ID 05:
Personalized Modeling and Multimodal Sensing for Imminent Fall Prediction in Geriatric Patients

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Falls are a leading cause of injury, hospitalization, and loss of independence in older adults. Falls happen during various Activities of Daily Living (ADL), like walking or standing up from chairs or beds or sitting down, in indoor and outdoor setting, often even while using mobility assistance devices. Despite substantial progress in long-term fall risk assessment and fall detection, current approaches remain fundamentally reactive, either identifying individuals at risk over extended periods of time or detecting falls only after impact. The critical time window immediately preceding a fall, i.e. the second or fraction of a second before, during which intervention could prevent injury, remains largely unexplored.

This project proposes a novel paradigm centered on imminent fall prediction, aiming to identify short-term instability states preceding falls. The central hypothesis is that these states manifest as subtle, individualized deviations in mobility patterns, including gait variability, balance disturbances, and near-falls, which can be captured through multimodal sensing and modeled using advanced data-driven approaches.

A key limitation in the field is the lack of valid datasets, as falls cannot be ethically induced in older populations and continuous monitoring raises concerns regarding measurement burden. This project addresses these challenges by focusing on near-falls, instability events, and (if occurred) actual falls, combined with privacy-preserving sensing strategies and controlled observational studies. Furthermore, the project introduces personalized digital twins, i.e., computational models of individual mobility and balance, to simulate fall scenarios, generate synthetic data, and support the development of novel health technologies for everyday use, ranging from sensor systems to assistive robotic devices.

Methodologically, the project will compare wearable, vision-based and ambient sensing approaches and evaluate the use of the personalized digital twins with different optimization and machine learning paradigms. By integrating real-world data, individualized modeling, and predictive simulations, the project aims to shift fall research from reactive detection to proactive, personalized prevention, contributing to safer aging and advancing data-driven healthcare.

Prof. Dr. Katja Mombaur

PD Dr. Carl-Philipp Jansen

Special requirements for applicants:

- Master's Degree in Computer Science, Engineering, Mathematics, or Physics
- Advanced programming skills
- Knowledge in optimization, control and machine learning
- Knowledge in mechanical whole-body modeling, modeling human biomechanics and motor control
- Experience with human movement experiments is a plus
- Experience with medical applications / BME, in particular in geriatrics or gerontology is a plus
- Interest in interdisciplinary research, combining theory, computational methods and experimental aspects
- Interest to collect data with human participants