

## Configurable Overall Skill Assessment in Ultrasound-Guided Needle Insertion

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**INTRODUCTION:** Computer-assisted training for ultrasound-guided interventions has proliferated over the last several years due to its efficiency over supervised training. Objective skill assessment can be used to monitor trainee performance as they follow a training course without the need for a preceptor. The interaction of trainees and preceptors with computer-assisted training systems, however, has not been well defined. We suggest that computer-assisted training systems must remain configurable and transparent such that instructors may configure the assessment to emphasize particular skills and both instructors and trainees may understand trainees' progression through the curriculum and how to interpret results into action.

**METHODS:** We implemented three configurable and transparent methods for overall skill assessment. The first method uses a weighted combination of percentile ranked metric values, where the weight associated with each performance metric is configurable. The second method uses a k-nearest neighbours approach, where the scale in each dimension of metric space is configurable. The third method uses a fuzzy inference system with kernel density estimates as the membership functions, where the user may add, remove, or weight fuzzy different if-then rules. These methods were all implemented within the Perk Tutor platform ([www.perktutor.org](http://www.perktutor.org)) which allows the input performance metrics and parameters to be configured. Furthermore, these methods are connected directly to the training system to provide immediate feedback.

We conducted a retrospective validation study to compare the accuracy of skill assessment with each of these methods using equal weights. Twenty medical trainees and eight experts performed either in-plane or out-of-plane ultrasound-guided needle insertion on a vascular access phantom, and were assessed using 10 performance metrics (**Figure 1**). We validated each method for classification of participants as novice or expert using the leave-one-out method, and we compared these results with the well-accepted SVM method [1]. Area under the sensitivity-specificity curve (AUC) was used as the measure of accuracy.



**Figure 1.** Trainee practicing out-of-plane needle insertion under ultrasound-guidance with augmented reality 3D display.

**RESULTS:** For classification into the novice and expert categories, AUC was 0.88 for the combination of percentile ranks method, 0.80 for the k-nearest neighbours method, and 0.83 for the fuzzy inference system method. This compares favourably to the 0.86 AUC for the well-accepted SVM method.

**CONCLUSION:** Configurable and transparent skill assessment methods allow trainees and preceptors to understand results and configure them to emphasize particular skills. We have shown that overall skill assessment accuracy using configurable methods and using well-accepted black box methods is comparable; thus, configurable methods may be adopted into practice without compromising accuracy. We expect accuracy to improve further when the methods are optimized based on expert knowledge.

- [1] B. Allen, V. Nistor, E. Dutson, G. Carman, C. Lewis, and P. Faloutsos, "Support vector machines improve the accuracy of evaluation for the performance of laparoscopic training tasks," *Surg Endosc*, vol. 24, no. 1, pp. 170–178, Jan. 2010.