INTRODUCTION

• With robotic surgery being adopted more widely, objective assessment and training for certification of robotic surgery are receiving increasing research attention.

• Training tasks, models, and metrics are all being developed and reported. However, published research quantities skill as a monolithic quantity and do not associate metrics with specific aspects of robotic surgery (e.g., surgical skills, or machine interaction aspects) or specific aspects of skill (e.g., a proficient technique or safe approach).

• We aim to develop automated objective measures of proficiency in robotic surgery, including the safety of manipulation and need for feedback.

• We are conducting a multi-center study which aims to collect data at regular benchmarking intervals from users of varying skill (trainees and experts).

OBJECTIVES

• Create metrics and measures for surgical and training environments for assessing operational skills quantitatively and can distinguish between experts and novices – with emphasis on man-machine interaction and safety.

• Create methods for providing quantitative and objective feedback to users for improving the efficiency of training.

METHODS

• Our multi-center data collection consists of robotic surgery trainees and experts providing benchmarking data from a standard set of tasks at regular intervals.

• Our data collection system (Figure 1) can be attached to the da Vinci system and can collect video and motion data without any user interaction.

• Using this portable recording system, we have longitudinally (approximately monthly) acquired stereo instrument video, time-stamped and synchronized with instrument and hand motion data from several benchmarking training tasks (e.g., suturing) from 28 subjects (trainee and expert surgeons, with none to more than 20 years of medical experience) over an approximately 2 year period.

• The acquired data was analyzed to assess a subject's ability to perform safe manipulation, and style aspects of safe manipulation across trainee and expert subjects.

• Using the calibration parameters for the endoscopic cameras, the motion of the instrument was projected into the camera workspace with accuracy greater than 40 pixels, sufficient to overlay the motion vector visually on the instrument shaft.

• The instrument motion outside the field of view (unseen instrument motion, or placement of instruments outside the field of view) in the integrated motion and video data was then automatically segmented.

• This unseen motion was then analyzed with respect to its distance from the field of view, cumulative motion statistics, and for comparison across the two classes.

• In addition, the image zoom and camera field of view were also assessed for each skill class.

ILLUSTRATIONS

CONCLUSIONS

• Results show that experts possess a much greater situational awareness.

• The cumulative distance moved by the instruments outside of field of view - which is commonly used to assess safe motion - was greater for the experts (e.g., experts 0.7m versus trainees 0.2m in one test), the envelope of such motion around the field of view was smaller (as was the standard deviation), compared to the trainees.

• Unseen instrument motion alone was not representative of skill in our data. The location of such unseen with respect to the field of view was also important.

• This finding was confirmed by measuring the average working distance maintained by the subjects (experts << trainees), resulting in experts often moving or placing instrument outside of the smaller field of view, but in "safe" or "known" areas.

FUTURE WORK

• Detailed statistical classification on segmented data to assess surgical skills and learning curves along with operational skills.

• Analysis of response times to errors and system events.

• Development of metrics across multiple systems like the da Vinci Skills Simulator, da-Trainer and the da Vinci systems themselves.

REFERENCES

1. Intuitive Surgical, Inc.: The Intuitive Surgical Robotic Surgery Training Program. (2008)

DISCLOSURES

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