A Survey on Needle Tip Estimation in Ultrasound Images

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Abstract - *Medical imaging is a method that simply develops a graphical representation of the interior of a body which can be used for medical analysis. Through these medical analyses diagnosis and treatment become faster and accurate. It can make drastic changes which help us to achieve many incredible goals. Advanced treatment with the help of these analyses can drastically improve and extends a patient's quality of life. In this paper we discuss about the scope of medical image processing and their advantages. Nowadays needles are inserted for biopsy collection and the needle tip estimation and localization is performed to make sure that the needle is not approaching any major vessels or internal organs. Hence needle tip estimation is an important task.*

Key Words: **Needle insertion, Percutaneous needle procedure, Invasive needle procedure, Needle tip estimation, Biopsy collection.**

1. INTRODUCTION

Extension and expansion of robotics in medical field along with biomedical image processing is actually a growing trend and researching field. As the name suggest medical image processing is a specialized application of image processing. Medical image processing simply extracts the clinically useful information of the patient in the form of image. And this extracted information can be used for health analysis and to provide the appropriate treatment. Nowadays in the fully automatic environment robots are used to insert the needle into the patient's body and this needle tip is under tracking. This type of needle tracking in 2D ultrasound images are very prominent application of medical image processing.

This paper is organized as follows. In Section II, we briefly summarize the different techniques used for needle tip estimation. Finally, we summarize and draw some conclusion in Section III.

2. LITERATURE SURVEY

In [1] introduces a method for localization and tracking of manually inserted needles. A three dimensional ultrasound probe which is mounted on a robotized arm is used for the insertion of the needle. Through online image processing, the system tracks the needle. In this paper the suggested algorithm for needle tracking has the capablity of robustly detecting the needle. The proposed algorithm detects the needle from the very next moment it is inserted and also any priori information about the insertion direction is not needed. The proposed algorithm is achieved by combining the random sample consensus (RANSAC) algorithm with Kalman filtering in closed loop. To keep the needle within the field of view here a control scheme is also proposed which automatically guide the ultrasonic probe .The scheme also take consideration about the alignment of axis with the ultrasound beam. The advantage of the proposed algorithm is that it support easy insertion of the needle by the operator, and accelerate the development of autonomous needle insertion by medical robot.

Nowadays needle insertion is one of the most commonly performed procedures in medical field. The key for successful diagnosis is the, accurate visualization of the needle during insertion. This paper presents the real-time three-dimensional tracking of flexible needles during insertion into a soft-tissue simulant using a two-dimensional (2D) ultrasound transducer. The transducer is placed perpendicular to the needle tip to estimate the needle position. The transducer is robotically repositioned to track the needle tip during the insertion. By using a compensator positioning of the transducer is accomplished. The compensator uses the needle insertion velocity corrected by needle tip velocities to determine out-of-plane motion. These all concepts are discussed in [2].

Ultrasound (US) guided biopsy is a commonly performed medical procedure routine in clinical practice. To improve the precision in the execution and the safety for the patient, the task could be performed by robotic systems. Both robotic and human procedures could greatly benefit from real-time localization of the needle in US images. The robot or the specialists can be guided by these retrieved information. The actual problem is that US data provide very low quality images of the needle making this task quite complex. In [3] the proposed algorithm presents a needle localization method which is able to extract the needle orientation and the tip position. Here use an optical tracking system to measure the position and the orientation of the needle and the US probe.

The needle should be detected precisely in the percutaneous needle procedures using ultrasound (US) imaging in order to avoid damage to the tissue and to get the samples from the appropriate site. The detection of the needle and its tip is actually too difficult due to the excessive artifacts and low resolution of the US images. Using image processing it is possible to enhance the needle tip. In [4] the algorithm proposes a novel needle detection method in 2D US images based on the Gabor filter. The suggested method enhances the needle outline along with the suppression of the other structures in the image. The needle insertion angle is estimated first. And then the needle trajectory is found with the RANSAC line estimator.

A minimally invasive surgical procedure for the treatment of malignant tumors is percutaneous image guided tumor ablation. In [5] we use a needle shaped ablation probe. To increase the accuracy and decrease the execution time of the procedure, automate the insertion of the needle by a robot. Extracting the needle tip position from the ultrasound (US) images is highly important in order to verifying that the needle is not approaching any forbidden regions. This paper proposes a method by introducing a dynamic selection of the region of interest in the US images and filtering the tracking results using either a particle filter or a Kalman filter.

Percutaneous needle procedures are mostly carried out with the guidance of 2D ultrasound (US) imaging. But the actual problems with US images are, they are inherently noisy and their resolutions are low. Hence, target tracking can be quiet complex task. To track the needle and the target image based tracking methods can be used .The paper [6] proposes visual tracking of multiple moving points, such as biopsy needles and targets. For that normalized cross correlation and mutual information similarity functions are used in 2D US images. Both moving and deformable targets can be tracked. For small and moving target tracking an affine motion model is used. And for deformable target tracking a thin plate spline motion model is used. Needle and target template images are updated with a template update strategy during the tracking. Use the Kalman filter to reduce the tracking error.

A design specification process for the development of intelligent surgical robots is described in [7]. Nowadays, the surgeons manually controlled the surgical robots by using teleoperation. This goal of fully automatic robotic surgery can only be achieved by means of a formal assesment of surgical requirements and these needs to translate into behavioral specifications. The application of Requirements Engineering to surgical knowledge formalization is also explained in the paper.

3. CONCLUSIONS

Nowadays robotics in medical field with medical image processing is a highly active research area. Even though many ideas and concepts have been proposed theoretically, they are not actually implemented to the real word environment. If we can develop a fully automatic medical robotic environment with précised medical image processing, it can be help us to suppress the faults in treatment and can improve the quality of life of a patient.

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