Chair of Applied Mechanics
TUM School of Engineering and Design
Technical University of Munich

Discovering human walking through humanoid locomotion

HiWi-/Semester-/Masterarbeit **starting 1.6.26**

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Introduction and Problem Description

Humanoid robots are fascinating precisely because they sit in that uncanny space between familiarity and difference: they look like us, with limbs, joints, and proportions that echo the human body, yet the moment they move, the illusion cracks in intriguing ways. Their gait can be stiff, overly precise, or dynamically unstable in ways that highlight just how remarkably adaptive and efficient human locomotion really is. This contrast is not a limitation but a powerful opportunity—by trying to make robots walk like humans and observing where they fail or diverge, researchers can uncover the hidden complexities of balance, coordination, and neuromuscular control that we usually take for granted. In this sense, humanoid robots become experimental mirrors, revealing the subtle mechanics and control strategies that underlie human gait and pushing us toward deeper biomechanical understanding.
For a motivated student in biomechanical engineering, this translates into a focused thesis opportunity centered on data analysis and comparison: existing datasets of humanoid robot locomotion—already captured using motion capture, force plates, and inertial sensors—can be analyzed alongside human gait data within a unified framework. The work would involve extracting and comparing key descriptors of global dynamics, such as center-of-mass trajectories, ground reaction force patterns, and measures of whole-body coordination, using established biomechanical methods. By systematically quantifying where and how robot gait deviates from human locomotion, the project can reveal which dynamical features are missing, exaggerated, or fundamentally different. This comparative analysis not only informs the design and control of humanoid robots but also sharpens our understanding of the principles that govern stable and efficient human gait.

Task Description

The student will analyze existing locomotion datasets with a focus on ground reaction forces, placing particular emphasis on the single-support phase. This includes evaluating the magnitude and temporal structure of vertical forces, as well as examining impact characteristics and the direction and progression of horizontal ground reaction forces. These features will be systematically compared to corresponding patterns observed in human gait data using established biomechanical metrics. The student is expected to quantify deviations between humanoid robot and human locomotion and to develop mechanical interpretations for these differences, linking them to aspects such as control strategy, compliance, and whole-body coordination

Requirements

The ideal candidate is a motivated and curious student with a strong interest in interdisciplinary engineering at the intersection of biomechanics and robotics. Proficiency in MATLAB for data analysis is expected, along with a solid foundation in mechanics and/or human movement science. The student should be comfortable working with experimental data, applying quantitative methods, and interpreting results in a physically meaningful way. An independent and structured working style, combined with the ability to critically reflect on results and communicate findings clearly, is essential. Prior experience with biomechanical data analysis and signal processing is advantageous but not required.

If interested, please write a short e-mail stating your motivation for this project and your main qualifications.