University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

Universität Zürich[UZH]

Master Thesis:
Intraoperative Registration of a Surgical Tool With Preoperative CT Data Based on Optical Tracking

Context: Joints in humans or animals are of vital importance, as they allow mobility of the skeletal system. Joints can get damaged due to excessive wear and tear, old age, or injury. If the damage is severely inhibiting the joint's function, it might need to be replaced by a prosthesis. In the case of the knee joint, this procedure is known as total knee arthroplasty (TKA). Although these are standard procedures, they occasionally need to be revised. It has been suggested that the most frequent reason for TKA revision is error in surgical technique [1]. These errors can lead to misaligned prostheses, which can in turn heavily impact postoperative performance. This insight gave rise to the development of surgical navigation tools, which can help the surgeon to perform cuts more accurately and consistently.

Task description: A possible approach to surgical navigation is to plan the procedure on preoperative CT data of the target bone and to intraoperatively register the surgical tool to this data. A software can then be used to assist the surgeon in properly aligning the tool, for instance by means of a graphical user interface showing the current deviations between the tool and the preoperatively planned tool path. The goal of this project would be to develop such an application. We will be working with a surgical drill (**a**), which will be fit with optical tracking markers, such that its pose in 3D-space can be retrieved by a tracking system (**b**). A 3D-printed target bone will also be fit with markers. Your application then needs to load given CT data of the bone and to register it with the physical bone and tool. You will validate your application by defining target axes in the CT data, drilling into the 3D-printed bone, and evaluating the deviations between the corresponding virtual and physical axes.

(a) A standard veterinary orthopedic drill ([3], bottom right) will be fitted with optical tracking markers ([4], top left).

(b) An optical tracking system will be used to retrieve the positions of the markers in 3D space.

Work packages:

- Review the relevant literature on optical tracking and registration in surgical settings.
- Detail requirements for tool registration and user feedback.
- Instrument a surgical drill and a 3D-printed bone with optical tracking markers.
- Create an application for tracking and registering the drill with given preoperative CT data of the bone, including a graphical user interface.
- Validate your workflow and application on the physical setup.

Benefits:

- Gain practical experience with user-oriented software development for biomedical applications.
- Learn to work with a state-of-the-art optical tracking system.
- Work in a highly interdisciplinary team of robot engineers and veterinarians.

Requirements:

- Solid background in engineering or computer science or a closely related field.
- Basic knowledge of mechanics and programming.
- Prior experience with optical tracking is a plus, but not strictly required.

References:

[1] R. A. Siston et al. "Surgical navigation for total knee arthroplasty: A perspective." *Journal of Biomechanics*, 40(4), pp. 728-735, 2007. doi.org/10.1016/j.jbiomech.2007.01.006

[2] Ruijin Medical. *What is the veterinary orthopedic drill?* (2018). Accessed: May 5, 2022. [Online]. ruijinmedical.com/what-is-the-veterinary-orthopedic-drill/

[3] W. R. Sherman and A. B. Craig. *Understanding Virtual Reality*. Elsevier, 2018. doi.org/10.1016/C2013-0-18583-2

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