Models and Methods for a High Autonomy, Self-Improving Surgical Training System

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***Abstract*—This paper is a summary of the presentation on how to incorporate high autonomy and self-improvement features into the prototype of the computer-assisted surgical trainer (CAST) developed in the author's laboratory.**

Keywords—minimally invasive surgery, surgical training, machine learning.

As one example for relevant work in the context of self-improving system integration [1], [2], we consider minimally invasive surgeries (MIS) in this talk.

Such procedures reduce recovery time and postoperative pain [3]. However, in these procedures surgeons may lose many of the tactile and visual cues that they rely upon in conventional surgery. Our work focuses on the use of high technology to assist in laparoscopy training [4]-[9]. This presentation will provide an overview of the advanced simulation, control, reasoning, and augmented reality concepts to support minimally invasive surgical training. It will discuss some of the existing systems, their advantages and shortcomings. Then, a design of a surgical training and assessment system that provides sensing and reasoning capabilities in laparoscopy education will be presented. We will discuss our efforts to develop sensing and machine learning models so that the system could self-improve in guiding trainees through progressively more complex surgical exercises so that proficiency could be achieved in a non-patient based setting [8]-[9]. The key to our guidance approach is a set of control algorithms that adjust the degree of haptic (force) assistance to a user who is to complete a particular surgical exercise based on the optimal (nominal) model [8]. The more the user deviates from the nominal model, the higher degree of support he or she receives from the system. We also use augmented reality overlays to provide visual cues (in addition to force navigation) to improve the trainees' situational awareness in the surgical field of view [7].

A training device prototype, called Computer-Assisted Surgical Trainer (CAST) has been developed and will be described as will our vision for the future use of this technology as a surgical assistant system in the operating room. Further reading can be found in [5].

ACKNOWLEDGMENT

The material which will be presented in the talk is being developed with the support of the National Science Foundation under Grant Number 1622589 "Computer Guided Laparoscopy Training". Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation

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978-1-5090-6558-5/17 $31.00 © 2017 IEEE
DOI 10.1109/FAS*W.2017.41

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