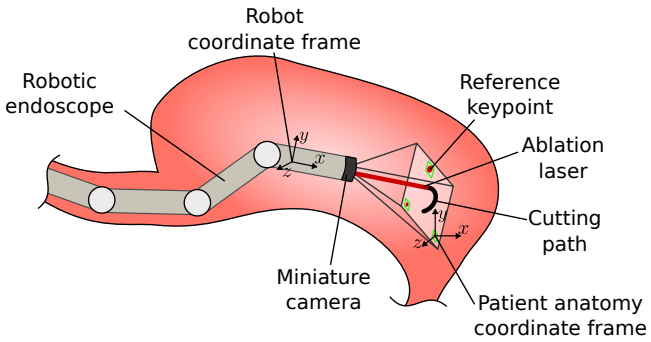
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

Master Thesis:
Vision-based Registration and Control of a Robotic Endoscope for Laser Ablation

Context: In recent years, more and more robots have found their way into operating rooms. Some of them enabled or improved minimally invasive procedures, i.e., procedures with a minimal number and size of skin incisions. Advantages of minimally invasive surgeries include the reduction of postoperative pain and a faster healing process. For the surgeon, manual handling of instruments through a small incision is difficult and robots can help to perform these interventions faster and with greater precision. We are working on equipping a surgical robot with a dexterous, snake-like tool called a flexible endoscope which allows to automate certain surgical tasks inside the body. In particular, we want to automate cutting tissue along a predefined path with a laser. To perform the cut safely and accurately, information about the endoscope's position relative to the patient anatomy is required. Previously, we used a miniature camera to close the control loop and to steer an endoscope prototype in two degrees of freedom. For surgeries, however, the endoscope should have a greater mobility and be able to manipulate in three-dimensional space.

Current endoscope prototype



Task description: In this project you will implement vision-based control of an articulated robotic endoscope, which should be able to register its position relative to the patient anatomy and use a laser to accurately cut along a predefined path in three-dimensional space. This includes the following work packages:

- Basic research and requirements analysis: Literature research is conducted on existing concepts for vision-based control, robot registration, and self-localization. The requirements for the system are investigated. Different concepts from literature research and own ideas are evaluated based on these requirements and the most suitable one is pursued.
- Hardware improvements: The current endoscope is extended such that it can manipulate in three-dimensional space. This increased mobility should also be observable (e.g., by adding a second camera for stereo vision).
- Control implementation: The control algorithm to register the robotic endoscope and move it along a path is developed using Matlab / Simulink and deployed to run on the TwinCAT3 real-time environment.
- Testing & Evaluation: The finished system is tested and evaluated regarding the initially defined requirements. Ideally, this is done using a mock-up laser which is guided through the endoscope in a fiber.

Start: ca. Sept. 2019
Duration: 6 months

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