Testing a neuromuscular locomotion control model against human experiments

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Summary

We compare the responses of a neuromuscular model and of humans for a range of gait disturbance experiments. Preliminary results of this comparison suggest that the model captures a substantial portion of the spinal reflex circuitry active during walking in humans.

Introduction

Several neuromuscular models of human locomotion achieve walking in simulation. However, not all of them may capture the neural control that humans use. One way to evaluate the physiological relevance of a specific human model is to replicate with it gait disturbance experiments and to compare the responses of the model to those of humans. We perform such a comparison with a neuromuscular model we recently proposed (Song and Geyer, 2015) for a range of experiments covering muscle, joint, and whole body disturbances.

Methods

The available literature on human gait experiments uses disturbances that broadly fall into three categories: electrical stimulations on sensory feedback pathways (Courtine et al., 2007), mechanical perturbations at local joints (Sinkjaer et al., 1996), and trip and slip perturbations at the entire leg (Schillings et al., 1999). We replicate the corresponding experiments in a series of simulations with our neuromuscular model and compare the immediate muscle activation responses between the model and humans (Fig-a).

Preliminary Results and Discussion

The model shows similar response trends with humans for most muscles (ex. Fig-b). Differences in some muscle responses provide ideas of how the control can be modified.

The observation that the control model shows human-like responses to a range of disturbances strengthens the plausibility of the model. Such response comparison study may be used to sort out a few good control models.

References

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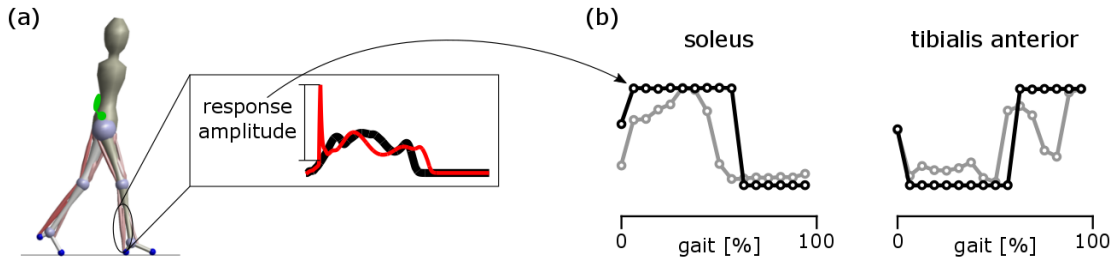

Figure. Example of disturbance response comparison. (a) Simulation experiment with the neuromuscular model. Response quantified as peak difference between muscle activations under disturbed and normal conditions. (b) Response trend over gait cycle compared between model (black dotted lines) and previously reported data on humans (gray dotted lines).