BeReal(Time): Real-Time Musculoskeletal Simulation for enhanced Rehabilitation

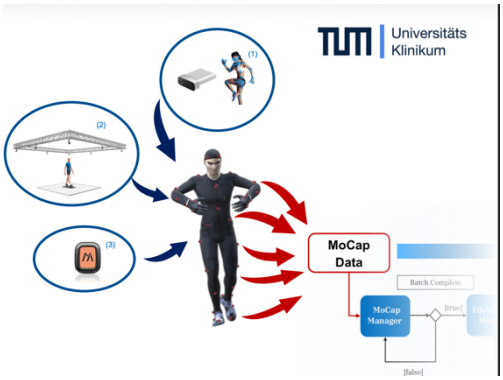
Project Type [BA, Guided Research, MA]

Project Title: Real-Time

Research Domain(s): Real-Time Rehabilitation, Unity

Project Director: Prof. Daniel Roth

Project Advisors: Daniel Homm & Julian Kreimeier



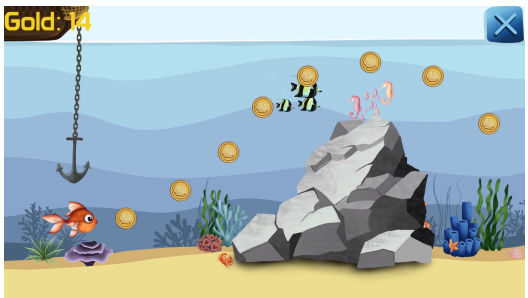
Project Abstract:

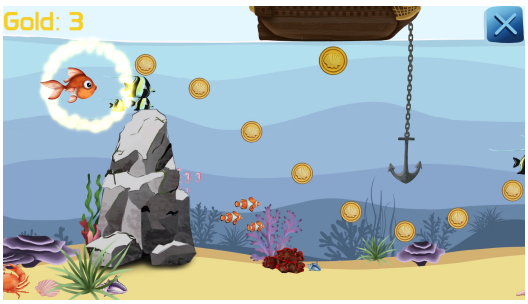
This project aims to improve boring exercises with real-time motion tracking and gamification approaches in combination with musculoskeletal simulations to get meaningful outputs.

More concrete this project builds upon an existing Unity project which already provides a real-time pipeline to visualize human pose data in real-time. Additionally, the project forwards data to a second module to calculate different biomechanical motion parameters.

The goals of the project can be split into three parts:

1. Translate the project a reusable Unity package that can be integrated into other Unity projects. Analysis and testing will be needed.
2. Embed “Knie Wieder” Unity game into the pipeline for better visualization.
3. Use Google’s MediaPipe and Microsoft’s Kinect as input to detect key-points on the human body and drive the Unity skeleton for visualization and biomechanical analysis.





Depending on your current state of study and your specific expertise the focus of the project can be adjusted.

Background & Motivation

Rehabilitation is a cumbersome process. Traditional rehabilitation is repetitive, effortful, and often boring, which reduces adherence and practice dose, especially in home programs where non-adherence rates reach 30–65% [1]. Serious games and exergames embed therapeutic movements into structured tasks with scores, levels, goals, and rewards, transforming monotonous “do 30 reps” into engaging challenges with clear objectives and visible progress. Current real-time feedback is limited to simple outputs like joint angles, range of motion, or basic stability indicators [3]. In contrast, our pipeline currently links simple visualization to a personalized simulation enabling feedback related to joint loads, muscle forces, and contact pressures in real time.

This information serves two purposes:

1. **For patients**: Processed outputs can be distilled into more accurate, easily comprehensible results, such as simplified load warnings or personalized form cues, beyond basic angle displays [4].
2. **For clinicians**: Raw or processed simulation data enables precise, data-driven feedback and intervention adjustments.

And this where you come in place!
We offer a thesis topic to enhance the pipeline with your ideas to make it functional in the real world. For this it needs to be reusable for games in varying environments, countering cumbersome physical rehabilitation with enhanced real-time feedback!

Key research areas include:

- Unity scripting and package creation
- Vision-based human pose estimation (with Google’s MediaPipe and Microsoft’s Kinect)

Recommended background (or motivation in learning):

- Good knowledge in Unity
- Some knowledge in vision based human pose estimation or key point detection

Please send your transcript of records, CV and motivation to: Daniel Homm (daniel.homm@tum.de) with CC to hex-thesis.ortho@mh.tum.de

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Literature:

[1] Argent, R., Daly, A., & Caulfield, B. (2018). Patient involvement with home-based exercise programs: Can connected health interventions influence adherence? *JMIR mHealth and uHealth*, *6*(3), e47. doi:10.2196/mhealth.8518

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[3] Paladugu, P., Kumar, R., Ong, J., Waisberg, E., & Sporn, K. (2025). Virtual reality-enhanced rehabilitation for improving musculoskeletal function and recovery after trauma. *Journal of Orthopaedic Surgery and Research*, *20*(1), 404. doi:10.1186/s13018-025-05705-3

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[5] Day, K. A., & Bastian, A. J. (2019). Providing low-dimensional feedback of a high-dimensional movement allows for improved performance of a skilled walking task. *Scientific Reports*, *9*(1), 19814. doi:10.1038/s41598-019-56319-9

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