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Notice:
This poster is associated with a Hands-On Demo

Haptic Teaching using Opposite Force Presentation

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1. Abstract

We propose a haptic teaching system that uses haptic devices to teach hand skills. Specifically, we chose some tasks with pencil-like devices and examined how to teach an expert's hand skills. We proposed a new haptic teaching method, in which the haptic device produces force that is in the opposite in direction. The trainee tries to cancel the force and consequently, necessary force is ''proactively'' generated. Our hypothesis is that this ''proactiveness'' is essential for haptic teaching. We made a prototype system and compared our methods with existing teaching methods.

2. Description

Let F_E and F_T be output force of the expert and the trainee. ''Proactive'' operation means that a trainee outputs the force that is necessary for operation and equal to the force F_E. We propose the following methods to realize this situation.

Expert's Phase: The expert's model motion and force F_E are recorded. The haptic device with a tool attached at the tip is used as a measuring machine.

Trainee's Phase: Following two methods are combined.

A) Opposite presentation of expert's force *along* trajectory (F_{inv})
- The haptic device generates the force that has the same amplitude of the expert, but in opposite direction. The trainee tries to cancel the force and consequently, necessary internal force is "proactively" generated.

$$F_T = -F_{inv} = F_E$$

B) The utilization of Virtual Fixtures [2] *orthogonal* to the trajectory (F_{vf})
- Information of the expert's motion is given (figure2), and the pathway is used as a ruler by using Virtual Fixtures technique.

$$F_{vf} = -k\,(x_T - x_E)^3$$

$$F_{disp} = F_{inv} + F_{vf}$$

3. Experiment / Result

The proposed method was compared with the following existing method, through an experiment of letter writing tasks.

- [Existing method] (**Slaved-Tracking Mode**)
  Passively following the expert's positional information as presented by the haptic device.

We recorded force history data while subjects wrote "mirror reversed" Greek letters with both the proposed and existing methods. First, to estimate the effect of these methods, we calculate these correlations between the subject's and expert's history data. Three components of the force (tangential, normal vertical, normal horizontal part(Fig.4)) were separately evaluated. The result is shown in Fig.5. Through comparison, we found our method can transmit tangential and normal horizontal force history to the trainee better than the existing method.

Second, we examine the learning effect of our proposed method and existing method by recording force history data between the iteration of practices. The result is shown in Fig6. We found our method achieves some result in learning tangential force and normal horizontal force.

4. References

[1] Gibson J.J.: Observations on active touch. *Psychol. Rev,* 69: pages 477-491, 1962.
[2] L. Rosenberg. Virtual fixtures: Perceptual tools for telerobotic manipulation. In *Proc. of IEEE Virtual Reality Int'l. Symposium*, pages 76–82, 1993.
[3] Y. Kuroda, M. Nakao, T. Kuroda, H. Oyama, M. Komori and T. Matsuda, "Interaction Model between Elastic Objects for Accurate Haptic Display", *International Conference of Artificial Reality and Tele-Existence (ICAT)*, pages. 148-153, 2003
[4] C. L. Teo, E. Burdet, and H. P. Lim. A robotic teacher of Chinese handwriting. In *Proc. of 10th Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, pages 335–341, 2002.

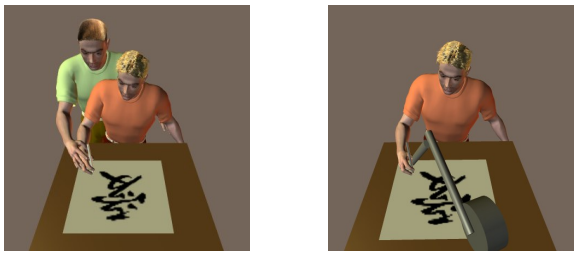


Fig.1: Existing methods

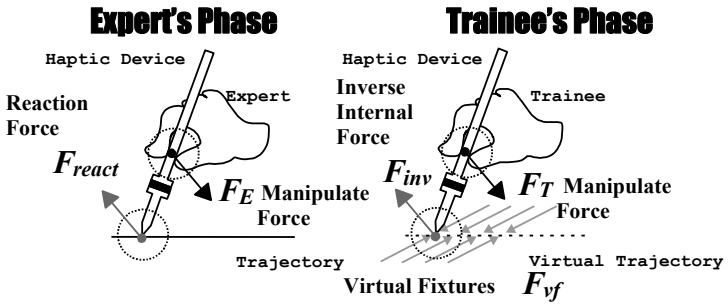


Fig.2: Proposed method

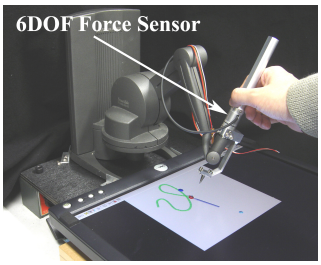


Fig.3: System overview

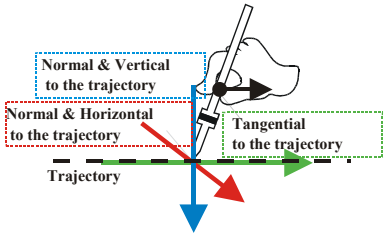


Fig.4: Separating force

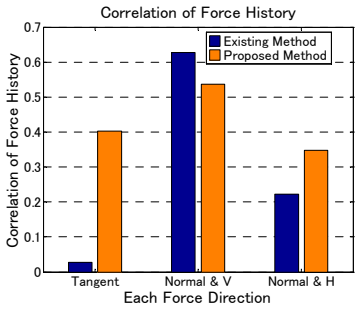
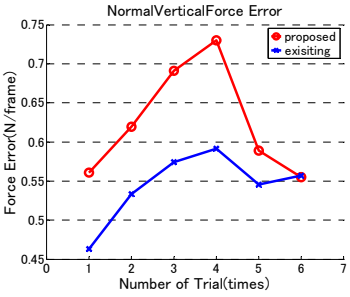


Fig.5: Correlations of force history



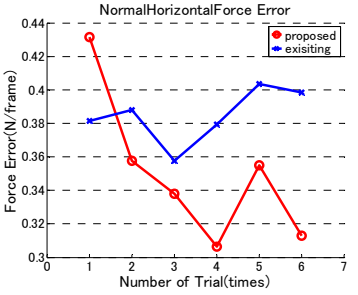


Fig.6: Learning Curves of Each Force