

O0136

Goal-oriented human movement simulation: applications in predicting subject-specific balance recovery

Jeffrey A. Reinbolt, Nicolas A. Vivaldi, Aravind Sundararajan

University of Tennessee, Knoxville, USA

Abstract

How the brain selects appropriate controls to achieve specific movement goals is an open question and computer simulations are a vital tool for providing answers. Individual transformations from neural control to purposeful, coordinated movement are highly complex. There is a lack of knowledge about how assessments from clinical exams and movement analysis map to disabilities needing improvements; the understanding of fall prevention can be expanded by novel discoveries filling this knowledge gap. An approach using computational tools based on mechanisms of neuromuscular control, dynamics, and function for behavioral tasks may help discover new movements as treatments and predict outcomes using pre-treatment data.

A scientific framework, combining simulations with experiments, is needed to reveal basic physical principles of behavioral tasks to maintain balance, such as goal-oriented task control and neuromechanics for improved balance recovery ability. To identify relationships concerning task-level contributions to balance, multidisciplinary approaches for studying neural modeling (motor control, neuromechanics) to execute mechanical balance tasks (e.g., robotics, biomechanics) must be developed. To identify relationships concerning neuromechanical contributions to balance, feasible sets resulting from neuromechanical analyses provide a potentially powerful tool when coupled with subject-specific models and simulations. We have been developing and applying these approaches to physics-based simulations of human movement.

Our research is moving towards discovering new balance control principles and facilitating the design of effective, subject-specific intervention aiming to decrease falls. We generate subject-specific, surrogate response surface models that represent multi-segment coordination of the behavioral goal of balance. We create dynamic simulations with supporting foot-ground contact forces that use these surrogate models. These simulations allow task prioritization within the operational space control to be systematically varied in terms of the priority hierarchy. The synthesis of goal-oriented task coordination simulations from subject-specific surrogate models enables the identification of control priorities to prevent falls. We use mathematical approaches quantifying the biomechanical capabilities of individual subjects to complete these goal-oriented

control priorities. The characterization of neural and mechanical interactions for balance recovery may identify new potential control priorities for generating balance recovery forces to prevent falls.

Computer simulations are playing an increasingly important role in solving complex engineering problems, and have the potential to revolutionize experimentally-based medical decision making and treatment design. The long-term goal of computer simulation of human movement research is to provide a scientific basis for planning, evaluating, and improving subject-specific functional outcomes. Due to lack of knowledge about how mobility impairments map to limitations needing treatment, disease prevention and treatment protocols can be significantly improved. New strategies using simulation-based medicine will lead to a better understanding of prevention and treatment for many human movement disorders, including balance recovery to minimize the number of falls and fall-related injuries.