Project: AI-based instrument detection for stroke treatment

Motivation

In minimally-invasive medical interventions, accurate localization of medical instruments is crucial for successful treatment. For example, during mechanical thrombectomy, a treatment for ischemic stroke, navigating catheters and guidewires in the blood vessels of the patient is necessary to reach and remove the blood clot causing the occlusion [Yoo2017]. During the intervention, fluoroscopic images are taken and subtracted from each other after contrast medium has been injected (digital subtraction angiography, DSA). This makes the vascular tree visible as a 2D projection, as shown in Figure 1.

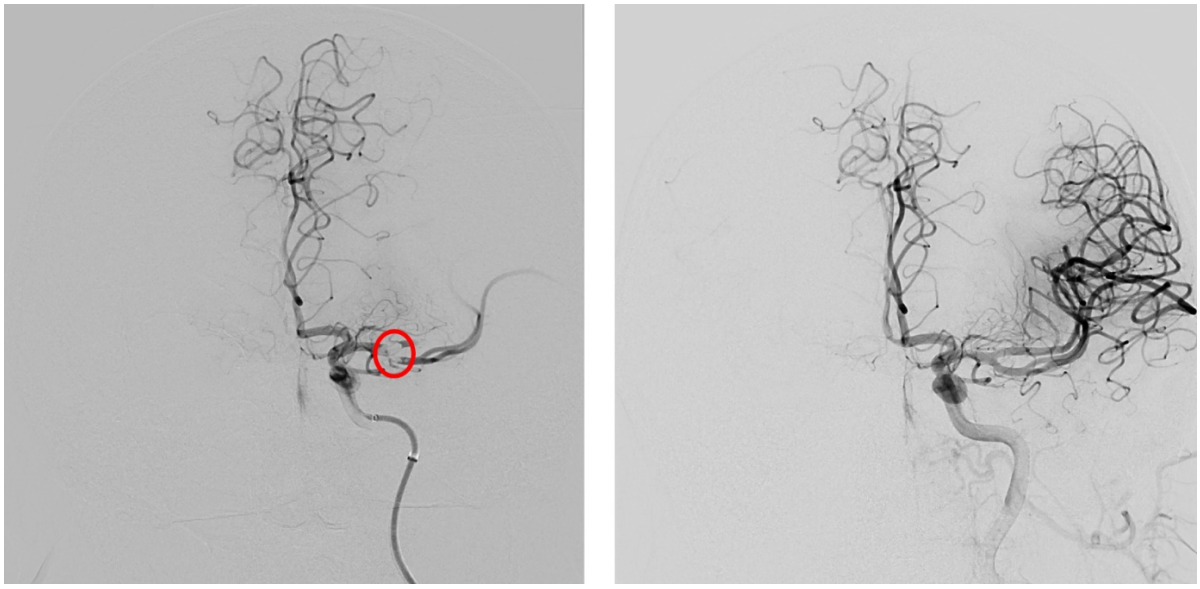

Figure 1 – (a) DSA image with vessel occlusion marked in red. (b) DSA image after the occlusion has been removed by thrombectomy.

Until now, clinicians have usually guided the instruments purely visually in DSA imaging, which is sometimes challenging and unfortunately not always successful [Yoo2017]. Computer-based localization (tracking) of the instruments makes it possible to provide clinicians with additional aids using computer assistance [Peters2008] that could potentially improve treatment. It has already been shown in dummies that 3D navigation in stroke treatment is possible using additional sensor technology as shown in Figure 2a) [Stevanovic2023]. However, additional sensors are difficult to integrate and purely image-based tracking would be much easier to use for clinical processes.

In preliminary work of a Bachelor's thesis at the THU [Morales2024], the feasibility of real-time capable AI-based instrument tracking on fluoroscopy data of a highly simplified vessel dummy has already been demonstrated. For this, the object detection model "You Only Look Once" (YOLO) [Redmon2016] has been finetuned to fluoroscopic images. Additionally, a method for convenient and automatic annotation of the instruments in the simplified dummy was developed.

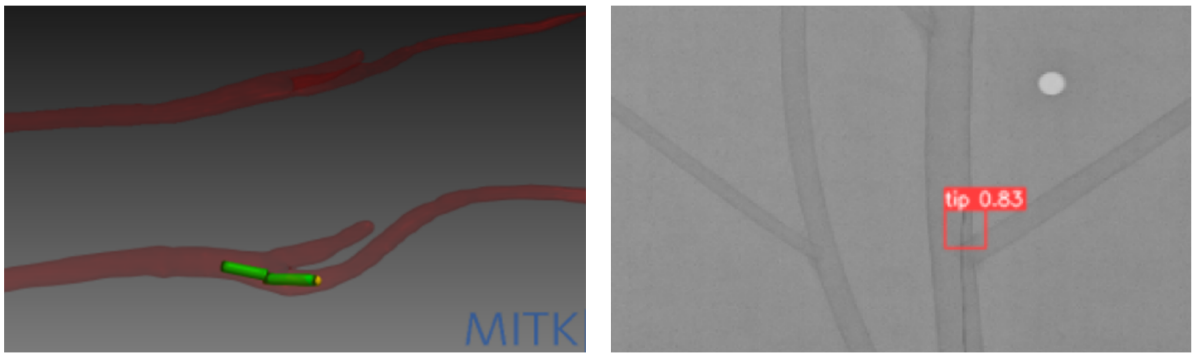

Figure 2 – (a) 3D navigation using sensorized instruments (green tubes) to reach a target (yellow) [Stevanovic2023].
(b) AI-based instrument detection in a highly simplified vessel dummy during the feasibility study [Morales2024].

Objectives

The aim of the new work is to build on the previous work by testing the approach on real patient fluoroscopy data and also to investigate the new possibilities of navigation by implementing a software prototype for an extended vessel dummy and simulation setup in the laboratory. As the project is planned for a larger group of students, there are several sub-goals that can be worked on in sub-groups:

a) Collect and annotate new data, e.g. from the WEISS Catheter Segmentation in Fluoroscopy Dataset (see below).
b) Setup a simulation environment and demonstrator in the lab.
c) Train and evaluate the YOLO or alternative models with existing and new data.
d) Implement a software prototype for real-time tracking in an example application based on the IGT Prototyping Tool (see below).
e) (optional depending on group size) Implement a software prototype for manual annotation based on the IGT Prototyping Tool that can be used for a).

Literature

[Peters2008] T. Peters and K. Cleary (Herausgeber), Image-Guided Interventions, ISBN 9780387738581, Springer (2008)

[Morales2024] Charissa Morales. A Deep Learning-Based Instrument Tip Localization for Mechanical Thrombectomy. Bachelor's thesis, THU 2024

[Redmon2016] Joseph Redmon et al. "You Only Look Once: Unified, Real-Time Object Detection". In: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR). June 2016.

[Stevanovic2023] Stevanovic, L. et al. (2023). Localizable Instruments for Navigated Treatment of Ischemic Stroke. In: Deserno, T.M., Handels, H., Maier, A., Maier-Hein, K., Palm, C., Tolxdorff, T. (eds) Bildverarbeitung für die Medizin 2023. BVM 2023. Informatik aktuell. Springer Vieweg, Wiesbaden. https://doi.org/10.1007/978-3-658-41657-7_61

[Yoo2017] Yoo AJ, Andersson T. Thrombectomy in acute ischemic stroke: challenges to procedural success. J Stroke. 2017:121–30.

Online Links

- IGT Prototyping Tool.
  https://github.com/NAMI-THU/IGTPrototypingTool
- WEISS Catheter Segmentation in Fluoroscopy Dataset.
  https://rdr.ucl.ac.uk/articles/dataset/WEISS_Catheter_Segmentation_in_Fluoroscopy_Dataset/24624243