**Matching of fiducial lines to slice intersection points in ultrasound images**

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***Abstract***

Ultrasound imaging devices are now part of prostate brachytherapy planning and delivery. Therefore, imaging system has to be calibrated and tested as precisely as possible to help physicians elaborate their diagnosis and operative plan with accuracy. Image quality assurance and geometric calibration of ultrasound imaging systems are performed on several types of phantoms containing fiducial lines in different configuration. Automatic fiducial line segmentation is therefore an important part of image quality assurance and calibration of ultrasound imaging systems. However, the current methods need to develop new code specific to a phantom. This operation is time consuming and the tolerance parameters are often fixed and obtained via a trial and error process. We propose a new method that will handle several configuration for the fiducial lines without requiring any change in the code, this method will detect coplanar lines that be contained in multiple planes for any number of lines per plane as well as any number of points per line. This method will also determine the tolerance parameters automatically from inputs such as maximum angular movement.

***Method***

The fiducial segmentation algorithm by (Chen, 2009) provides a list of fiducial points sorted by intensity that the method takes as an input.

From the list of fiducial points, N-point lines are computed and sorted by their intensity so that we have a list of lines each made of N fiducial points. The number or fiducial lines (fiducial points in a cross plane) is provided in the phantom configuration file, as well as their basic structures such as parallel fiducial lines and Z-shaped fiducial structure. The number of these structures is not limited and is provided in the phantom configuration file. Then, an exhaustive search will be performed on the N-point lines found previously to match the actual lines made from the fiducial points from the phantom configuration file. Once the lines are correctly matched, we can determine from image orientation and a transform matrix the correspondence between the fiducial points we found the actual one and therefore register them to the labels provided in the phantom configuration file.

The different thresholds to accept points on a line or to register a potential line to an actual one is computed by the algorithm instead of implemented directly after a trial and error process. From the angular maximum movements of the probe, we can determine how far from the actual position the candidate line can be. This angular maximum movement provides the range in which the image can actually be as the image plane might not necessarily be perpendicular to the fiducial lines due to user movements, or could be slightly rotated to one side or the other. These angular parameters can be obtained from the phantom configuration file and the input data and would allow an optimal choice of threshold parameters are automatically determinedfor any line configuration in the phantom.

The method has been developed in C++ with the **Insight Segmentation and Registration Toolkit** (ITK) and the Visualization Toolkit (VTK) for portability, speed and robustness. A 3D Slicer module has been developed for visualization of input data and results. This module was extensively used for software debugging, testing, and creation of ground truth data sets for automatic testing.

***Results and Discussion***

***References***

1. Chen, T. T. (2009). Chen, T.K., Thurston, A.D., Ellis, R.E., and Abolmaesumi, P. *Ultrasound in Med. & Biol, 35(1) pp. 79–93*.