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Abstract: Stability and Control of Amputee-Walking on Slopes

Studying sloped walking for amputees is especially important because a slope is often provided as an alternative to stairs for people with disabilities. Our research aims to investigate dynamic stability and control strategies of amputees wearing lower-limb prostheses and compare them across different inclinations and speeds. Results from amputee subjects will also be compared with results from non-amputee subjects. We will do this by studying how deviations to the body's center of mass, occurring due to small intrinsic perturbations, are corrected using foot placement and forces. Subjects will be requested to walk on a treadmill for 3-4 minutes at different slopes and speeds. Control subjects will be matched with amputee-subjects age and activity level. Three-dimensional motion information will be collected using marker-based motion capture with four markers on each segment on both legs. For the zero-slope condition, ground reaction forces will also be collected with the help of force plates embedded in a split-belt treadmill. The motion and force data will be analyzed by fitting linear models between deviations in body states to body states from one step to the next, where eigenvalues are computed to analyze the step-to-step stability. Similarly, we will also fit linear models between input body states and deviations in output controls like foot placement, ground reaction forces and stance times. We expect higher variability in body states for amputees as compared to non-amputee controls. For instance, we expect higher knee flexion when walking on slopes versus when walking on level ground and subsequently, higher signal-dependent variations in the knee flexion. We predict significant increase in the various control gains for amputees when compared to non-amputee sloped walking. We also expect the control gains to change with the slope and speed at which the amputee walks. Additionally, we expect that amputees will have greater center-of-mass error resulting from comparative lack of musculature in amputees compared to non-amputee controls.