Musculoskeletal Simulation of Human Stance Postural Control

Humans perform high-level stance postural control, which keeps their center of mass on their small base of support. Understanding the mechanism of control is essential to providing effective rehabilitation. In attempts to model human postural control, torque-driven inverted pendulum models have been widely used as a human body. However, internal forces contributing to posture maintenance are not represented when using a torque-driven model. Muscle forces and three-dimensional location information of skeletal bones are to be treated.

We propose a neural controller model (Fig. 1) to maintain a musculoskeletal model (Fig. 2) in a stance posture. This neural controller model consists of feed-forward control to send constant necessary muscle tonus for stance and feedback control based on sensory inputs. In simulations with the neural controller model, the contribution of muscle tonus at a stance posture was confirmed[1], and the changes in muscle activations for different sensory inputs were reproduced[2]. This neural controller model could maintain a stance posture even under external forces, and the features of the magnitude of muscle activations and passive ankle stiffness were consistent with experimental results in previous studies. We are trying to understand what kind of change occurs in behavior when body change occurs through predictive simulations.

Keywords: postural control, musculoskeletal model, biological simulation

Reference

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[3] K. Kaminishi, P. Jiang, R. Chiba, K. Takakusaki, and J. Ota, "Postural control of a musculoskeletal model against multidirectional support surface translations," PLoS One, vol. 14, no. 3, p. e0212613, 2019.

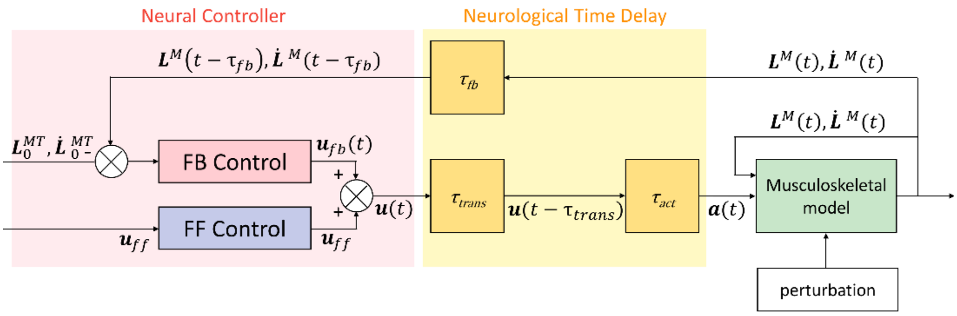

Fig. 1 Neural controller model. It consists of feedback control based on muscle length and lengthening speed and feed-forward control of constant value.
$\boldsymbol{u}$: total control, $\boldsymbol{a}$: muscle activation, $\boldsymbol{L}^{MT}$, $\boldsymbol{L}_0^{MT}$: current and objective muscle length,
$\dot{\boldsymbol{L}}^{MT}$, $\dot{\boldsymbol{L}}_0^{MT}$: current and objective muscle lengthening speed,
τ_{trans}, τ_{fb}, τ_{act}: transmission, feedback, and activation time delay.

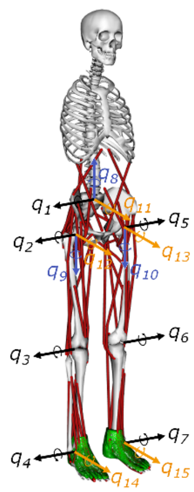

Fig. 2 Musculoskeletal model.