Intensity based MRI/TRUS data fusion for prostatic guided biopsy

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Purpose

Magnetic Resonance Spectroscopic Imaging (MRSI) has been shown to provide a structural and metabolic evaluation of prostate cancer location, aggressiveness and staging. On the other hand, transrectal ultrasound imaging (TRUS) is commonly used in order to guide the

biopsy of the suspicious area, with the difficulty of being unable to exactly localize the area of interest seen in the pre-biopsy MRSI. A tool capable of fusing the MRSI image with the US scan in real-time will greatly improve the biopsy protocol by reducing the number of biopsies, thus reducing patient recovery and stress.

The purpose of this work is to present a novel method for guiding prostatic biopsy procedures by fusing information from 3D US and pre-biopsy MRSI images based on intensity information. In contrast with other existing works, the proposed method does not require any manual intervention [1,2], or specific biopsy [1] or tracking [3] devices, thus it can be applied to current clinical practice with modern existing ultrasound machines

Methods

The proposed methodology is based on combining two different image registration approaches for the alignment of the MRSI and TRUS images.

The method assumes that a pre-biopsy MRSI volume is available which will contain the localization information for guiding the biopsy needle. Subsequently a 3D TRUS volume of the prostate is obtained in order to register it with the MRSI (3D-3D registration). This volume can be acquired using existing 3D ultrasound probes, external positioning sensors or exploiting speckle inter-slice correlation information. In this work the volume is directly obtained using a 3D probe with a Siemens Antares system. After this first and off-line registration, another registration (2D/3D registration) is performed when the biopsy procedure is taking place. It is a 3D to 2D real-time registration, where the current ultrasound scan is rapidly registered to the TRUS volume, hence, obtaining obtain a final correspondence between the current US scan and the MRSI volume. Figure 1 illustrates the steps of the proposed methodology.

The 3D-3D multi-modal registration approach is based on a rigid registration transform of the MRSI and TRUS volumes. The parameters of this transform, $T_{MRI/US3D}$, are found by maximising a mutual information measure [4]. In addition, a multi-resolution approach is implemented in order to avoid local minima and obtain more robust results. Before the registration, with the aim of obtaining a more robust registration, the MRSI and TRUS volumes undergo different pre-processing steps. In the case of the MRSI, a bias correction filter is used in order to minimise the effect of the non-homogeneous magnetic field [5], whereas for the TRUS volume, a mask is obtained segmenting the prostate area from the background. This is obtained by applying an anisotropic diffusion filter in order to minimise speckle noise while preserving prostate contours. Subsequently, a level-set segmentation method [6] with automatic seed placement is used to obtain the final mask.



Fig. 2 MRI/TRUS Registration. (a) MRI and (b) TRUS Slices and (c) registration

The 2D-3D registration process is approached as a volume-to-slice registration. This needs to be robust but also specially efficient thinking of applying it to real-time biopsy procedures. The process is as follows: the current US scan is captured by a frame grabber, and is registered to the 3D US volume by minimising the sum of squared error between the scan and the coronal slices, obtaining the $T_{US3D/US2D}$. Again a multi-resolution approach is adopted here. Due to computation constraints, the transformation only accounts for 3D translations, assuming that the scan will follow the coronal direction and probe rotations will be minimal.

Results

Initial results using the proposed methodology are presented based on data obtained from a prostatic phantom (CIRS). Figure 2 shows axial slices from the (a) MRI and (b) TRUS volumes and the (c) results after registration. Although further quantitative evaluation is needed, the spatial agreement can be considered qualitatively satisfactory. **Conclusion**

Initial results indicate the feasibility of proposed MRI/TRUS image fusion methodology for guiding prostatic biopsy using only image information. Although prostatic phantom data has been used in this work, future work will focus on quantitatively evaluating the methodology using a larger number of images, specially using patient data. Real-time and clinical implementation issues will be also an important aspect our future research. A novel methodology has been proposed which can help to change the current diagnostic of prostate cancer: perform an accurate single biopsy of a suspicious target, instead of the current protocols of multiple blinded biopsies.

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Fig. 1 Overview of the proposed method