Development System for Intelligent Surgical Box-Trainer Research
2018-19 FRACAA Award

Project #: 161, Award Amount: $10,000

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Introduction

Laparoscopic surgery, also referred to as **minimally invasive surgery,** describes the performance of surgical procedures with the assistance of a video camera and several thin surgical instruments. During the surgical procedure, small incisions of up to half an inch are made and plastic tubes called ports are placed through these incisions. The camera and the surgical instruments are then introduced through the ports which allow access to the inside of the patient. The video camera becomes a surgeon's eyes. Excellent eye-hand coordination capabilities are crucial to carry out **laparoscopic surgery procedures.** Gaining basic laparoscopic skills such as transferring an object, cutting, and clipping are essential tasks and can be achieved with the use of a very basic low-fidelity laparoscopic setup, such as a surgical box-trainer.

There is an ongoing research collaboration between the faculty of the Department of Surgery and the ECE Department for over three years that has led to the development of two, intelligent box-trainer devices enhanced by sensors and HD digital video cameras along with a fuzzy logic-based performance assessment system. Two of these devices have been installed in the Surgery Simulations Laboratory, in WMed, and are being used by surgery residents for laparoscopic surgery skill training.

Objectives and Significance

The goal of this project was to develop an integrated hardware/software solution for an intelligent performance assessment support system. A relatively new research area, the proposed system is intended to add objective data to an area which has traditionally relied solely on subjective evaluations. Using fuzzy logic to implement an intelligent decision support, or assessment support system is a new approach in the field of medical training devices. Fuzzy logic allows the fusion of domain expert knowledge (i.e., the skill levels and accumulated knowledge of practicing surgeons) with measured data in a vague and imprecise context. The experts can be interviewed to assess the recorded data, and define what sort of results constitute "Bad", "Good" and "Excellent" to name a few outcomes. By setting up fuzzy IF THEN rules a knowledge base can be built for assessment (i.e., a linguistic model of the system). Once the knowledge base has been created, a fuzzy inference mechanism will take the fuzzified test input data (i.e., measured force values, tool tip movements with respect to nested, virtual 3D "boxes" and the time taken) and then devise the corresponding fuzzy set outputs. After defuzzification, the system will deliver the assessment

results using linguistic terms. An advantage of using fuzzy logic for this project is that the initial fuzzy IF THEN rules can be set up by having very few, or even no experimental trainee data at all. As a contrast to this, no statistics-based system can be created without a large body of recorded data.

Functional Block Diagram

The system's block diagram is illustrated in Fig. 1.

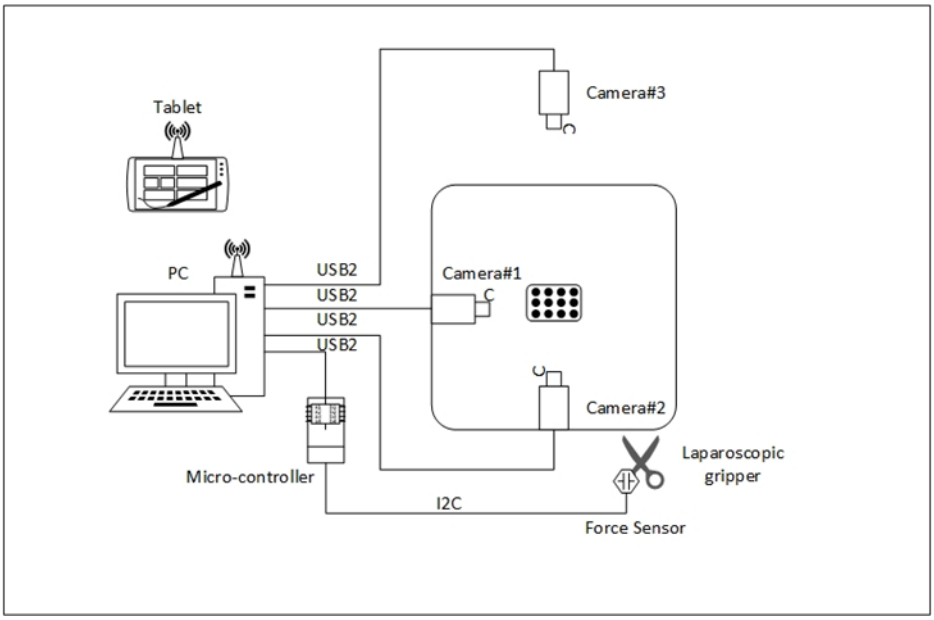
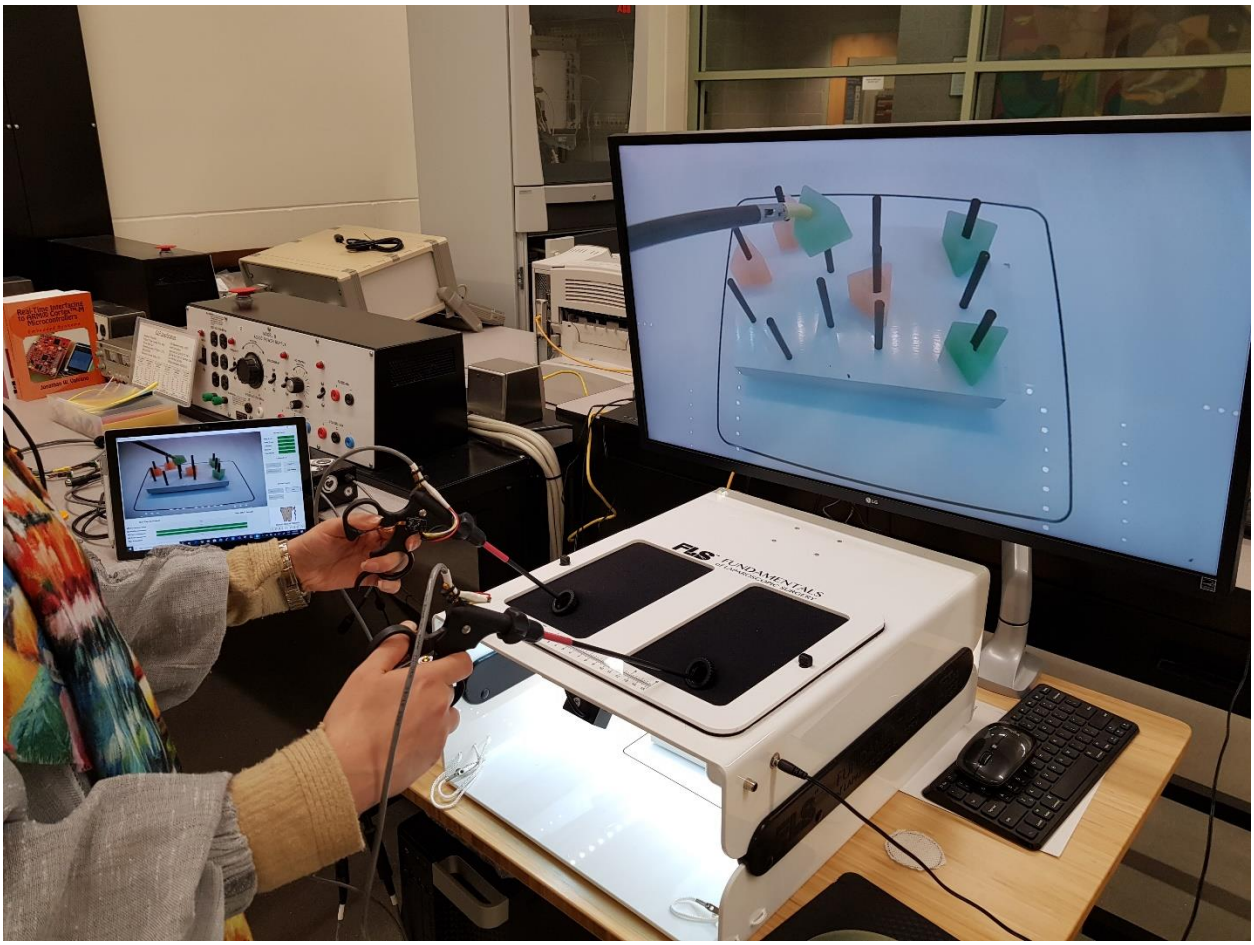
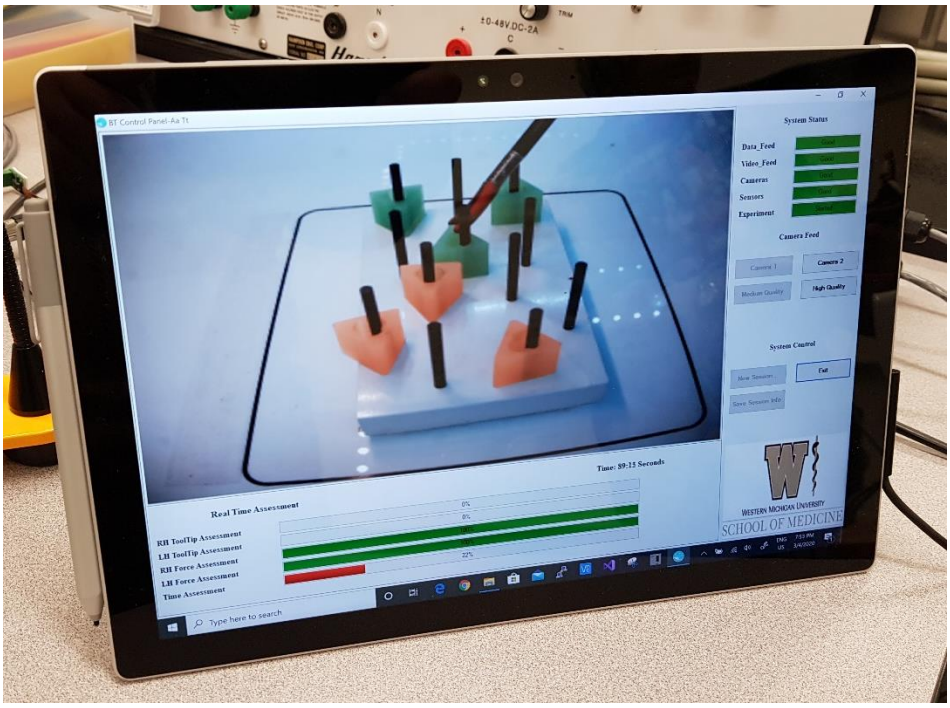


Figure 1. Development System for Intelligent Surgical Box-Trainer Research

Implementation


FLS FUNDAMENTALS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System Status
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Video_Feed
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Experiment
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Camera 2
Medium Quality
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Time: 89:15 Seconds
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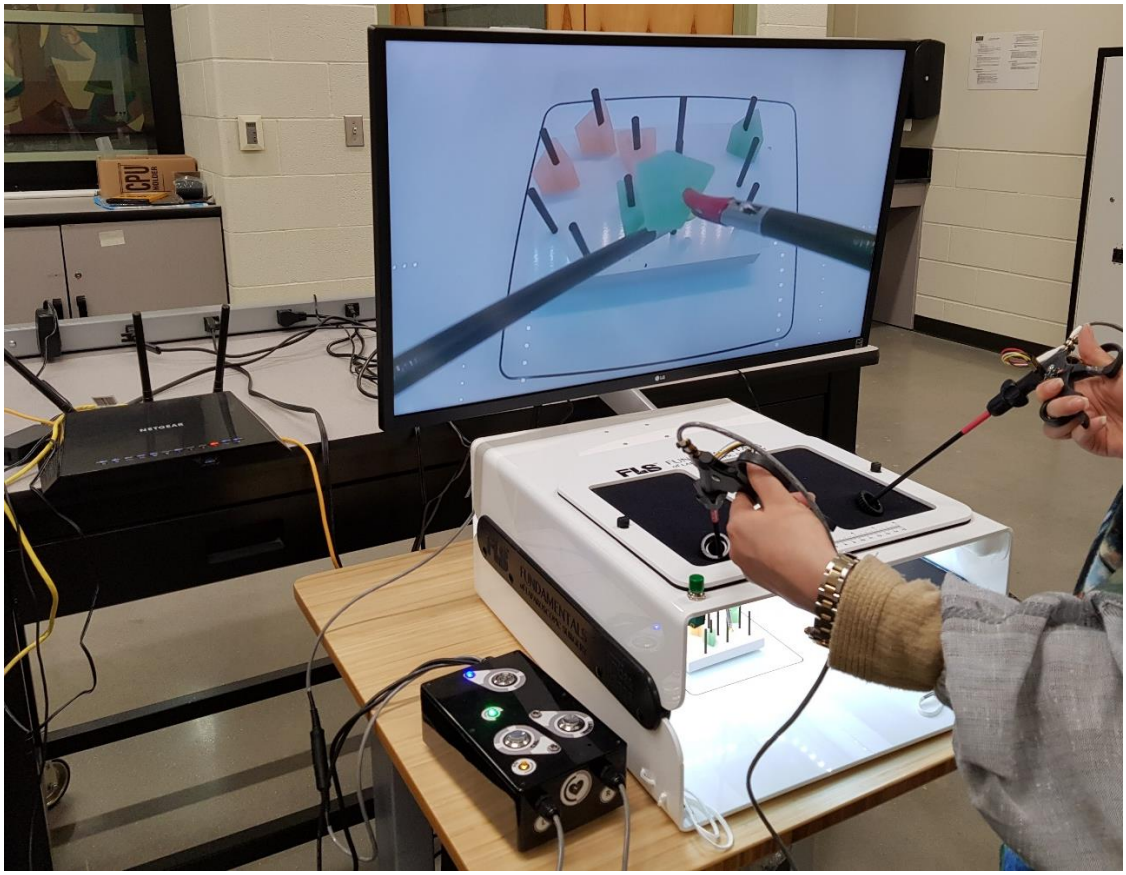

Further Research Plans

- Extend our intelligent assessment system to support all five test procedures which are carried out by using the universally accepted Fundamentals of Laparoscopic Surgery (FLS) Trainer device. According to our knowledge, there is now such system currently available in the surgery simulations area.

- Development of a Virtual Coach (VC) System for Laparoscopic Surgery Skill Assessment and Training. By adding various sensory devices, HD video cameras, ESD protection, AR and VR devices, a main computer workstation, a tablet computer and digital video image processing and computational intelligence software (fuzzy logic and neural networks) to the standard FLS Box-Trainer device, our objective is to develop a Virtual Coach System which will offer intelligent, objective, automated real-time assessment of laparoscopic surgery test procedures (in FLS Test Mode) and will also provide audio and visual coaching feedback for the user to train for laparoscopic surgery (in Virtual Coach Mode).

- Develop and submit a proposal to the Technological Development Fund, ORI, WMU, to build a hardware prototype of the VC System

- Develop and submit research grant proposals along with faculty of the Department of Surgery, WMed, to NIH and NSF, to secure funds for our Virtual Coach System research.

Publications

Janos L. Grantner, Aous H. Kurdi, Mohammed Al-Gailani and Ikhlas Abdel-Qader, Robert G. Sawyer, M.D. and Saad Shebrain M.D., Multi-Thread Implementation of Tool Tip Tracking for Laparoscopic Surgical Box-Trainer Intelligent Performance Assessment System, Acta Polytechnica Hungarica, Special Issue, Vol 19, Issue 9, September 16, 2019, http://www.uni-obuda.hu/journal/Issue96.htm

Janos L. Grantner, Aous H. Kurdi, Mohammed Al-Gailani and Ikhlas Abdel-Qader, Robert G. Sawyer, M.D. and Saad Shebrain M.D., Intelligent Performance Assessment System for Laparoscopic Surgical Box-Trainer, in the Electronic Proceedings, 2018 World Congress on Computational Intelligence, WCCI/FUZZ-IEEE, July 8-13, 2018, Rio de Janeiro, Brazil