A Biomechanics Visualization Tool For Motion Tracking with Inertial Sensors and Smartphone Cameras

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Motivation

- **Biomechanical Analysis:** Precise motion tracking is crucial for diagnosing and monitoring musculoskeletal disorders during rehabilitation.
- **Limitations of Existing Tools:** OpenSim, the leading biomechanics platform, lacks flexible camera calibration, video overlay, and multi-skeleton rendering, making qualitative comparison of motion tracking methods challenging.
- **IMU Preprocessing Constraint:** OpenSim does not process raw inertial IMU data, requiring preprocessed orientations as inputs.

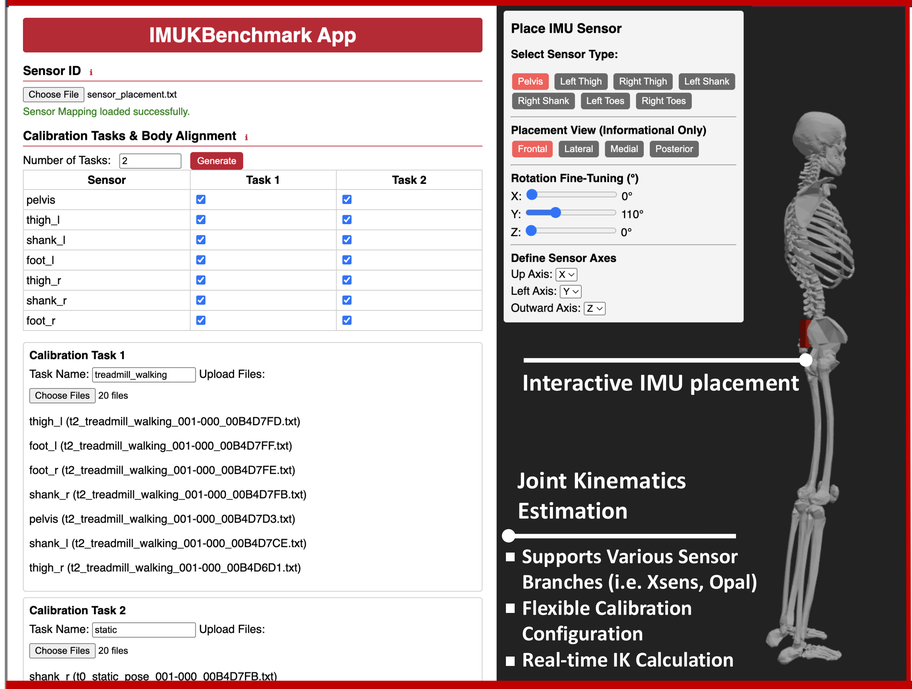
Key Idea

We introduce a **biomechanics-informed visualizer**, enabling comprehensive, real-time qualitative assessments in various settings.

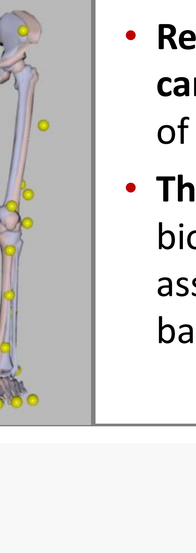
Methodology

- **Precise Camera Control:** Independently configures parameters (intrinsic/extrinsic) for precise viewpoints and easy reconfiguration.
- **VTK Mesh Loading:** Extracts vertex and face data to construct 3D meshes of skeletons.
- **Quaternion-Based Rotations:** Uses quaternions to represent body segment orientations, avoiding issues such as gimbal lock and allowing for smooth interpolation.

Kinematics Visualizer for Joint Kinematics Computation



Produces IK Results & Motion Visualization



Raw Inertial Data to Motion

Accelerometer, Gyroscope, Magnetometer

Directly processes raw IMU data, eliminating preprocessing offering real-time or offline analysis of joint kinematics.

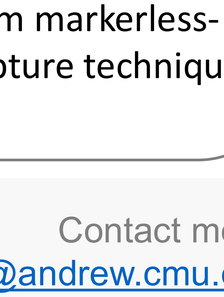
State Estimation Filters

Kalman, Madgwick, Mahony and more

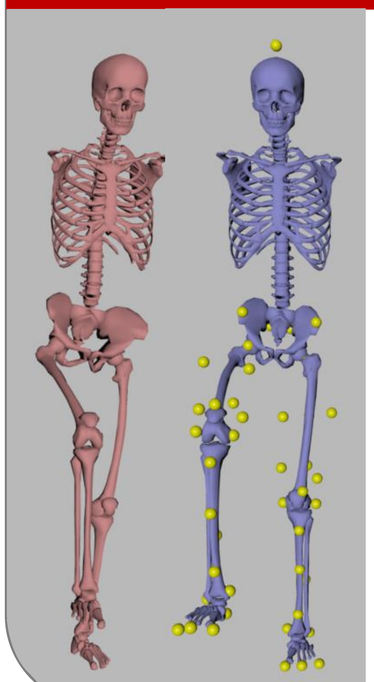
Incorporates a wide range of state estimation filters for balancing accuracy and run-time.

Left Ankle Angle Plot

Lateral Step Down
3 Repeated Trials



Flexible Camera Calibration



Multi-Skeleton Rendering

Renders multiple skeletons simultaneously, either overlaid or side by side

Marker Visualization

Better evaluate motion tracking accuracy and detect marker bias

Hip region appears narrower compared to ground truth

Vision-Based Estimation

Ground Truth

Takeaway

- **Our work offers** new pathways for improving the qualitative assessment of biomechanical results in various settings from clinics to homes
- **Researchers and biomechanists can** visually compare the outputs of AI models and ground truth.
- **This enables** clinicians and biomechanists to compute and assess results from markerless-based motion capture techniques

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