Measurement of Operating Force and Determination of Training Index for Acupuncture Training System

Ren Kanehira [a*], Weiping Yang [b] & Hideo Fujimoto [c]
[a] *FUJITA Health University, Japan,*
[b] *Aichi Shukutoku University, Japan*
[c] *Nagoya Institute of technology, Japan*
[*]kanehira@fujita-hu.ac.jp

Abstract: An acupuncture training system was proposed in this study paying special attention to the fine movements. The measurement, quantitative analysis and index of evaluation of the operation force in insertion and quick sting operations were carried out. Because the acupuncture is an experiment-based technique so there has been no quantitative attempt nor for training index in the traditional training style. In this study, we have made equipment to measure the operation force of doctors. The force values of experienced doctor and trainees were recorded at the same time, and the results were compared with each other to obtain a quantitative index for better training effect. Our study showed that training can be done with specific targeting values through quantification of the fine movements in acupuncture techniques, and the effect can be evaluated by a real-time true-false judgment from the training system.

Keywords: Computer Learning and Training system, Acupuncture, Insertion, quick sting, Operation force, Quantification of technique, Training Environments for Skills

Introduction

Acupuncture is an experiment-based technique requiring repeated practice in training. However, because such training, if only performed on real human body, is always accompanied by pain and thus almost impossible in practical training [1]-[2]. Furthermore, because acupuncture is composed of fine movements with tiny force performance, which is usually mastered from long-time experience, the representation of such force and movement are very difficult by words and phrases. As a result, it takes a long time to become an acupuncture doctor. Therefore, a much more effective training system, better with the use of the advanced computer technology, is expected [3].

In this study, we have made such equipment to measure the operation force of a doctor during acupuncture operations. The force values of experienced doctor and trainee in acupuncture operation were recorded at the same time, and the results were compared with each other to obtain a quantitative index for training. Our study showed that training can be done with specific target values through quantification of the fine movements in acupuncture techniques, and the effect was evaluated by a real-time true-false judgment using the training system.

1. Proposed System

1.1 Construction of the System

The final purpose of the system is to make a training of the whole process in acupuncture possible, including the learning of basic theory and the mastering of the acupuncture technique. A human acu-points model is firstly created within the computer space, and then the necessary software for training is constructed. Fig. 1 shows the construction of the proposed acupuncture training computer system. The system is constructed by a display, a 3D sensor, a computer, and other training devices made by us. Information on the position and attitude of trainees is detected from the head sensor, and from the information the field of view is calculated in the computer and output from the display. The trainees can get a 3D view of the human acupoint model and are then trained with real presences. Further with the use of a force feedback device developed in our Lab., it is possible to learn the acupuncture techniques most closely to the practice.

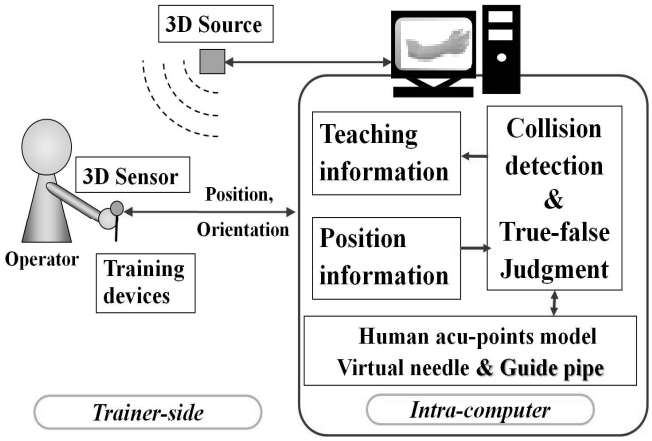

Fig. 1 The construction of the training system

1.2 Acupuncture and Training

Acupuncture is a medical treatment using acupuncture needle to stimulate the acu-points of body according to different symptoms. An acu-point is the point on the body receiving the needle and proper stimulus. So acupuncture has technique of not only holding and insertion, but also those of stinging, trail, whirl, according to different symptoms. 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.

In our research for solving around acupuncture education and training problems, we have proposed a training system using the computer simulation technology, in which a 3D human body model with acu-points for positioning and a real-timely true-false judgment [4], and the ability of teaching of insertion angle [5], the measurement and training of insertion speed, have been studied and developed [6]. Figure 2 shows the acupuncture process and the flow of our research focus points.

In the development of the training system, it has been pointed out that the quantified indexes to the training of acupuncture is important [7]-[9], and for this purpose that the system should be developed with real time true-false judgment.

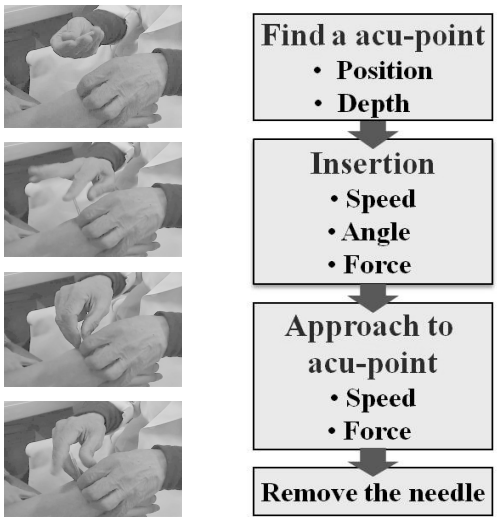

Fig.2 Acupuncture process & Research Focus points

2. Measurement of the Insertion Force

2.1 Measurement Device

A device for the measurement of the insertion force during stinging was made. The device was applied to both doctor and intern for practice operation. It is considered that quantitative values for a good acupuncture treatment with proper tapping force can be obtained by comparing the measurement results from the teacher and the trainee.

The insertion force along the insertion direction was measured with the system in Figure 3. The system is composed of a cantilever bridge with 4 strain sensors attached on an aluminum sheet. Real needle and tube were used in the tapping part, and an acrylic pipe covered with skin gel was used as a support for the human hand.

2.2 Measurement Experiment

The insertion force was measured with the above system. Experiment was done in Institute of Oriental Medicine located in Chikusa-ku, Nagoya, Japan. A total number of 12 persons, including 5 of the experienced doctor and 7 of trainees were asked to join the experiment. Measurement was done for each person after 1 minute practice time. Then measurement was started with one person to tapping 6 times, in each time he was given a 10 second time to start tapping freely on his willing.

The results of tapping force vs. tapping time were plotted in Figure 4 for the trainees and Figure 5 for the experienced, as the representatives of the average for the 6 tries. It can be seen that the difference in tapping force from the experienced doctor is apparently much less (28gf) than the trainees (306gf). The 2 figures indicate clearly the fact that the experienced doctor carry out much stable insertion than the trainees, and the system quantitatively tell the difference.

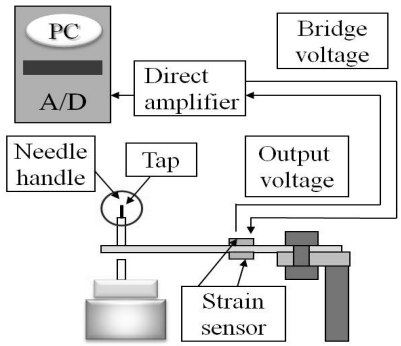

Fig. 3 Measurement device

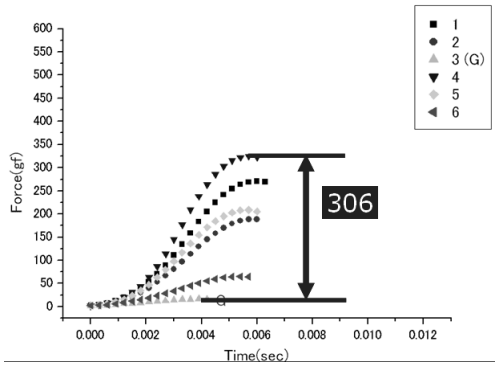

Fig. 4 Results of trainee

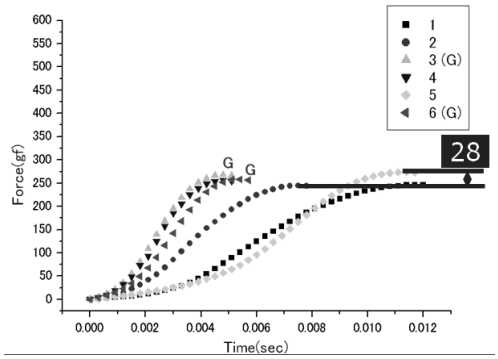

Fig. 5 Results of expert

2.3 Index of the insertion force

A proper value of 260gf was obtained after analyzing the experiment results. This value can then be applied as the standard tapping force of insertion as the index used in the system to judge real-timely an insertion training process.

3. Measurement of Operation Force in Quick Sting

3.1 Quick sting

Therapy technique is the most important and basic operations in acupuncture treatment, which include such actions as to insert the needle into the skin and move it up and down or rotate around for getting proper stimulus on the acupoint of the patient. When therapy technique is carried on, precise control of tiny force from the operation hand is necessary,

because a precise and tiny control of the operation force is directly related to the painful feeling and healing effect.

This study has paid attention to the action of “quick sting” which is the most basic operation in acupuncture. A quick sting is accompanied by the operation of further move the needle, which has already been inserted 3-4cm into the skin, straightly down. The force from the hand to the needle during the quick sting is then measured and evaluated. The force measured is shown in Fig. 6, which is one that parallel to the needle length.

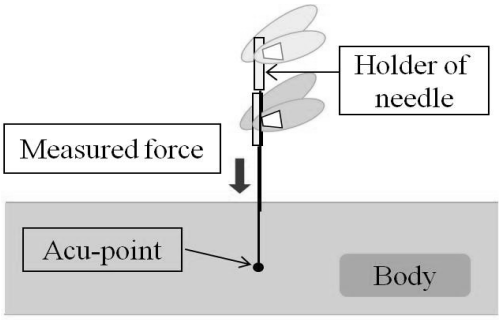

Fig. 6 Force measured in a quick sting

The measuring system and its calibration, experiment process and results are described in the following.

3.2 The Device and System of Measurement

The force used in a quick sting is comparatively with a longer time and timely adjustable in response to the reactions from a patient, in comparison to the force used in an insertion operation. Based on the characteristic of the quick sting, the measurement should be such using a nearly practical needle and stinging into the real skin.

The schematic construction of the measurement system used in this experiment is shown in Fig. 7. The handle is made of plastic and with the size as near as possible to a real needle. A strain gage (Showasokki Co., Ltd.) for pressure measurement (MPA-100KPA) is connected to the handle. The needle is bonded to the face center of MPA-100KPA, and the whole was covered with Al foil and fixed with vinyl tape.

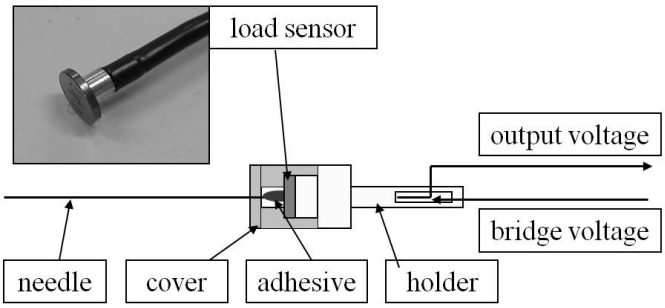

Fig. 7 Schematic of the device

The system was connected to other equipment shown in Fig.8 to construct the whole measurement system. A DC amplifier（AM20: Unipulse Co.）was used to add voltages to the input to transfer the change of resistance into that of voltage and to adjust the level, and the voltage change was read from the output. The above was connected to a PC through A/D board（PCI-3135:Interface Co.）. The ART-LINUX was chosen as the PC operation system for real-timely control, ensuring a correct data collection within the range of operation period of 300-10000μsec.

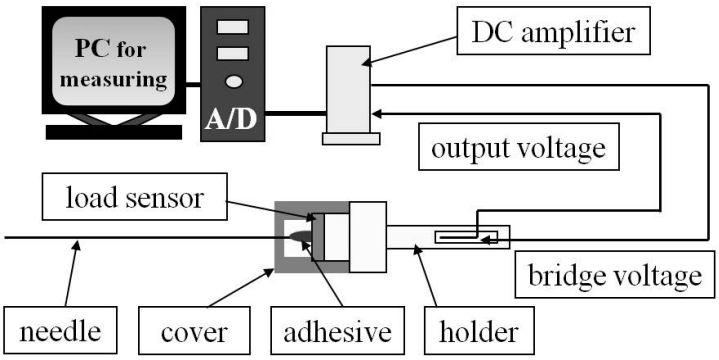

Fig. 8 Force measurement system in quick sting

3.3 Measurement System Calibration

The system calibration was done with experiment shown in Fig.8. A force from the measurement system was applied to the force-gage axis to give the force value, and a voltage value and the applied force value were imputed on the 1ch and 2ch of the A/D board. A formula (1) was then obtained by comparing the above 2 values, converting E(V) to F(gf).

$$F = 78.5 + 115.2 \ln(E + 0.5) \quad \cdots(1)$$

3.4 Measurement Experimental Method

The described system was used to determine the characteristics of the push force in quick sting from 5 expert doctors (Oriental Medical Center®, Chikusa-ku, Nagoya, Aichi, Japan) and 7 trainees (being trained in the institute) doing quick sting. In fact, it is the most ideal to use the human body for sting. However, this has been impossible due to health restrictions. Thus, experiment was done on apples which are quite similar to the human body and are practically used in acupuncture training now. Experiment was done according to the flow as following, 3-4 times for each person.

1) Sting into the apple 2-3cm with the measurement system (insertion state)
2) Making a start, doing 1 quick sting within 10 seconds by pushing the measurement system.
3) Pulling out the needle from apple.

Actually, pushing forces in quick sting differ from acupoint to acupoint [1-2]. The point of Hegu which is one of the most frequently used acupoints was used in this experiment. Hegu is positioned around the point by the roots of thumb and index finger. A measurement period of 300μsec was used.

3.5 Measurement results and Index of the quick sting

The pushing force of a doctor on the needle when doing quick sting was measured in the experiment. The place and persons in experiment were the same with the former one. An apple was chosen as an object, and the acupoint of Hegu was used for stinging. Measurement was done after 1 minute of exercise. It was done in such a way that an experimenter makes a push upon his own time in duration of 10 seconds, repeated 4 times for each experimenter.

Figure 9 shows the result of the 18 recorded data (including 2 error data) from the total 5 experimenters, where the data have been normalized by equation (2) with the horizontal axis in seconds and the vertical axis normalized to unit. The light gray curves are the 18 raw data, and the dark and thicker curve is the result of 18 data after

approximation. Furthermore, L(t) in equation (2) has been normalized, and Force(t) is the push force at the time t during 1 try, Force_MAX the peak force of it, and the approximation was done using equation (3).
From the above results, it was seen that though the experienced doctor shows certain tendency, the trainees show scattered data by a slow speed to move the needle, or move the needle without rhythm (Fig.10).

$$L(t) = \frac{Force\ (t)}{Force\ \_\ MAX} \quad \cdots (2)$$

$$L(t) = 1.06 \exp(-\exp(-Z) - Z + 1)$$
$$Z = (t - 0.392) / 0.919 \quad \cdots (3)$$

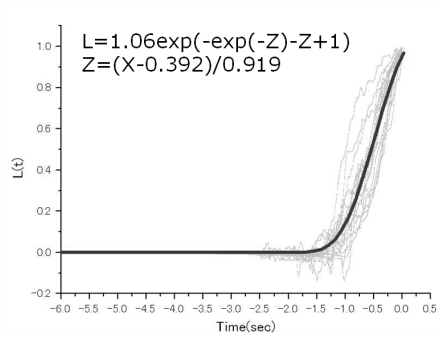

Fig. 9 Normalization of the expert data

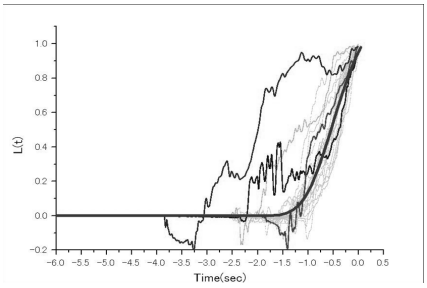

Fig. 10 Compare trainee data with normalization

3.6 Quick Sting Training

A training system for quick sting was built, taking the equation (3) as the index for good, and an apple was used for training. The result from students was demonstrated in Figure 11 together with the index curve. As can be seen, an improvement in quick sting will be obtained when curves of students get near to the index one.

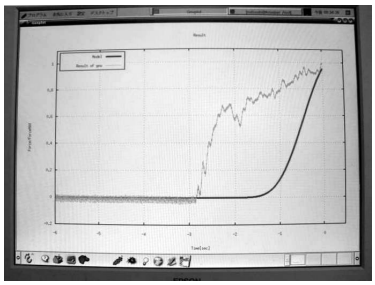

Fig. 11 Training for quick sting approach

4. Conclusions and Future Work

An acupuncture training system was proposed in this study, paying attention to a skill-up of acupuncture operations. A device capable of measuring the operation force in fine movements during acupuncture treatment was made, and quantitative evaluation index for a good performance in the basic insertion and quick sting was obtained. An experienced doctor shows stable tapping according to his own operation index in the insertion operation, and similar speed and rhythm for acupuncture in quick sting. A training system for quick sting was built by taking the data from experienced doctor as the index for good operation.

Further research subjects such as the enrichment of the acupuncture data base and related environment. 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 quantitatively study, training, and evaluation.

Acknowledgements

This study was done partly with the finical support from the JSPS Grant-in-Aid for Scientific Research(C).

References

[1] Mori, H. (1971). Initiation of acupuncture, IDO-NO-NIPPON SHA INC. (p.8-14) (in Japanese)
[2] Sugiyama, I. (2003). Manual of acupuncture. *Gensosha, Inc*. (pp.13-21) (in Japanese)
[3] Watanabe, K. and Kashihara, A. (2010). A View of Learning Support Research Issues Based on ICT Genealogy, Jan. J. Educ. Technol., 34(3), 143-152.
[4] Kanehira, R., et al. (2008). Development of an acupuncture training system using virtual reality technology, *Proceedings of 5th FSKD*, (pp. 665-668). IEEE press.
[5] Kanehira, R., et al. (2009). Insertion angle teaching for an acupuncture training system, *Proceedings of CSEDU2009*, (pp. 281-284). IEEE press.
[6] Kanehira, R., et al. (2009). Indexing of insertion speed for acupuncture training system, Human-Computer Interaction, LNCS 5610, *Springer*, 692-696
[7] Chen, L.Y., et al. (2007). Basic experiment for analysis of acupuncture technique, *Proceedings of 6th EUROSIM*, (pp. 1-6). ELES Press.
[8] Kanehira, R., et al. (2010). Insertion Force of Acupuncture for a Computer Training System, Lecture Note in Computer Science, LNCS 6320, *Springer*, 64-70
[9] Kanehira, R., et al. (2011). Acupuncture Education System with Technique-oriented Training, *Proceedings of 8th FSKD*, (pp. 2524-2528). IEEE Press.