Robotic Ultrasound Calibration

Project Management and Software Development
for Medical Applications

General Info

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Project Abstract

Ultrasound (US) is one of the most popular medical imaging tools in various clinical scenarios. Due to high intra- and inter-operator variations of freehand US examinations, robotic technology has been considered as a good solution. Thanks to the high stability and precision of robotic manipulators, the problem of low reproducibility of freehand US can be overcome. However, the accuracy of the robotic US system (RUSS) is largely determined by the US calibration, which is defined by the transformation from the robot base frame to the US image frame. An accurate and autonomous calibration method plays an essential role in building a RUSS.

Background and Motivation

In recent years, robotic 3D US reconstruction is extensively applied for intraoperative guidance to reduce the clinician's workload. However, the accuracy of US reconstruction is severely influenced by the quality of US image calibration. An incorrect US image calibration can lead to severe 3D volume distortion. Therefore, it is important to have a reliable, easy-to-follow and accurate US image calibration procedure for the robotic US system.

Li et al. implemented and compared three different calibration phantoms in freehand US systems to RUSS, namely, cross-wire phantom, sphere phantom and Z phantom [1]. Ma et al. introduced an improved US calibration method based on the N-wire calibration [2]. Ahmad et al. also proposed an optimized approach of N-wire calibration method, which achieved an accuracy of 1.67mm RMS [3].

Student's Tasks Description

In this project, the student should try to investigate the existing US calibration methods as mentioned in the references. They should work with the supervisor to implement those calibration methods and compare their performance.

Technical Prerequisites

Python or C++

Robot Kinematics fundamentals

ROS fundamentals

References

[1] Li, Ruixuan, et al. "Comparative Quantitative Analysis of Robotic Ultrasound Image Calibration Methods." 2021 20th International Conference on Advanced Robotics (ICAR). IEEE, 2021.

[2] Ma, Guangshen, et al. "A Novel Robotic System for Ultrasound-guided Peripheral Vascular Localization." 2021 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2021.

[3] Ahmad, Awais, M. Cenk Cavusoglu, and Ozkan Bebek. "Calibration of 2D ultrasound in 3D space for robotic biopsies." 2015 International Conference on Advanced Robotics (ICAR). IEEE, 2015.

Please send the completed proposal to ardit.ramadani@tum.de, zl.jiang@tum.de, lennart.bastian@tum.de and tianyu.song@tum.de. Please note that this proposal will be evaluated by the BMC coordinators and will be assigned to a student only in case of acceptance.