**Figure 1:** Dynamic MRI frames of knee motion during a full flexion-extension-flexion cycle. Each frame represents a 2-degree increment in knee angle. Frame 0 shows maximum flexion, with subsequent frames progressing through extension and returning to flexion in the final frame.

**Figure 2:** Visualization of the transformation computation process for the tibia edge. Left: Binary edge of the tibia (white) from a frame during knee extension with reference points (orange dots) from the initial frame, showing misalignment due to bone movement. Right: The same binary edge with reference points (green dots) after applying the optimal transformation parameters, demonstrating successful alignment with the bone boundary. This illustrates how the algorithm transforms the reference points established in the first frame to match the bone position at any point during the motion cycle.

**Figure 3:** Schematic overview of the semi-automated pipeline for bone shape tracking. The process includes: (I) Canny edge detection for detection of bone boundaries; (II) Connected-component labeling to isolate edges; (III) Extraction of reference points along edges; and (IV) Computation of transformation parameters for frame-to-frame tracking. The final panel shows segmented tibia and femur overlaid on the MRI image after applying the transformations obtained from semi-automated tracking to manual segmentation performed in the first frame.

**Figure 4:** Example of semi-automatically tracked segmentation of the tibia (blue) and femur (orange) at different points during the knee motion cycle overlaid on the base CINE frames.

**Figure 5:** Comparison of relative bone motion parameters during knee flexion-extension cycles using semi-automatic and manual segmentation. Panels show anterior-posterior (left) and superior-inferior (right) centroid distances between tibia and femur. Top row represents extension phase (flexed to extended), bottom row shows flexion phase (extended to flexed). Shaded areas indicate variability across subjects: orange for manual and blue for semi-automatic segmentation.