Automated Recognition and Quality Assessment of Surgical Techniques

A new project in the CISST ERC has applied statistical modeling techniques, originally developed for speech recognition, to recognize common surgical maneuvers. The hypothesis is that a small basis set of surgical skills, such as suturing, retraction, dissection and so forth, form the underlying "vocabulary" for the larger "language" of surgery. These skills thus provide a structured, objective basis for assessing the overall technical ability of a surgeon. Automated methods for recognizing basic manipulation skills can also providing a means for contextual information feedback, semi-automated robotic assistance, and automated annotation of physiological or video data from a surgery. Furthermore, they can be used to provide diagnostic feedback to a surgeon-in-training, thus enabling automated, "intelligent" tutoring of surgical technique.

Work to date was performed on a corpus of 15 trials of an expert surgeon and 12 trials of an intermediate surgeon; each trial consisting of a four-throw suturing task performed on the daVinci robot. After analysis of the suturing task by an expert cardiac surgeon, a motion vocabulary of eight rudimentary surgical gestures was defined. The three statistical classification methods, linear discriminant analysis (LDA), hidden Markov models (HMM) and support vector machines (SVM), were applied and yielded a 93 % recognition rate.

Two representative data traces and the corresponding output of a three-dimension projection computed by LDA on the expert and intermediate data is shown in Figure 1. Figure 2 shows the reliability of LDA in separating motion data into 6 distinct regions in a 3-dimensional projection space. An intermediate surgeon's motions tend to not separate as well, indicating less consistent motions. Figure 3 shows the resulting segmentation which indicates that all of the segmentation errors occur at the boundaries between gestures. Current work is continuing to develop more sophisticated models of the "language of surgery," and the development of methods to make use of both motion and video data to improve the breadth and quality of information acquired using automated observation methods.

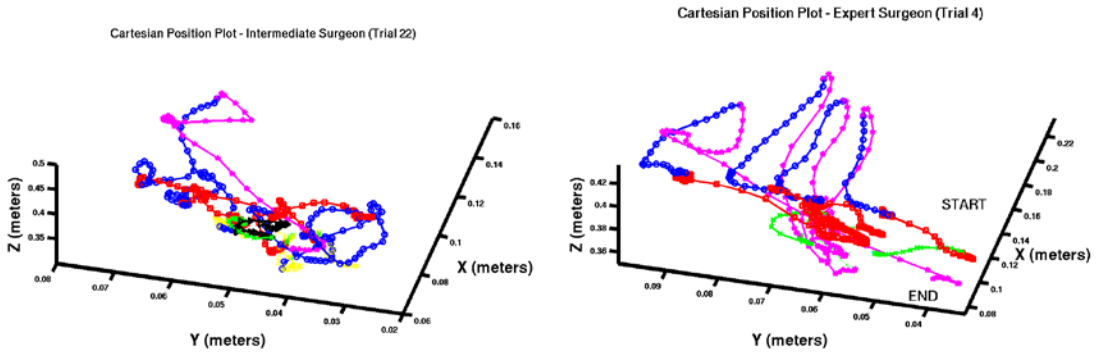

Figure 1. A plot of the Cartesian positions of the da Vinci left master manipulator, identified by surgical gesture, during performance of a 4-throw suturing task. The left plot is that of an expert surgeon while the right is of a less experienced surgeon.

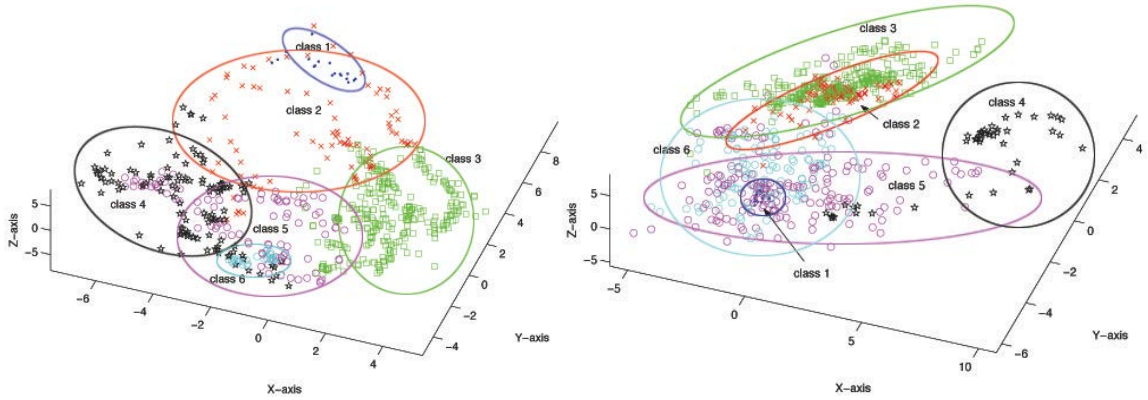

Figure 2. The result of LDA reduction with m=6 and d=3. The expert surgeon's motions (left) separate more distinctly than the less experienced surgeon's (right).

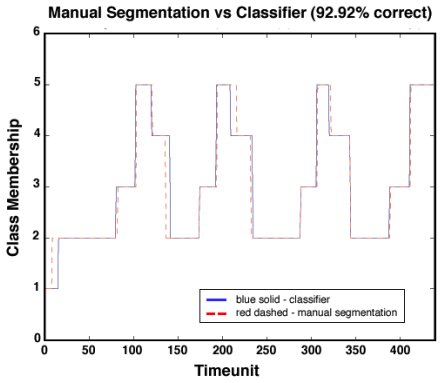

Figure 3. A comparison of automatic segmentation of robot-assisted surgical motion with manual segmentations in one of the trials. Note that most errors occur at the transitions.