Title:

Reducing Cost and Complexity in Computer-Assisted Training for Lumpectomy

Authors:

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Background:

With the ongoing implementation of competency-based medical education, continually monitoring trainee performance is crucial. Unfortunately, it is infeasible from a staffing perspective for experts to constantly monitor trainees. Instead, computer-assistance may be used to provide automatic feedback and assessment when a supervisor is not present. This reduces the expert workload and allows trainees to perform self-guided practice.

Unfortunately, most computer-assisted training setups require many sensors and instruments to measure performance. This makes these setups too complicated to be run without technical support and too expensive to deploy in mass. We hypothesize, however, that many of these sensors are unnecessary. We suggest the complexity and cost of many training setups can be reduced by using only the necessary sensors, without compromising accuracy.

Objective:

The objective of this work is to determine computationally the minimal set of sensors which are necessary for computer-assisted assessment of technical proficiency in lumpectomy.

Methods:

We retrospectively analyzed a dataset from a simulation-based training study on breast lumpectomy. This dataset included lumpectomies recorded from a group of junior surgical residents and from a group of expert surgeons as reference. In each case, sensors were affixed to participants' hands and surgical instruments to automatically measure performance.

To determine which sensors were necessary, we developed a mathematical formulation based on factor analysis to evaluate the reliability and redundancy of the information provided by each sensor. We also used this formulation combined with domain knowledge from an expert to identify which facets of skill each sensor measured. Subsequently, the information from each sensor was combined into an overall technical proficiency level (i.e. proficient vs. not proficient) for each participant. We evaluated whether using information from the subset of sensors we identified to be necessary was as reliable for technical proficiency assessment as using information from all sensors.

Results:

We identified that the sensors measured three facets of skill in lumpectomy: excision efficiency inside tumour safety zone, excision efficiency outside tumour safety zone, and palpation efficiency. We identified that of the six sensors used the in training setup, the two sensors attached to the hands were unnecessary. Using just the subset of necessary sensors, we achieved 82% accuracy in overall technical proficiency assessment compared to 88% using all sensors.

Conclusions:

We have shown how to reduce systematically the complexity and cost of a computer-assisted training setup for lumpectomy, while maintaining enough information to estimate technical proficiency when an expert is not present. This makes the setup more accessible for deployment in surgical training curricula. These methods can be similarly applied to other computer-assisted training setups and have already seen success in training for FAST examinations, central line insertion, and lumbar puncture.