Centralized Data Recording for a Distributed Surgical Skills Trainer to Facilitate Automated Proficiency Evaluation

Christoph ASCHWANDEN[1, 2], Craig CORNELIUS[3], Lawrence BURGESS[2]
Kevin MONTGOMERY[3], Aneesh SHARMA[3]
[1]*caschwan@hawaii.edu*
[2]*Telehealth Research Institute (TRI)*
[3]*Stanford-NASA National Biocomputation Center*

Abstract. Virtual reality simulators have the capability to automatically record user performance data in an unbiased, cost effective manner that is also less error prone than manual methods. Centralized data recording simplifies proficiency evaluation even more; however is not commonly available to date for surgical skills trainers. We will detail our approach in implementing a framework for distributed score recording over the Internet using a database for persistent storage.

Keywords. Surgery, Trainer, Simulator, Virtual Reality, Haptics, Force-Feedback, Touch, Fine-Motor Skills, Simulation, Laparoscope, Metrics, Benchmark, Recording, Proficiency, Evaluation, Distributed, Internet, TCP/IP, Database, Remote, HTTP, 3D, VR, Human-Computer Interaction, SPRING, VRMSS

1. Introduction

Minimal invasive surgery has been shown to have advantages over conventional open methods. Laparoscopic procedures now represent the 'gold standard' for various surgical procedures. However, lack of 3-D depth perception as well as the fulcrum effect of the body wall on instrument handling pose major obstacles that make effective training imperative. Surgeons are currently trained using conventional box trainers as well as virtual reality simulators.

Physical box trainers benefit from lower cost and much greater availability compared to VR simulators. However, their data recording and score taking capabilities are limited, and detailed performance assessment on inanimate box trainers requires subjective human-monitored evaluation, which is not only costly but also error-prone [7].

2. VRMSS and Distributed Score Taking

To broaden access to such training, a Virtual Reality Motor-Skills Simulator (VRMSS) was implemented [1]. VRMSS features distributed surgical 3D motor-skills training using Haptics for touch and feel feedback, and is designed as a low-cost alternative to current state-of-the-art practices in place. VRMSS is built using SPRING, a real-time soft-tissue modeling engine [5].

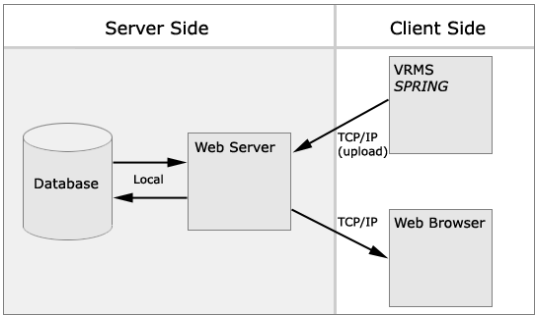

Figure 1 - System Setup

VRMSS has been equipped with automated logging capability which allows for data recording over TCP/IP, i.e., a local network or the Internet. See **Figure 1** for details. The system provides functionality for upload and download of training data on the client side, with the server offering persistent storage as well as basic data analysis/visualization capabilities for a single or multiple users.

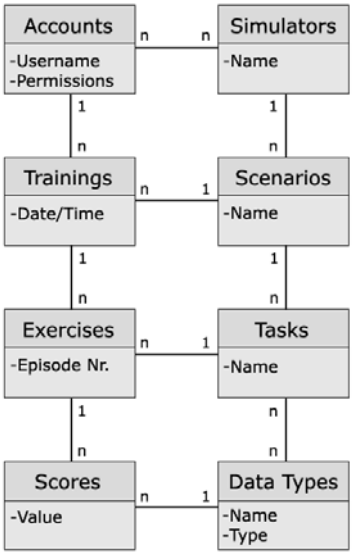

Figure 2 - Database Schema

A web-based prototype system to allow data recording for various types of simulators was constructed [2]. The database schema is depicted in **Figure 2**. The tables on the right-hand side hold the metadata defining the simulators, scenarios, tasks and data types to record. The tables on the left-hand side contain the actual data recorded including trainings, exercises and scores.

Current types of data elements recorded include task duration, collisions, distance, rotation, errors, hand jitter and steadiness. Preliminary pilot tests were completed successfully. Data was successfully recorded over the Internet and persistently stored in the database.

3. Contributions and Future Directions

A framework for remote data recording was created, tested and made available to interested 3rd parties [2]. The metadata tables in the framework allow for custom scenario creation, i.e., configuring the system to specify what data will be collected. To date, scenarios for the VRMSS as well as a Nephron simulation have been implemented. The framework can be accessed from any operating system including Windows, Macintosh, Linux and UNIX. A custom HTTP request allows data uploading/downloading to/from the framework. The HTTP protocol supports tunneling through Firewalls and Proxy servers, thus removing limitations of other available solutions. A MySQL database server in the background is responsible for persistent data storage, and the database is backed up regularly.

The ultimate goal is to provide wider access to surgical training, be it in the lab, at home, or in remote areas. Students can learn on their own time, being monitored through the automated data recording framework. Proficiency levels are determined automatically, and score-taking is unbiased.

References

[1] Aschwanden C, Sherstyuk A, Burgess L, Montgomery K. A Surgical and Fine-Motor Skills Trainer for Everyone? Touch and Force-Feedback in a Virtual Reality Environment for Surgical Training. Medicine Meets Virtual Reality 14, 2006.

[2] Data Recording Framework. http://www.tri.jabsom.hawaii.edu/surgicalsimweb

[3] Dev P, Montgomery K, Senger S, et al. Simulated medical learning environments over the Internet. J Am Med Inform Assoc.

[4] Heinrichs, W. L., Srivastava, S., Montgomery, K., and Dev, P. (2004). The Fundamental Manipulations of Surgery: A Structured Vocabulary for Designing Surgical Curricula and Simulators, J Am Assoc Gynecol Laparasoc, 11(4), 450-456.

[5] Montgomery, K., Bruyns, C., Brown, J., Sorkin, S., Mazzella, F., Thonier, G., Tellier, A., Lerman, B., Menon, A. (2002). Spring: A General Framework for Collaborative, Real-time Surgical Simulation, In: Westwood, J., et. al. (eds.): Medicine Meets Virtual Reality, IOS Press, Amsterdam, 2002.

[6] Seymour, N. E., Gallagher, A. G., Roman, S. A., O'Brien, M. K., Bansal, V. K., Andersen, D. K. and Satava, R. M.(2002). Virtual reality training improves operating room performance: results of a randomized, double-blinded study, Ann. Surgery, 236(4), 458-464.

[7] Woodrum DT, Andreatta PB, Yellamanchilli RK, Feryus L, Gauger PG, Minter RM. Construct validity of the LapSim laparoscopic surgical simulator. Am J Surg. 2006 Jan; 191(1):28-32.