Figure Captions

Figure 1:

Representative frames from dynamic MRI sequence of the knee during a flexion-extension cycle. Images were acquired using a 2D radial golden-angle gradient echo FLASH sequence, providing high temporal resolution to capture continuous knee motion. These frames serve as input data for subsequent semi-automated segmentation and kinematic analysis.

Figure 2:

Schematic overview of the semi-automated segmentation pipeline for tibiofemoral kinematic analysis. The process consists of four main steps: (I) Edge detection using the Canny algorithm to identify bone boundaries; (II) Connected-component labeling to isolate specific bone edges; (III) Extraction of reference points along the labeled edges; and (IV) Computation of transformation matrices to track bone movement across frames. The final panel illustrates the result of this process, showing the segmented tibia and femur overlaid on the original MRI image, similar to those seen in Figure 1.

Figure 3:

Comparison of kinematic parameters derived from manual and semi-automated segmentation for an exemplary dataset during a knee flexion-extension cycle. (Left) Angle between the long axes of tibia and femur plotted against flexion cycle percentage, where -100% represents maximum flexion, 0% full extension, and +100% return to maximum flexion. (Right) Rate of change of angle (angular velocity) over the flexion cycle, with negative values indicating flexion and positive values extension. The semi-automated method (blue) demonstrates smoother trajectories compared to the manual method (orange) in both angle and angular velocity plots, potentially indicating more accurate representation of continuous knee motion.

Figure 4:

Rate of change of the tibiofemoral angle throughout the knee flexion-extension cycle. Data from automatic (blue) and manual (orange) segmentation methods are shown, aggregated across all datasets. The x-axis represents the flexion percentage, where -100% indicates maximum flexion, 0% represents full extension, and +100% indicates return to maximum flexion. Solid lines represent the upper and lower bounds of one standard deviation from the mean, with the shaded area between these lines indicating the range within one standard deviation. The derivative nature of this plot results in negative rates during the initial flexion-to-extension phase and positive rates during the extension-to-flexion phase. Note that the automatic method demonstrates less variability (narrower shaded areas) compared to the manual method, particularly near full extension (0% flexion).

Figure 5:

Comparison of the Coefficient of Variation (CV) for frame-to-frame angle changes between the automatic and manual segmentations. The CV, expressed as a percentage, quantifies the consistency of tracking knee motion, with lower values indicating more consistent tracking. Each point represents the CV for one dataset. The automatic method (blue) demonstrates consistently lower CV values across all datasets compared to the manual method (orange), indicating improved consistency in tracking knee kinematics. The boxplots show the median, interquartile range, and full range of CV values for each method.