment in sting was studied with the system, and the results were tested by repeated exercises of trainees with real-timely true- false judgments.

1. Learning and Training of Acupuncture Skills

1.1 Needle Therapy

Acupuncture therapy is a medical treatment using acupuncture needle or moxibustion to stimulate the acu-points of body according to the symptoms. An acu-point is the defined point on the human body, going to receive the needle with proper stimulus. There are hundreds of such acu-points located on the important positions over the human body on the meridian. And the meridian is such an imaged flow (you may not see them) connecting the acu-points to the internal organs. Therefore, it is very important to find the correct position of the acu-points, and the proper stimulus for the highest healing effect.
That is, the acupuncture education requires both a textbook for memorizing, and repeated practice/exercises to master the skill. With the help of advanced computer technology, a better training effect can be expected using the textbook with the series of processes of basic theory, case prehension, treatment policy, acu-points combination and handling, which are systematically combined with a computer.
Acupuncture has techniques of not only holding and insertion, but also those of stinging, trail, whirl, according to different symptoms (Fig. 1). It is further required for good healing to use different techniques such as the stinging angle, the speed, and the depth upon different acu-points for each symptom. Therefore, it is especially important to be trained by repeated practice.

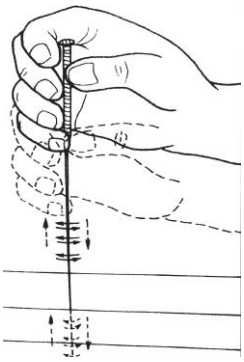

Fig. 1 Normalized of vertical needle speed

1.2 Training with Force Feedback

The proposed system can be roughly divided into two parts. One is the software for teaching and explanation of the sequence of basic theory, case prehension, treatment policy, acu-points combination and handling. The software contains detailed description on the names, position, depths of meridian and meridian point, and its flow or moving, some are demonstrated by 3D expressions for a better understanding. Another, and one of the most important things in the acupuncture training, is the development of a training system with force feedback function with a precise correspondence to the acu-point model. For such a system with force feedback function, firstly, information of operation forces from well-experienced doctors are measured and stored in the computer as a training index. Then,

training functions are input to the computer based on the human model and basic techniques of acupuncture.
A trainee is trained, using the system with force feedback, to master the basic techniques such as the methods of holding, stinging, and so on (Fig.1). He gets the correct feeling by repeated practice referring the standard from well-experienced doctors. The system has the character of real-timely response, giving a true-false judgment during the practice. The results are evaluated by the computer.
As stated above, while the former part can be found a lot in the E-learning or database fields, the latter part is quite few because of being a kind of practice training accompanied by technical difficulties. This study has paid attention to the latter, and experiment was done for a development of a computer training system for acupuncture. In this paper, the construction of a training system using force feedback device PHANTON was done, and the problems and perspectives were addressed.

2. The Acupuncture Training System

2.1 System Construction

A 3D human acu-point model was created on a computer. A training system was constructed upon the 3D model. The schematic of the system composed of a computer (XPS6, 30Dell) for simulation, a monitor to show the information, and a haptic device (PHANTOM Omni®. SensAble Technologies, Inc.), and the software of OpenHaptic toolkit, is shown in Figure 2.

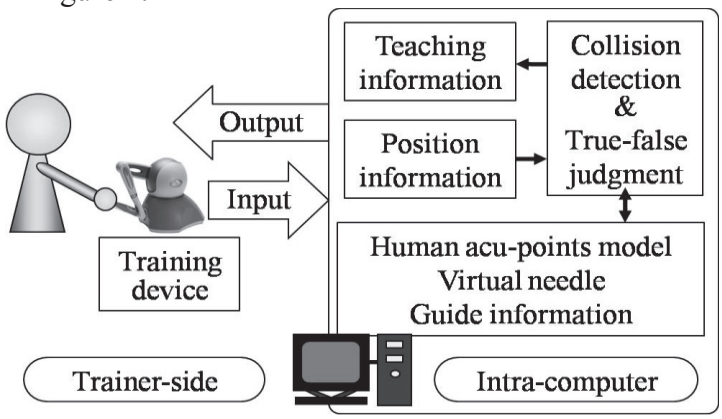

Fig.2 The construction of the training system

Computer system development environment is shown in Table 1.

Table 1 System development environment

OS	Window XP
CPU	Pentium4 2.8G
Memory	480MB
Video card	OpenGL compatible video card
Interface	IEEE1394 Board
Haptic devices	PHANTOM Omni
Software	Microsoft Visual Studio 6.0 OpenHaptics Toolkit version 2.0

2.2 Haptic Devices- PHANTOM-

The PHANTOM is a 3D input-output haptic device capable of force interaction with high precision. The interaction between a 3D object and the operator makes it possible to present not only visual but also force information. The reaction force from the hand when touching an object, therefore, can be real-timely represented, to achieve a high operational effect with real-time response.
The PHANTOM Omni model (Fig.3) is one of the most high cost-effective haptic devices available today. Portable design, compact footprint, and IEEE-1394a FireWire® port interface ensure quick installation and ease-of-use performance. The PHANTOM Omni specification is shown in Table 2.

Fig.3 PHANTOM Omni haptic device

Table 2 PHANTOM Omni specification

Model	**Model The PHANTOM Omni Device**
Force feedback workspace	~6.4 W x 4.8 H x 2.8 D in > 160 W x 120 H x 70 D mm
Footprint Physical area the base of device occupies on the desk	6 5/8 W x 8 D in ~168 W x 203 D mm
Weight (device only)	3 lb 15 oz
Range of motion	Hand movement pivoting at wrist
Nominal position resolution	> 450 dpi ~ 0.055 mm
Backdrive friction	<1 oz (0.26 N)
Maximum exertable force at nominal (orthogonal arms) position	0.75 lbf. (3.3 N)
Continuous exertable force (24 hrs.)	> 0.2 lbf. (0.88 N)
Stiffness	X axis > 7.3 lb/in (1.26 N/mm) Y axis > 13.4 lb/in (2.31 N/mm) Z axis > 5.9 lb/in (1.02 N/mm)
Inertia (apparent mass at tip)	~0.101 lbm. (45 g)
Force feedback	x, y, z
Position sensing ..... **[Stylus gimbal]**	x, y, z (digital encoders) ..... [Pitch, roll, yaw (± 5% linearity potentiometers)]
Interface	IEEE-1394 FireWire® port: 6-pin to 6-pin*
Supported platforms	Intel or AMD-based PCs
OpenHaptics® SDK compatibility	Yes

The PHANTOM is equipped with position sensors capable of doing precise force operations. A reactive force corresponding to the hand movement is produced by reverse rotating of inner motors to wind the wires. A 3D force vector is output on the tip of the stylus by controlling the torque of the DC motor. The maximum force output is 3.5N. A high rate of input-output change is achieved by 1 kHz high speed processing. The PHANTOM was then introduced into the system considering such characteristics. Acupuncture training with high reality, most near the practical sting, is expected with the system.

3. System Functions

The functions of the system can be that to provide information on both visual and operational (force) at the same time, satisfying the skill training with presence.

3.1 Presentation of the Information not Visible in the Real World

The precise positions of the acu-points, which are usually invisible on the human body with the human eyes, can be easily displayed on the 3D model on a computer. The acu-points of a human body in the ordinary textbook are described in a 2D form so it is difficult to identify the 3D information (such as the depth of the acu-points). The developed system, however, is with the ability to demonstrate 3D information because of the use of a 3D human body model, resulting in a highly improved understanding of the 3D position of acu-point including the depth and the relationship with the surrounding organs, which has not been possible in the conventional training.

3.2 Repetitive Training with Force Feedback

It is easy to use the system to carry out exercises repeatedly almost without limitation, which is very important for learning and training skills of acupuncture in contrast to the conventional training using human body. In conventional training process, a trainee usually learn technique by sting the points of himself or between the trainees each other and this may lead to a resistance or fear to continue further the acupuncture practice.
A trainee is trained, using the system with force feedback, to master the basic techniques with tiny force operations such as the methods of stinging, insertion, holding, and so on. He gets the correct feeling by repeated practice referring the standard from well-experienced doctors. The system has the character of real-timely response during the practice. The results are evaluated by the computer.

3.3 True-False Judgment in Real Time

A precise judgment of a correct stinging to the proper acu-point position with the proper force has been difficult in the conventional training method, while it can be easily and real-timely done with the developed computer system. Using the device with force feedback on hand movement promotes the training towards the most practical one. It is also possible to do reliable true-false judgment on a sting using the computer system, because a beginner is difficult to judge the correct force used to sting into an acu-point. A trainee gets acupuncture experience not only by visual information, but also from sensing the force information with a true-false judgment of his movement being real-timely given during the exercise. The teaching of the tiny force adjustment in sting was studied with the system, and the results were tested by repeated exercises of trainees.

4. Conclusions and Future Work

In summary of this research, a computer training system for acupuncture with force feedback functions was proposed. An acu-point model with precise name, position, flow, sting techniques and healing function, was created on a computer. The information on each operation, especially the tiny force adjustment was obtained and made visualized on the computer. A trainee gets experience not only by visual information, but also senses the force information with a true or false judgment of his movement being real-timely given during the exercise. The system has the character of doing exercise repeatedly without pain, and the ability of reducing operation mistakes at low cost, even with more information not yet possible in reality. The system is expected to contribute to a successful training of acupuncture doctors through the realization of the series processes of study of the basic theory, case prehension, decision of the treatment policy, acu-points combine and technique training on computer.

One of the research subjects for the next step is the enrichment of the acupuncture data base and training-related environment. The quantification of operation force has to be done in more detail using the system by more experiments and analysis. For this purpose, more operation data from the experienced doctors are to be introduced as the standard for training. Further, evaluation and score-taken of the trainees are to be added. Continued studies are carried on towards the realization of a simulation system capable of quantitative study, training, evaluation etc.

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