The HUMOSIM Ergonomics Framework: A New Approach to Digital Human Simulation for Ergonomic Analysis

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The potential of digital human modeling to improve the design of products and workspaces has been limited by the time-consuming manual manipulation of figures that is required to perform simulations. Moreover, the inaccuracies in posture and motion that result from manual procedures compromise the fidelity of the resulting analyses. This paper presents a new approach to the control of human figure models and the analysis of simulated tasks. The new methods are embodied in an algorithmic framework developed in the Human Motion Simulation (HUMOSIM) laboratory at the University of Michigan. The framework consists of an interconnected, hierarchical set of posture and motion modules that control aspects of human behavior, such as gaze or upper-extremity motion. Analysis modules, addressing issues such as shoulder stress and balance, are integrated into the framework. The framework encompasses many individual innovations in motion simulation algorithms, but the primary innovation is in the development of a comprehensive system for motion simulation and ergonomic analysis that is specifically designed to be independent of any particular human modeling system. The modules are developed as lightweight algorithms based on closed-form equations and simple numerical methods that can be communicated in written form and implemented in any computer language. The modules are independent of any particular figure model structure, requiring only basic forward-kinematics control and public-domain numerical algorithms. Key aspects of the module algorithms are “behavior-based,” meaning that the large amount of redundancy in the human kinematic linkage is resolved using empirical models based on laboratory data. The implementation of the HUMOSIM framework in human figure models will allow much faster and more accurate simulation of human interactions with products and workspaces using high-level, task-based control.