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 the 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 keep a musculoskeletal model (Fig. 2) in a stance posture. This neural controller model consists of feed-forward control to send constant necessary muscle activations for stance and feedback control based on multisensory inputs. The neural controller model could simulate human-like muscle activations as well as activation change for different sensory input conditions. We also use this neural controller model to simulate a perturbed stance. We succeeded in maintaining the stance posture of a musculoskeletal model under multidirectional perturbations, and the trends of the magnitudes of muscle responses were consistent with experimental results in a previous study.

Keywords: postural control, musculoskeletal model, biological simulation

Reference

[1] P. Jiang, R. Chiba, K. Takakusaki, and J. Ota, "A postural control model incorporating multisensory inputs for maintaining a musculoskeletal model in a stance posture," Adv. Robot., vol. 31, no. 1–2, pp. 55–67, 2017.

[2] P. Jiang, R. Chiba, K. Takakusaki, and J. Ota, "Generation of the Human Biped Stance by a Neural Controller Able to Compensate Neurological Time Delay," PLoS One, vol. 11, no. 9, p. e0163212, 2016.

[3] K. Kaminishi, P. Jiang, R. Chiba, K. Takakusaki, and J. Ota, "Proprioceptive postural control of a musculoskeletal model against horizontal disturbances," in 2017 IEEE International Conference on Robotics and Biomimetics (ROBIO 2017), 2017, pp. 1270–1275.

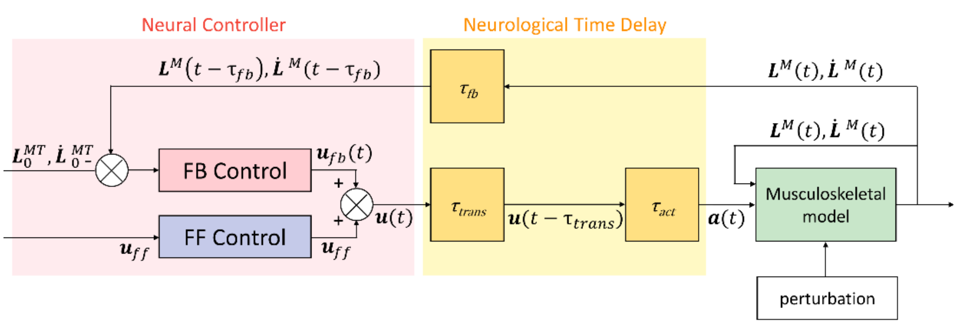

Fig 1. Developed mobile robot (above) and tilting manipulation using two mobile robots (bottomFig. 1 Neural controller. It is composed of feedback control based on muscle length and lengthening speed and feed-forward control of constant value. u: total control, a: activation,

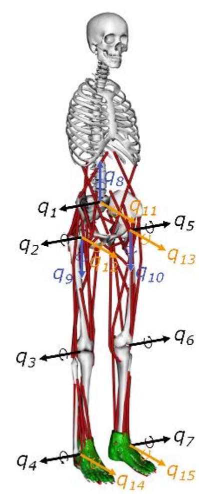

Fig. 2 Musculoskeletal model.