Professur für Sportgeräte und -materialien
TUM School for Engineering and Design
Technische Universität München

Masterarbeit / Semesterarbeit / IDP – Informatik (m/w/d)

Statistical Methods and Machine Learning in Medical Engineering – Foot Landmark and Bone Registration Estimation

Background

In the diagnosis of foot-related conditions, it is not always feasible or advisable to acquire CT scans. This project aims to explore the extent to which CT imaging can be avoided and whether features contained in CT data can be estimated from 3D foot surface scans – potentially lowering patient radiation exposure and speeding up diagnosis. Several sub-projects are available as part of this research, which can be pursued in parallel and in close cooperation.

Description of Sub-Projects

Shared tasks for all theses:

- Generation of a gold-standard dataset:
  CT data will be segmented using an interactive nnUNet pipeline, and anatomical landmarks/points of interest will be annotated.

Sub-Project 1 – Statistical Shape Model (SSM) of the Foot Surface

- Develop an SSM representing the foot shape, based on the foot surface geometry extracted from CT data.
  - Conduct a literature review on state-of-the-art SSM tools and methods (e.g., *Scalismo*, https://scalismo.org).
  - Choose a method/framework.
- Apply the SSM to both CT test datasets and 3D foot scan datasets & compare the distances of selected surface points between:
  (a) the original CT surface,
  (b) the CT-based SSM surface, and
  (c) the scan-based SSM surface.

Sub-Project 2 – Machine Learning-Based Bone Registration

- Conduct a literature review on state-of-the-art bone registration (alignment of estimated bone structures to a reference) methods.
- Assess identified architectures in terms of suitability under given (hardware) constraints and select one for implementation.
- Train a model using the chosen architecture on the available training data, then validate it on test data.

Sub-Project 3 – Machine Learning-Based Estimation of Internal Landmarks

- Similar to Sub-Project 2, but instead of estimating full bone geometries, the focus will be on predicting discrete internal landmarks and features.
- Work will be carried out in close cooperation with Sub-Project 2 to ensure methodological alignment.

Prerequisites

- Strong interest in the research topic and in exploratory investigations
- Independent working style
- Logical thinking skills and experience with statistical methods or machine learning
- Experience in data processing, with awareness of data quality and attention to detail
- Ability to work in an interdisciplinary team
- Preferably, experience in Python

Possible Formats SA/MA/IDP (For students of the departments: Informatics and Mechanical Engineering)

For more information please contact (both):
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