USING SUBJECT-SPECIFIC SIMULATIONS TO UNDERSTAND MUSCLE FUNCTION DURING WALKING

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We are interested elucidating the functions of muscles for two reasons. First, motivated by a desire to explain normal walking mechanics, we would like to understand how muscles control a complex articulated linkage and render seemingly simple dynamic behavior. Second, because muscles are often the targets of treatment, we would like to understand muscle function to provide a scientific basis for planning treatment interventions. We have developed methods for generating subject-specific, muscle-actuated simulations of walking, and other activities, and for analyzing these simulations to understand muscle function.

The method for generating a simulation is comprised of four steps. In Step 1, segment lengths, masses, and moments of inertia of a generic model are scaled based on measured subject data. In Step 2, an inverse kinematics problem is solved to find the joint angles that best reproduce the input kinematics. In Step 3, a residual elimination algorithm is used to remove any dynamic inconsistencies between the experimental kinematics and external reactions. In Step 4, computed muscle control is used to find values of muscle excitations that produce the measured joint kinematics. Once a simulation has been obtained, we compute how individual muscles contribute to various aspects of gait. Computed muscle control has allowed us to generate muscle-actuated simulations of gait accurately and efficiently, (Figure 1). The simulations typically track experimental data with errors in the joint angles that are less than 1 degree, and these simulations can be generated with less than 20 minutes of CPU time on desktop computers.

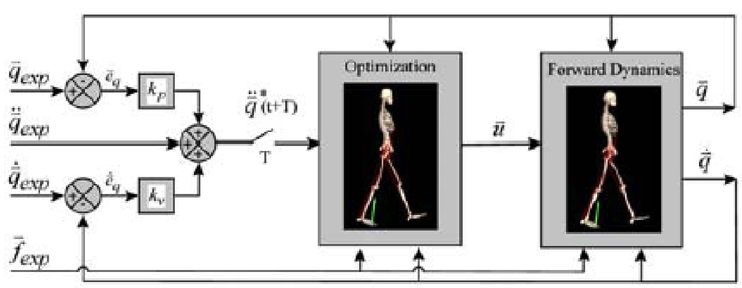

Figure 1: Computed Muscle Control Algorithm

Dynamic simulations of gait have allowed us to quantify how muscles contribute to support and progression, examine how muscles coordinate both stance- and swing-limb joint angles, identify the potential causes of abnormal motion in individual subjects, and evaluate the likely biomechanical effects of surgical and non-surgical treatments.

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