INTRODUCTION

- The da Vinci surgical teleoperation system (Intuitive Surgical Inc., Sunnyvale, CA) has achieved wide user acceptance in complex surgical procedures such as prostatectomies, hysterectomies, nephrectomies, mitral valve repairs, and several otolaryngology procedures.
- Robotic surgery training often focuses on massed training composed of a small set of console operated training tasks.
- To train our subjects in every aspect of robotic head and neck surgery, we report on a novel robotic surgery training regimen integrating objective skill assessment and consisting of four training modules of increasing complexity, including procedure specific training for transtracheal base of tongue surgery.

OBJECTIVES

- Development of curricular robotic surgery training methods specifically for otolaryngology – transoral robotic surgery procedures.
- Development of metrics and measures for quantitative assessment of operational skills for effectively distinguishing between experts and novices.
- Development of methods for effective feedback during robotic surgery training and customization of training for each trainee.

METHODS

- Our data collection system (Figure 1) can be attached to the da Vinci system without any additional configuration.
- The da Vinci system provides an application programming interface (API) which gives us access to the tool, camera, master handle Cartesian positions, motion velocities including joint angles, gripper angles, joint velocity and torque data.
- Over approximately one year in 2010-2011, 8 otolaryngology residents from an academic hospital participated in four distinct phases of robotic surgery training.
- These modules included:
  1. didactic module,
  2. operational skills module,
  3. patient side system setup module, and
  4. ex-vivo surgical extrusion of a simulated “tumor” located in the base of an ex-vivo porcine tongue.
- Trainees performed four iterations of each module approximately at a week’s interval.
- In addition to trainees, baseline performance data was obtained for four experts with two executions of each training module.
- Endoscopic and operating room scene video and instrument motion was recorded for each module and analyzed using offline automated analysis. All recorded sessions were also assessed by multiple experts using structured assessment (OSATS Likert scale of 1 to 30) in addition to automated analysis.

RESULTS

- Study results show experts and trainees are well separated at the beginning of each training module. Computed automated measures (for example, average task completion time 943sec, std.dev. 227sec for experts versus 146sec, std.dev. 484sec for trainees for module 1 at week 1, and expert margin measurement time of 19.5 sec compared to an average time of 62.6sec for trainees for module 2 at week 2.
- Computed performance measures correlate with OSATS assessment for each module. Subjective assessment by experts, and measurement of margins for the removed tumor verified the clinical utility of the stage 3 surgical environment.
- A survey of trainees consistently rated it as very useful in progression to human operating room assistance.

ILLUSTRATIONS

![Image of data collection system](https://example.com/data_collection_system)

![Image of training tasks](https://example.com/training_tasks)

**Figure 1:** System setup and training tasks for the three training modules [3]

LEARNING CURVES

![Image of learning curves](https://example.com/learning_curves)

**Figure 2:** Selected Learning curves. OSATS scores range 0 to 30 over the four sessions and three modules. Experts appear in the upper left hand corner. In future iterations of the training regimen, the average expert scores will be used to graduate trainees to the next module [3].

CONCLUSIONS

- Structured multi-module training may provide a more complete training regimen for robotic surgery residents.
- Automated objective assessment promises to reduce the overhead for mentors, and measurements show trainees improving towards the better expert scores over the course of the training in each aspect of robotic operation.
- Anecdotally, trainees performing their initial human surgeries have reported favorably on utility of their training experience.

FUTURE WORK

- Additional statistical analysis on segmented motion data for development of automated feedback methods.
- Analysis of response times to system events and errors.
- Integration of simulation module in the training process.
- Development and application of the development methods in curricular use and customization of training modules for trainees.

REFERENCES


DISCLOSURES

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