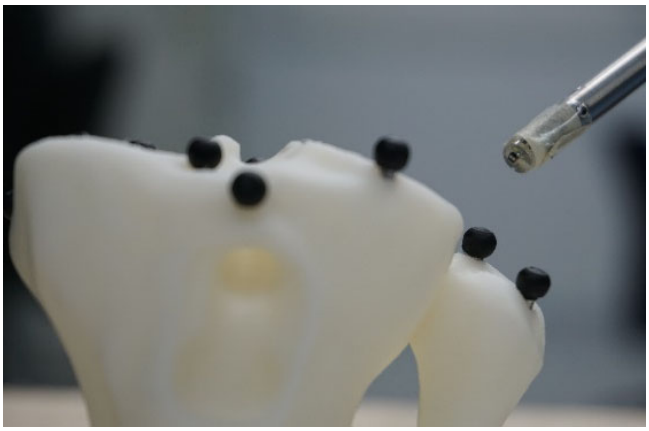
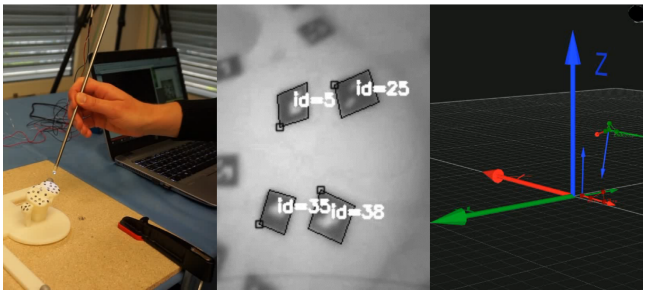
University of Basel

Department of Biomedical Engineering

Vision-based registration of a robotic endoscope



A miniature camera mounted to the endoscope's tip was used to estimate the pose of the endoscope relative to a knee phantom. (Mia Meyer)



Pose estimation process (left to right): 1. acquire endoscopic images, 2. process the images to find the location of image markers, 3. estimate the pose of the endoscope relative to the anatomy. (Mia Meyer)

Master Thesis by Mia Meyer (ETH Zürich) at the BIROMED-Lab

Advances in minimally invasive surgery come with enormous advantages for the patient, such as fewer skin incisions, faster recovery, and shorter hospitalization time. On the other hand, minimally invasive surgery introduces challenges for surgeons such as restricted vision on the surgical scene, less freedom of movement with the surgical instruments, and limited haptic feedback. Robot-assisted surgery tries to overcome these challenges and to support the surgeons. To automate and optimize several surgical tasks, robot-assisted surgery requires to localize the surgical robot relative to its environment.

In this thesis, a vision-based method was introduced to localize an endoscope with a miniature camera relative to the anatomy of the patient. Markers with a previously known location relative to some coordinate system were tracked. The known location of the markers and their corresponding image coordinates were used to estimate the pose of the camera. Three different feature trackers and three different pose estimation approaches were employed to achieve continuous and robust endoscope localization.

The proposed localization method was validated on a 3D-printed human knee phantom. We could show that our method outperformed existing vision-based localization approaches resulting in a smaller pose error of the endoscope. We achieved a Euclidean distance error of 14.52 mm and an angular error of 26.64 degrees.

Even though the developed localization method is not yet robust enough to use in real surgery, the results are promising, considering that only one camera with a low resolution was used for the localization. We anticipate that our localization method could be the starting point of localizing an endoscope autonomously in the patient, enabling us to automate specific surgical tasks.

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