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Automatic real-time annotation of important landmarks in ultrasound-guided femoral nerve blocks

Frank Lindseth[1,2], Linda Leidig[2] and Erik Smistad[1,2]

[1] SINTEF Medical Technology, Trondheim, Norway
[2] Dept. of Computer and Information Science, Norwegian University of Science and Technology

ABSTRACT

The main focus of the preliminary work presented here is the automatic real-time annotation (detection and tracking) of the important structures seen in an ultrasound image taken from a femoral nerve block, i.e. the femoral artery, the facias (lata and illiaca) and the femoral nerve.

Categories and Subject Descriptors (according to ACM CCS): I.3.8 [Computer Graphics]: Applications−Medical

1. Introduction

Regional anaesthesia (RA) has several benefits compared to general anaesthesia (GA), e.g. reduced morbidity and mortality, reduced postoperative pain, earlier mobility, shorter hospital stay, and lower costs. Still, GA is more widely used due to the fact that this technique more successful and reliable. Ultrasound-guidance has increase the success rate of RA but the technique is challenging, especially for inexperienced physicians and in difficult cases. Good theoretical, practical and non-cognitive skills are needed in order to achieve confidence in performing RA and to keep complications to a minimum. The RASimAs project (Regional Anaesthesia Simulator and Assistant) is a European research project which aims at providing an assistant to lessen the cognitive burden and help performing RA procedures. The assistant will guide the user to 1) find a good probe placement and view of the target injection site, 2) insert needle and 3) inject local anaesthetics. In step 1, segmentation of the structures of interest and registration of a generic 3D model will be used to guide the user to the target area.

The main focus of the preliminary work presented here is the automatic real-time annotation (detection and tracking) of the important structures seen in an ultrasound image taken from a femoral nerve block, i.e. the femoral artery, the facias (lata and illiaca) and the femoral nerve.

2. Methods

The assistant hardware consists of an Analogic Sonix MDP scanner with a linear probe and electromagnetic tracking (SonixGPS) of both probe and needle. The images are streamed from the ultrasound scanner to the assistant using the Plus toolkit and the OpenIGTLink protocol. So far, automatic vessel and facia annotation methods have been developed for the assistant. The vessel is detected and tracked automatically in real-time using an elliptical vessel model and a Kalman filter. The facias are detected using dynamic programming in the facia probability map (ridge probability multiplied with the location probability based on the artery position and extent). The methods must be able to process the images in real-time to be useful for the femoral nerve block assistant. This is achieved by implementing the assistant with the FAST framework which uses GPUs and OpenCL for processing and visualization.

3. Results

Several ultrasound sequences of the femoral region were acquired. In each of the sequences some of the frames where manfully segmented by clinical experts. The automatic annotation results were compared to the "gold standard" at those control frames and several quality metrics were calculated, e.g. dice similarity coefficient, Hausdorff distance etc. The vessel and facia detection were successfully in all the sequences. The vessel detecting and tracking algorithm as well as the facia detection algorithm achieved an average dice similarity coefficient and Hausdorff distance around 1 mm. In some testes the automatic methods performed as good as the clinical experts (variability).

4. Conclusion

The presented methods are able to automatically and accurately detect and track the femoral artery as well as the facias in real-time 2D ultrasound images.

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