Surgical planning system for twin-to-twin transfusion syndrome fetal surgery

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1. Introduction

Twin-to-twin transfusion syndrome (TTTS) is a serious condition that affects around 20% of twin pregnancies with monochorial (MC) placenta [1]. The first line treatment of severe TTTS is fetoscopic laser photocoagulation, which is associated to improved survival rates but if vessel ablation is incomplete, TTTS could reappear reducing survival of both twins. The surgery is in fact very complex and risky, because of several constraints proper of the fetal clinical setting. For all these reasons, the choice of the correct entry point is probably the most critical factor of the intervention as it directly affects the maneuverability of the fetoscope and the possibility to reach all the anastomoses. In this paper we present a software for planning the insertion trajectory taking into account the specific localization of the placenta.

2. Methods

In order to plan the ideal insertion point, we create a high resolution model of the womb including the fetuses, the placenta and the vascular tree, extracted from MRI data of the patient. Once the model is created, we use it to simulate the insertion of the fetoscope and calculate the probability that all the targets can be successfully reached. The software uses proven open source technology such as VTK, ITK, MITK, Qt, and SOFA, and is designed to be compatible with the most popular operating systems.

3. Results

The software was developed and tested in a laboratory setting and underwent several iterations with clinical partner BCNatal- Hospital Clinic and Hospital Sant Joan de Deu to assess usability in the clinical setting. The current implementation of the software is composed of different modules that define the following workflow:

Image acquisition, fusion and reconstruction - We acquire single 2D MRI images of the moving uterus and fetus fast enough so that motion does not affect the image quality. Specifically, three stacks are acquired for the whole womb and the placenta with a voxel size of 1.25x1.25x3.5 mm in the axial, sagittal and coronal view. In order to obtain a full 3d volume, those stacks are fused together using a Super Resolution method (SR) [2]

Patient Specific placenta modeling – Once the image has been reconstructed in (SR), we use a combination of local features and Support Vector Machine (SVM) classifiers to detect the placenta in an automatic way [3]. The resulting model of the placenta created in this step is shown in yellow in Figure 1.

Vessel detection: Small vessels are also quite difficult to recognize in MRI scans, because the size of their lumen is close to the spatial resolution limit of the images, even if they are reconstructed in SR. We perform an initial detection using local image features, which is shown in red in Figure 1.

Virtual insertion: In our simulated surgical scene, we load a model of a 2.0 mm fiber fetoscope and let the surgeon inspect the insertion point interactively.

Reporting: After the exploration is complete, a report is generated for the clinician to review.

We are planning to move soon in the clinical validation phase.

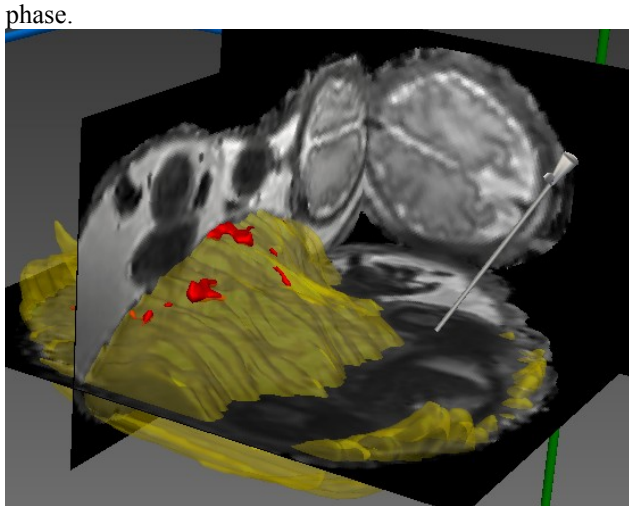

Figure 1: Example view of the surgical planning system, where we can examine the reconstructed placenta and vessels model in yellow and red respectively, and simulate the entrance of the fetoscope in the uterus to test whether the detected vessels are accessible under the constraints imposed by the anatomy of the fetus.

4. Conclusions

We presented a software for the estimation of patient specific fetoscope insertion path for use in TTTS. The software represents a collaborative effort in integrating different imaging modalities to improve the quality of the information available to the surgeon to plan the intervention.

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Referencias

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