Feature Selection and Classification Models for Endotracheal Intubation Training Devices

Introduction: Endotracheal intubation (ETI) is a medical procedure by which a tube is inserted into the trachea to open the airway and support breathing. Since unsuccessful attempts and prolonged time to complete can lead to serious complications, continuous ETI training is required, even for senior doctors, to acquire and refine the skills for ETI to be performed in a short period of time. However, current practice of ETI training relies heavily on the use of bulky and costly mannequin with supervisor’s observation, which complicates continuous training. To overcome the challenge, this project aims at developing wearable gloves embedded with sensors for self-training. To this end, this study presents identification of features that can discriminate between novices and experienced providers by analyzing data collected from accelerometers. Based on the selected features, classification models are developed and tested to evaluate the potential of this approach in developing efficient devices for ETI training.

Materials and Methods: Simulated ETI procedures were performed for data collection by two groups: a group of novices with <10 prior ETI attempts and a group of experienced providers with >100 prior ETI attempts. Each person performed ETI on a mannequin 6 times where the hand motion was captured by accelerometers that provide roll, pitch, and yaw measurements. Two critical hand motion segments were found to require more complicated skills: 1) inserting laryngoscope into the mouth to secure the path for a plastic tube by left hand; and 2) inserting a plastic tube into the trachea by right hand. For each of the segments, we analyzed hand motion data with roll/pitch/yaw in time domain for standard deviation (std) and in frequency domain for the max amplitude (amplitude) and the frequency at the max amplitude (frequency) using MATLAB. A total of 18 features were analyzed for their significance to remove features with high p-value. Subsequently, correlations between the features were investigated for feature selection by removing highly correlated features. With the reduced feature set obtained, artificial neural network (ANN) models were developed to classify subjects into the two groups.

Results and Discussion: 18 features were extracted from the dataset collected from 12 novices (59 samples) and 5 experienced providers (28 samples). Among the 18 features, 8 features were found to be significant: std of pitch/yaw (p-values of 0.012 and < 0.001, respectively), and amplitude of yaw (p-value = 0.003) in left hand; and std in roll/pitch/yaw (p-value = 0.007, 0.002 and 0.019, respectively), and amplitude in roll/pitch (p-value < 0.001 for both) in right hand. An ANN classifier trained with the 8 features achieved an accuracy of 88.14%. The correlation analysis identified only 5 features from 8 features: std of yaw and frequency of pitch in left hand; and std of yaw and amplitude of roll/pitch in right hand. Figure 1 shows box plots of the five features on the two groups. This result shows that experienced providers tend to make more active yet stable movements in ETI. An ANN classifier trained with these 5 features improved the accuracy by 3.03% (91.17%).

Translational Impact: We identified important features to discriminate novices from experienced providers and developed ANN classifiers based on the selected features. The results can be applied to develop wearable gloves for ETI training and algorithms to give feedback to trainees. With the wearable gloves, trainees in medical schools as well as experienced doctors due to lack of training resources can practice continuously to maintain their level of ETI skills. In the future, we will investigate more features obtained from different types of sensors and test their significance and contributions to improving classification accuracy.

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