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Neuroscience 2013

Presentation Abstract

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Presentation Title: Large-scale neuromusculoskeletal model used to investigate neurophysiological mechanisms behind upright stance control

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Topic: ++G.06.a. Computation, modeling, and simulation

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Abstract: Several models have been employed to study the basic mechanisms underlying postural control in humans. Nevertheless, the vast majority of these models are based on a control engineering framework, so that the nervous system is approximated by a proportional-integrative-derivative (PID) linear model. While this may be a valid assumption, it fails in providing a close link between theory and physiology. In this study, our aim was to develop a biologically-based large-scale neuromusculoskeletal model intended to investigate the problem of upright stance control from a neurophysiological point of view. Some of its components are: i) conductance-based spinal neuron models (motor neurons and interneurons) arranged in three motor pools (for the Soleus and Gastrocnemii muscles); ii) muscle spindle model providing Ia and II afferent feedback; iii) Hill-type muscle models; iv) inverted pendulum model, which is a first approximation to the body biomechanics during upright posture. The randomness of the system is mainly due to the stochastic point processes that describe the descending neurons' and afferents' activities. The main findings were that the intrinsically unstable mechanical system might be stabilized by appropriately setting the level of fusimotor activity. The resultant values of COP RMS and mean velocity were compatible with those reported from vestibular loss subjects standing on a stable surface without visual information. In addition, there was a small cross-correlation peak at a lag around 300 ms between simulated COP and EMG from the Triceps Surae's muscles. The more interesting finding was that an intermittent pattern of muscle activation emerged from this posture control model, suggesting that the spinal architecture and organization, along with the modulation of afferent activity, may account for the apparent intermittent control that has been postulated by some researchers. From our knowledge this is the first large-scale neuromusculoskeletal model used to control an unstable biomechanical system which approximates human standing. Several other studies may be carried out using this model, for instance, the investigation on how neuromuscular changes associated with aging or specific diseases influence postural control.

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COMPUTATIONAL MODEL

MOTOR CONTROL

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