# Robotic Ultrasound Catheter Tracking based on Intermediate Ultrasound Representations

Project Management and Software Development
for Medical Applications

## General Info

Contact Person: Yordanka Velikova

Contact Email: dani.velikova@tum.de

## Project Abstract

During endovascular procedures the location of inserted catheter needs to be shown in real-time to the interventionist. Currently, this is accomplished through X-ray fluoroscopy, which emits harmful radiation. In this project, an alternative approach using a robotic ultrasound system for catheter tracking and navigation should be implemented. Instead of relying on the registration of pre-operative images for tracking, a novel method for generating intermediate ultrasound images to simplify catheter detection in B-modes will be used.

## Background and Motivation

Minimally invasive vascular procedures are performed by guiding a catheter to a target such as a tumour or aneurysm. The current gold standard is via X-ray fluoroscopy, which gives real-time visual feedback of the catheter's position. However, it exposes the patient and medical staff to ionizing radiation. In contrast, ultrasound (US) is a radiation-free imaging modality, but its interpretation relies greatly on the sonographer's experience due to lower resolution and smaller field of view. Robotic manipulators, on the other hand, can provide standardized imaging results by programmatically adjusting the probe. Langsch et al. [1] present a framework for real-time catheter tracking with robotic US guidance for aortic aneurysm treatment. However, an external camera and MRI atlas are needed to locate the trajectory, reducing the methods usability. Additionally, acoustic artifacts in US imaging make catheter guidance extremely challenging.

In this project, we want to develop a robotic US system for automatic catheter tracking in real-time without the need of preoperative imaging. The tracking will rely on a novel approach [2] that generates, for each B-mode, an intermediate ultrasound representation image in which the vessel is segmented. The segmentation is used as a region of interest (ROI) in which thresholding is applied for catheter localization. A visual servoing loop will guide the US probe during manual catheter insertion. The approach will be validated on a phantom with a realistic vessel structure.

## Student's Tasks Description

- Setup the robot with attached US probe.

- Acquire US image stream in real-time over ROS.

- Aquire intermediate ultrasound representation image by inferring through a pretrained network.

- Develop a visual servoing image-based control loop to navigate the robot.

- First, the probe moves axially to keep the vessel always centralized in the image.

- Second, the probe moves sagittal to track the tip of the catheter.

## Technical Prerequisites

Good Python Programming level

Experience with ROS (Robot Operating System)

Please send the completed proposal to ardit.ramadani@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.

## References

[1] F. Langsch, S. Virga, J. Esteban, R. Go¨bl, and N. Navab. Robotic ultrasound for catheter navigation in endovascular procedures. In *2019 International Conference on Intelligent Robots and Systems (IROS)*.

[2] Y. Velikova, W. Simson, M. Salehi, M. F. Azampour, P. Paprottka, and N. Navab. CACTUSS: Common anatomical CT-US Space for us examinations. *In 2022 Medical Image Computing and Computer Assisted Interventions (MICCAI)*