SURVEY ON ROBUST REAL-TIME NEEDLE TRACKING IN 2-D ULTRASOUND IMAGES USING STATISTICAL FILTERING

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Abstract:- This paper presents a survey of the automation of needle insertion by a robot. The main advantage of this method is to increase accuracy and decrease the execution time. For the treatment of malignant tumors, there is a minimally invasive surgical procedure by using a needle or a needle-shaped probe. There are different methods has been developed for insertion of the needle. In this method, the needle tip is extracted from ultrasound images for verifying that the tip is not come to close any forbidden regions. The method for estimating the tip has been developed by using Hough transform, image filtering. This paper improves introducing a method for selection of the region in the ultrasound images and to finding the needle tip and needle axis by using Kalman filter and Particle filter.

Key Words: *Kalman filter, Particle filter*

1. INTRODUCTION

The advantages compared with manual insertion is to demolish only a small amount of healthy body parts, low cost, and faster retrieval. Image techniques are used for finding the needle axis and needle tip from the ultrasound images. Ultrasound guidance is the commonly used for thermal ablation and biopsy. A needle inserted from the outside of into the human body which destroys one or more pathologic tissue through the manual insertion of the needle. The insertion of the needle by a robot which increases the accuracy and decreases the execution time. The robot insertion will reduce the number of CT scans.

The needle is the endfeet of the robot for tracking the needle tip position. The needle tip estimation from the ultrasound images for verifying that the needle is not reaching any forbidden regions. There are several methods for tracking the needle tip during the insertion. The insertion of the needle is directly controlled by the Robot as the feedback variable for estimating the correct tip position. In addition, when a robot is inserting the needle, the insertion path is planned using ultrasound images and the movement during the interposition from precalibrated design. In manual insertion, the insertion of the needle tip is very difficult and hard compared with automatic insertion. The automatic insertion of the needle is very helpful to increase the accuracy.

There are several methods for tracking the needle axis and estimating the needle tip. But there is no method using ultrasound image feedback signal during the insertion of the needle. There are different real-time algorithms for detecting needle tip based on the Hough transform, which does not provide a good accuracy for needle tip position. There are different real-time methods for finding the curved needles tip in ultrasound images. This algorithm finds the needlepoint but does not provide a well-founded estimation of the needle tip position.

In this method, a new real-time algorithm for finding the needle tip based on the 2D ultrasound images. This method is presented for improving some following aspects. First, finding the region of interest for estimating the needle tip. Second, statistical filters are used to increase the accuracy and precision of the tip tracking. The algorithm can also rely on velocity measurements to improve tracking accuracy when the insertion is performed by a robotic system.

The performance of the algorithm in manual and robotic insertions are in different ways. The insertion of the needle by a robot is a better way than manual insertion. In this method, the implementation of the algorithm by using statistical filters. The Kalman filter and Particle filter are used for the implementation of the algorithm for estimating the needle axis and tracking the needle tip position. These filters have been used to improve the accuracy and precision of the tip tracking, to filter out the noise, and to cope with outliers. There are main two objectives in this paper. First is to design an accurate and robust observer for a robotic system inserting a needle. Second is provide a method that may assist physicians inserting a needle manually.

2. RELATED WORKS

There are several robotic approaches to find the needle insertion, but there is no method use ultrasound image feedback during the insertion. In this paper, the method is an automatic insertion of the needle by using Robot could increase the accuracy and decrease the execution of time. This method is introducing a selection of the region of interest in the ultrasound images by using Kalman filter and Particle filter. These filters are used to improve the accuracy and precision of the tip tracking, to filter out the noise. There are different methods for needle insertion. But none of them have accurate results.

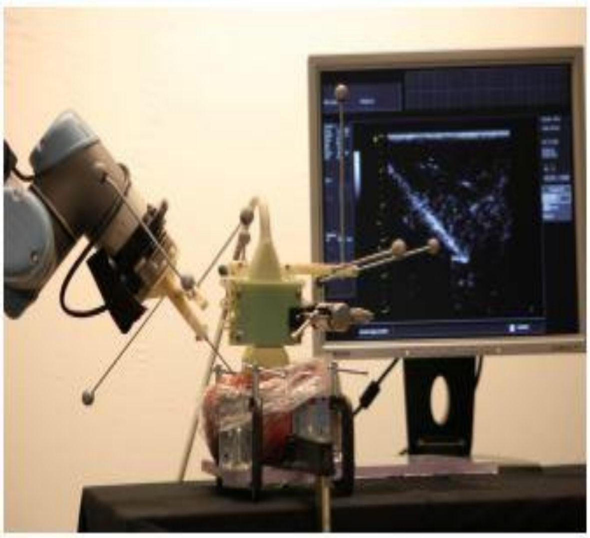

Fig. 1. Experimental setup

Nowadays, surgical robots are used for the treatment of malignant tumors [1]. The main objective of this method is to provide surgeons with robots to assist them. Robot assistants, like surgeon extenders and auxiliary surgical supports, provide a fundamental aid to the tasks surgeons in the execution of critical surgical. They perform simple surgical actions. Medical image processing simply extracts the clinically useful information of the patient in the form of an 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 a very prominent application of medical image processing.

In [2], a new method is introduced for finding the needle axis and needle tip position by manual insertion of the needle. This method uses a 3 D ultrasound image. This method proposed a new real-time algorithm for tracking the needle tip. This algorithm is used to detect the needle and it provides a feedback signal as the feedback variable. Extracting the needle tip position from the ultrasound images by using this algorithm and also verifying that the needle tip is not close to any forbidden regions.

Nowadays, automatic needle insertion is one of the most commonly performed procedures in the medical field. It improves the accuracy and decreases the execution time. The advantage of this algorithm is an easy insertion of the needle. This paper presents [3], a real-time algorithm for the tracking of flexible needles during insertion into a soft-tissue using an ultrasound transducer. The transducer is used to measure the needle tip movement. In this algorithm, a compensator is used for out of plane motion and also determine the needle tip velocity to find the out of plane motion.

Percutaneous needle procedures, such as biopsy and drug delivery, are commonly used in medical practices. Visibility of the needle plays an important role in the success of these procedures. Particularly in biopsies, if the needle is misplaced, erroneous samples might be collected and organs might be punctured leading to internal bleeding. In order to prevent such failures, the trajectory of the needle has to be predetermined and the needle tip should be tracked using medical imaging techniques.

Ultrasound-guided biopsy is a commonly performed medical procedure routine in clinical practice. To improve the precision in the execution and the safety of 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 this retrieved information. The actual problem is that US data provide very low-quality images of the needle making this task quite complex. In the [4] proposed algorithm presents a needle localization method which is able to extract the needle orientation and the tip position. Here using 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 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 ultrasound images. Using image processing it is possible to enhance the needle tip. In the [5] 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 design specification process for the development of intelligent surgical robots is described [6]. 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 assessment 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. CONCLUSION

Nowadays robotics in the 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 in the real word environment. If we can develop a fully automatic medical robotic environment with précised medical image processing, it can help us to suppress the faults in treatment and can improve the quality of life of a patient.

REFERENCES

[1] P. Chatelain, A. Krupa, and M. Marchal, "Real-time needle detection and tracking using a visually servoed 3D ultrasound probe," in Proc. IEEE Int. Conf. Robot. Autom., May 2013, pp. 1676–1681.

[2] E. M. Boctor, M. A. Choti, E. C. Burdette, and R. J. Webster, III, "Threedimensional ultrasound-guided robotic needle placement: An experimental evaluation," Int. J. Med. Robot. Comput. Assist. Surgery, vol. 4, no. 2, pp. 180–191, 2008.

[3] G. J. Vrooijink, M. Abayazid, and S. Misra, "Real-time threedimensional flexible needle tracking using two-dimensional ultrasound," in Proc. IEEE Int. Conf. Robot. Autom., May 2013, pp. 1688–1693.

[4] G. J. Vrooijink, M. Abayazid, and S. Misra, "Real-time threedimensional flexible needle tracking using two-dimensional ultrasound," in Proc. IEEE Int. Conf. Robot. Autom., May 2013, pp. 1688–1693.

[5] M. Kaya and O. Bebek, "Needle localization using Gabor filtering in 2D ultrasound images," in Proc. IEEE Int. Conf. Robot. Autom. (ICRA), May/Jun. 2014, pp. 4881–4886. G. J. Vrooijink, M. Abayazid, and S. Misra, "Real-time threedimensional flexible needle tracking using two-dimensional ultrasound," in Proc. IEEE Int. Conf. Robot. Autom., May 2013, pp. 1688–1693.

[6] M. Bonfè et al., "Towards automated surgical robotics: A requirements engineering approach," in Proc. 4th IEEE RAS EMBS Int. Conf. Biomed. Robot. Biomechatronics (BioRob), Jun. 2012, pp. 56–61.

BIOGRAPHIES

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