AUTOMATIC ULTRASOUND NERVE DETECTION

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Introduction: The purpose of this project is to derive an optimal algorithm to allow for automatic ultrasound (US) detection of the sciatic nerve at the popliteal fossa.

Methods: The software was written in MATLAB® R2011b (MathWorks®, Natick, MA, USA). The first step was to apply a Wiener filter on the US image, in order to reduce noise. Next, K-means clustering was used to divide the US image into three clusters, one of which contains the nerve. The appropriate cluster was the one containing the brightest pixels as these tissues appear as the brightest regions in an US image. Muscle fascia was then eliminated by discarding objects having a width greater than two times the length. The largest remaining object was then assumed to be the popliteal nerve. The study consisted of two parts; in part 1, 20 US images were obtained (TH) from both sciatic nerves in 5 authors. To evaluate the algorithm, two US-experienced anesthesiologists were asked to manually locate the nerve in the US images. Both anesthesiologists detected the same regions on all of the US images as being the sciatic nerve. The manual nerve locations were then compared with those detected automatically using two levels of comparison: first, whether the center of the automatically identified nerve lies within the area of the manually identified nerve; and second, the percentage of overlap of areas created around the nerve centre by drawing circles ranging in diameter from 1 mm to 1 cm around the centers of the automatically identified nerves and the manually drawn area (Figure 1). In part 2 of the study, 100 US images of the sciatic nerve (5 per side and author) were taken in 5 authors. The algorithm was applied with the objective to determine the percent of the images where the automatically defined nerve centre was within the manually detected nerve area and to determine whether the maximum area drawn around this centre to allow for a minimum of 95% overlap between manually identified nerve area and automatically drawn area around the nerve centre – as determined in part 1 of the study – could be confirmed in this larger number of US images.

Results: In part 1, the automatic nerve centre was within the manual nerve area in 96% of the US images. Percentages of overlap ranged between 92% (1 mm diameter) decreasing to an overlap of 63% (1 cm diameter). The maximum diameter for at least 95% overlap was determined as 0.5 cm. In part 2, the automatically detected nerve centre was within the manually detected nerve area in 99% of the images. Overlap ranged between 100% (1 mm diameter) and 69% (1 cm diameter) Figure 2. Percentage of overlap at a diameter of 0.5 cm was 95% and at 0.4 cm 98%, respectively.

Conclusion: The automatic ultrasound nerve detection system proved to be reliable in detecting the sciatic nerve in the popliteal fossa. Using this system, drawing a circle of 0.4 cm around an automatically detected nerve centre produces an overlap of almost 100% with a manually detected nerve area. A target area of a circle with 0.4 cm diameter seems a clinically sufficiently large target area for nerve block needle placement. This system will pave the way for the development of a completely automated robotic nerve block system.

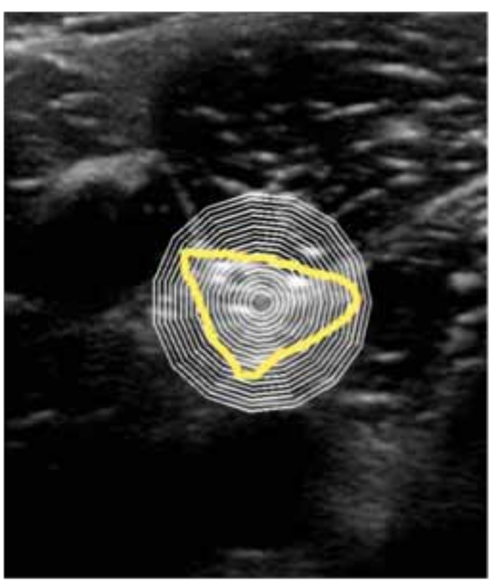

Figure 1: Automatic detection areas (white), and manual detection (yellow)

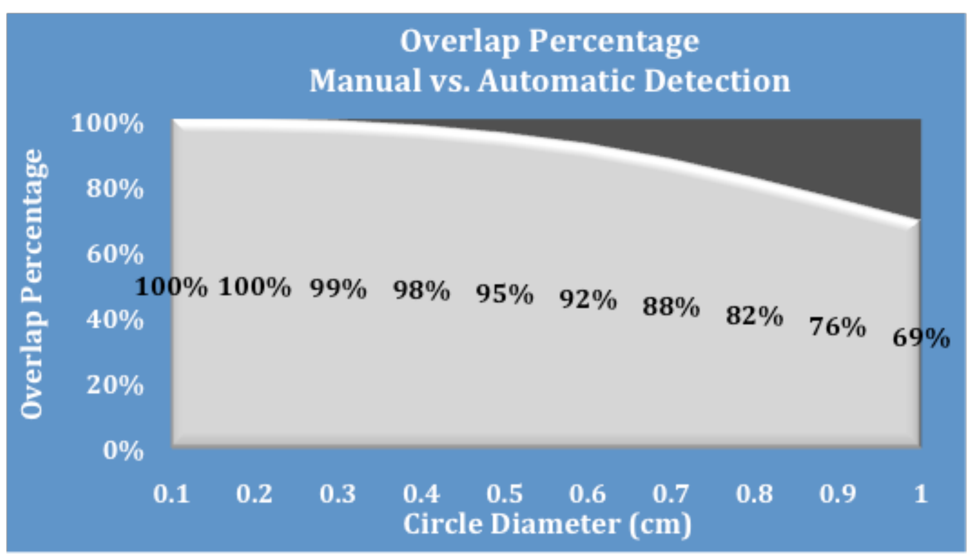

Figure 2: Percentage of Overlap between the automatic and the manual detections