

Retraining MobileNet with highly variable data for tool detection in central venous catheterization

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Introduction: Central venous catheterization (CVC) is a vital medical procedure with many possible complications. Complications that arise from improper technique can occur in as high as 12% of procedures [1]. As such, training to reduce complication rates is important. Central Line Tutor guides users through this process, providing real-time instructions and feedback [2]. Using MobileNet, a convolutional neural network, a tool in use is identified, indicating proper adherence to the procedure. The efficacy of the network is dependent on variation in training set images. This study evaluates the accuracy of a MobileNet that has been retrained using a high variation training set for identifying tools used in CVC.

Methods: To effectively retrain a neural network, numerous training images with high variation are needed. 17,500 images of each of the 7 tools used in CVC were gathered. Additionally, 25,000 images of the workspace without tools were collected, for a total of 147,500 images. To maximize variation, these images were taken in various tool positions, lighting conditions and camera angles. Furthermore, images were collected with and without medical gloves, and the tools were handled with different handedness. These variations are illustrated in 5 sample images from the scalpel training set (Fig. 1). The initial layers of a MobileNet network were then retrained on the ImageNet dataset, and the final layer was retrained on the collected training set using 100,000 training steps. To test the accuracy of the retrained network at identifying tools, 5 trials of the procedure were recorded using Central Line Tutor. These recordings were separated into frames, and classified manually and by the retrained network. The performance of the MobileNet was evaluated by comparing the manual and automatic classifications, measuring accuracy of the network across all frames, and its precision for each tool. The precision of classification is a percentage of correct classifications out of total classifications for a given tool. The accuracy of the network is the percentage of correct classifications from all of the recorded frames.

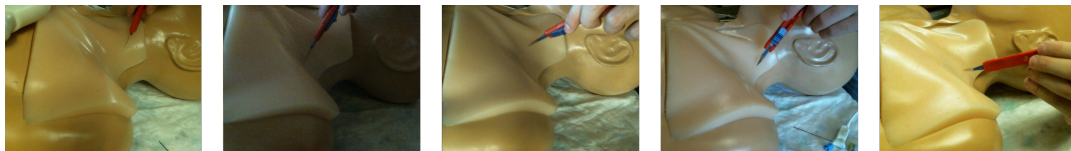


Figure 1. Sample images from scalpel training set

Results: On average, 62.4% of the 4,376 recorded frames were correctly classified. The best identified tool was the scalpel, with 95.7% precision. The least was the guidewire casing, with a precision of 21.7%. Tools fell into two distinct groups, and either had a high precision (70-100%) or a low precision (20-40%). High precision tools consisted of the scalpel, catheter, anesthetic and syringe, and low precision tools were the guidewire casing, guidewire and dilator.

Conclusions: These results indicate that the high variation training set was effective for identification of some tools used in CVC. Tools that were small in size with non-distinct colour, such as the guidewire or dilator, were classified less accurately. Tools with distinct shape and colour like the scalpel or catheter were reliably classified with the retrained network. A limitation may have stemmed from only one person gathering training images; multiple people would have introduced more variation. Further work can be done to improve the training set in order to better recognize those tools with low precision.

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1. Kornbau C, Lee KC, Hughes GD, Firstenberg MS. Central line complications. *Int J Crit Illn Inj Sci.* 2015 Sep; 5(3): 170–178.
2. Hisey R, Ungi T, Holden MS, Baum ZM, Keri Z, McCallum C, Howes DW, Fichtinger G (2018) Real-time Workflow Detection Using Webcam Video for Providing Real-time Feedback in Central Venous Catheterization Training. *SPIE Medical Imaging* 2018.