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

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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]: 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 de-

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3. Results

Several ultrasound sequences of the femoral region were acquired. In each of the sequences some of the frames were manually 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 successful 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 2 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.

Figure 2: Manual vs. automatic annotations. a) Manually annotated fascia (green) and femoral artery (red), b) Same image but with automatic segmentations.

Figure 3: Hausdorff distance of the fascia lata segmentation. Three comparison groups are shown.

Figure 4: Initial results: Real-time segmentation of artery, fascia and femoral nerve.

Figure 5: Initial results: Real-time 3D artery reconstruction and model registration.