Improving Human Motion Capture Algorithms for Orthopedic Assessments

Project Management and Software Development
for Medical Applications

General Info

Contact Person: Dr. Lara Marie Reimer

Contact Email: lara.reimer@ukbonn.de

Project Abstract

This project focuses on researching existing human pose estimation algorithms, especially focusing on lower limb motion, and adapting these algorithms to enable assessing joint motion in orthopedic assessments.

Background and Motivation

Assessing a patient's joint range of motion is an important task in the orthopedic examination during diagnosis, treatment, rehabilitation, and outcome documentation. Enabling automatic joint assessments at home is a promising approach to improve patient care. It enables faster documentation, as the current process involves manual measurement using a goniometer. Moreover, it promises a more accurate and frequent monitoring during treatment and rehabilitation by enabling measurements at home. One of the most important metrics is the range of motion (ROM), describing the difference between the minimal flexion and the maximal extension of the joint in different directions depending on the type of joint (e.g., flexion-extension, inversion-eversion). Certain diseases and injuries limit the ROM, while surgery and rehabilitation aim at extending the ROM to a close-to-normal range again.

However, the most common human pose estimation algorithms such as OpenPose or Apple ARKit often detect joint angles with significant error rates [1-3] or do not enable tracking the angles of smaller joints at all, such as the ankle angles. These algorithms also showed a tendency to underestimate the full ROM. In their current state, these algorithms therefore cannot be used for joint assessments. Recently developed algorithms [4-5] provide more accurate motion capture and might represent a solution for the given use case.

Student's Tasks Description

This project aims at adapting existing algorithms for human pose estimation for the given use case of assessing joint ROM in different directions of motion with a focus on lower limb motion (hip, knee, ankle). The task of the student includes research for suitable algorithms with a focus on ankle/foot detection and adaptation of the selected algorithm. Semi-implicit models like the ones described in [4,5] should serve as a baseline for the research.

A data set consisting of labelled data and short videos of the joints annotated with the measured degree of flexion will be provided.

The student will have the opportunity to get an extended understanding of the topic of orthopedic joint assessment through close contact with the Institute for Digital Medicine and the Clinic for Orthopedics/Trauma Surgery at the University Hospital Bonn. In addition, the student will gain

experience in using and improving human pose estimation algorithms, especially focusing on lower limb analysis.

Technical Prerequisites

Having a strong interest in analyzing human motion and working closely with experts from Digital Medicine and Orthopedics is important for success in this field. Knowledge in C++/C# and Python is recommended, Swift is beneficial.

References

[1] Reimer, L. M., Kapsecker, M., Fukushima, T., & Jonas, S. M. (2022). Evaluating 3D Human Motion Capture on Mobile Devices. Applied Sciences, 12(10), 4806. https://doi.org/10.3390/app12104806

[2] Reimer, L. M., Weigel, S., Ehrenstorfer, F., Adikari, M., Birkle, W., & Jonas, S. (2021). Mobile Motion Tracking for Disease Prevention and Rehabilitation Using Apple ARKit. Studies in Health Technology and Informatics. IOS Press. https://doi.org/10.3233/SHTI210092

[3] D'Antonio, E., Taborri, J., Palermo, E., Rossi, S., & Patane, F. (2020). A markerless system for gait analysis based on OpenPose library. In 2020 IEEE International Instrumentation and Measurement Technology Conference (I2MTC). IEEE. https://doi.org/10.1109/i2mtc43012.2020.9128918

[4] Osman, A. A. A., Bolkart, T., Tzionas, D., & Black, M. J. (2022). SUPR: A Sparse Unified Part-Based Human Body Model. European Conference on Computer Vision (ECCV). https://supr.is.tue.mpg.de

[5] Pavlakos, G., Choutas, V., Ghorbani, N., Bolkart, T., Osman, A. A. A., Tzionas, D., & Black, M. J. (2019). Expressive Body Capture: 3D Hands, Face, and Body from a Single Image. Proceedings IEEE Conf. on Computer Vision and Pattern Recognition (CVPR), 10975–10985.

Please send the completed proposal to ardit.ramadani@tum.de, tianyu.song@tum.de, vanessag.duque@tum.de and shervin.dehghani@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.