Modeling Human Stance Postural Control through Forward Dynamics Simulation

Stance postural control, which allows individuals to maintain an upright stance, is one of the most important and basic requirements for a comfortable life. Most previous literature used an inverted pendulum without muscles to represent human body, which is not physiologically plausible. In addition, inverse dynamics simulation was used to identify the hypothetical neural controller models based on experimental data. The method only reproduce the experimental data and cannot prove whether or not the proposed neural controller model is correct. Modeling human postural control by musculoskeletal forward dynamics simulation is necessary.

We propose a neural controller model (Fig. 1) to keep a musculoskeletal model (Fig. 2) in a stance posture. This model consists feed-forward control to send constant necessary muscle activations for stance and feedback control based on multisensory inputs. The parameters in the controller are designed by optimization of energy consumption during stance. As a result, the proposed model can simulate human-like muscle activations as well as activation change for different sensory input conditions, indicating that the proposed model is physiologically plausible. Currently, we use this controller to simulate the upright standing against disturbances.

Keywords: postural control, musculoskeletal model, biological simulation

Reference

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2. Jiang,Ping, Chiba,Ryosuke, Takakusaki,Kaoru, & Ota,Jun. (2016). Generation of the human biped stance by a neural controller able to compensate neurological time delay. PLoS ONE, 11 (9): e0163212. doi:10.1371/journal.pone.0163212.

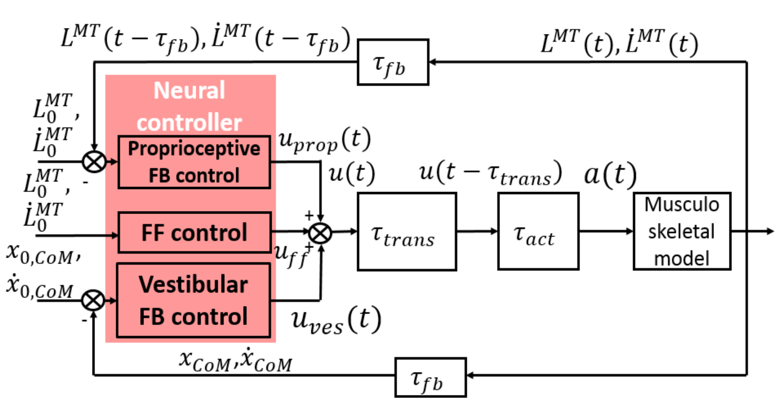

Fig. 1 Neural controller model. u : total control; a : activation;
L^{MT}, L_0^{MT} : current and objective muscle length, respectively.
$\dot{L}^{MT}, \dot{L}_0^{MT}$: current and objective muscle lengthening speed respectively.
$x_{CoM}, \dot{x}_{CoM}$: displacement and velocity of center of mass in anterior-posterior direction; $\tau_{trans}, \tau_{fb}, \tau_{act}$: transmission, feedback and activation time delay.

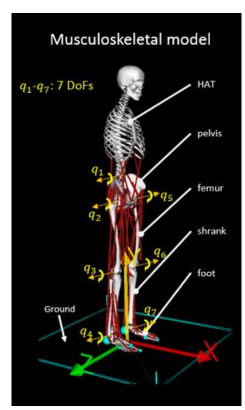

Fig. 2 Musculoskeletal model