A Surgical and Fine-Motor Skills Trainer for Everyone? Touch and Force-Feedback in a Virtual Reality Environment for Surgical Training.

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Abstract. Access to the laboratory component of a class is limited by resources, while lab training is not currently possible for distance learning. To overcome the problem a solution is proposed to enable hands-on, interactive, objectively scored and appropriately mentored learning in a widely accessible environment. The proposed solution is the Virtual-Reality Motor-Skills trainer to teach basic fine-motor skills using Haptics for touch and feel interaction as well as a 3D virtual reality environment for visualization.

Keywords. Surgery, Trainer, Simulator, Virtual Reality, Haptics, Force-Feedback, Touch, Fine-Motor Skills, Simulation, Laparoscope, Suction, Extraction, Implantation, Bimanual, 3D, VR, Human-Computer Interaction, SPRING

1. Introduction

Didactic learning is taught to large audiences in a conventional classroom setting with the lecture hall further expanded for distance learning, using either live teleconference or archived video to provide wider educational access for students. However, this luxury is not afforded to the teaching of motor skills or manual tasks, as an expert instructor traditionally interacts with students in a laboratory environment. Access to the laboratory component of a class is limited by resources, while lab training is not currently possible for distance learning.

To overcome the problem a solution is proposed to enable hands-on, interactive, objectively scored and appropriately mentored learning in a widely accessible environment. The ultimate goal of such a solution is to preserve faculty resources, which would in turn provide either wider access to live laboratory exercises, or the ability to expand the curriculum for the same number of students. Likewise, with distance learning possible, geographically isolated rural populations or persons with confining disabilities will have greater access to training.

The addition of Haptics (Touch & Feel) to computer-assisted learning has broader societal implications, as auditory and visually impaired persons with disabilities would have a new tool to enhance learning for all disciplines and all age groups. The proposed solution is the Virtual-Reality Motor-Skills trainer (VRMS) to teach basic laparoscopic skills using Haptics for interaction and a 3D virtual reality environment for visualization.

2. Related Work

Computer assisted VR simulation has successfully been applied to various fields in medicine. Simulation systems exist for microsurgery [1], sinus surgery [3] and operative hysteroscopy [10] among others. Surgical simulation has found to support learning in numerous studies conducted [4][6][11]. The SPRING software framework used for this research has successfully been applied to various projects [8][9]. SPRING is specialized in soft-tissue modeling and Haptics.

Previously, costs for a dual-handed Haptics station were in the area of $20,000. Laparoscopic simulators are in the neighborhood of $100,000. However, efforts are underway to produce a low-cost Haptics interface device targeted at the consumer market for under $100 a piece[1]. This makes the system very affordable. Distributed capabilities of the software framework further allow for easier access as well as centralized data collection.

3. Motor-Skills Trainer

The goal of this interdisciplinary research is to move toward an understanding of human performance in skills development through computer assistance as well as to increase laboratory access and distributed learning.

The Virtual-Reality Motor-Skills trainer created is specifically designed to teach baseline fine-motor skills used in surgery, in a non-threatening abstract environment. Bead-like objects of various sizes are manipulated in 3D virtual space. Complexity is increased or decreased by changing the following factors: requirement for non-dominant or bimanual hand use with and without wrist rotation; environmental changes (depth of field, decreased exposure, smaller objects, and obstacles). Haptics is utilized for touch and force-feedback to provide more human-computer interaction and realism then previously possible for personal-computer applications. Figure 1 depicts the surgical simulator incorporating hinge operation and blood suction.

The performance measures being scored include motor skills (speed, accuracy, efficiency of motion) and cognitive skills (appropriate procedure selection). Dominant, non-dominant hands working in tandem will be trained and evaluated. The learning outcome will be progressive learning improvement and successful task acquisition based on expert and peer standards.

[1] Novint Technologies, http://www.novint.com/ (Novint Falcon)

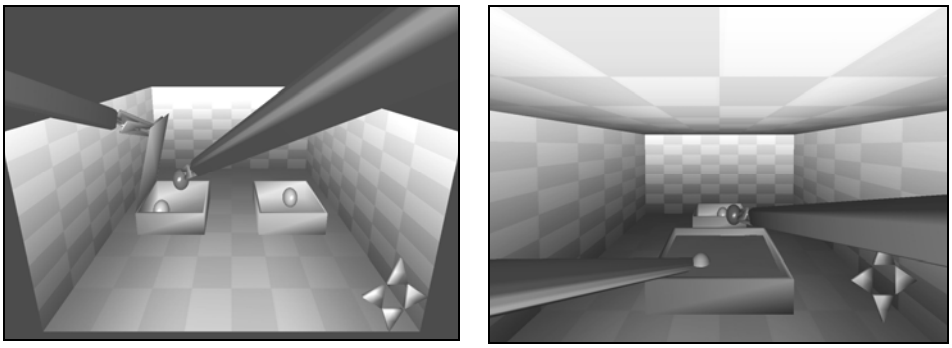

Figure 1 - Virtual Reality Motor-Skills Trainer

4. Contributions and Future Directions

The surgical trainer created is designed to teach surgical extraction and implantation skills focusing on motor, surgical and cognitive proficiency. Currently, no empirical studies were conducted, which are planned next to evaluate learning and usability of the system.

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