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Estimation of muscle activity using higher-order derivatives, static optimization, and forward-inverse dynamics

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Abstract

We propose a new method to estimate muscle activity in a straightforward manner with high accuracy and relatively small computational costs by using the external input of the joint angle and its first to fourth derivatives with respect to time. The method solves the inverse dynamics problem of the skeletal system, the forward dynamics problem of the muscular system, and the load-sharing problem of muscles as a static optimization of neural excitation signals. The external input including the higher-order derivatives is required for a calculation of constraints imposed on the load-sharing problem. The feasibility of the method is demonstrated by the simulation of a simple musculoskeletal model with a single joint. Moreover, the influences of the muscular dynamics, and the higher-order derivatives on the estimation of the muscle activity are demonstrated, showing the results when the time constant of the activation dynamics are very small, and the third and fourth derivatives of the external input are ignored, respectively. It is concluded that the method has a potential to improve estimation accuracy of muscle activity.

Keywords: Musculoskeletal system, Estimation, Higher-order derivative, Inverse dynamics, Forward dynamics, Optimization

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