Framework of Lower-Limb Musculoskeletal Modeling for FES Control System Development

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Abstract

In recent years, the demand of interest in functional electrical stimulation (FES) is increasing due to the applications especially on spinal cord injury (SCI) patients. Numerous studies have been done to regain mobility function and for health benefits especially due to FES control development for the paralyzed person. In this paper, the existing general framework modeling methods have been reviewed and the new modeling framework approach has been discussed. In general modeling and simulation can greatly facilitate to test and tune various FES control strategies. In fact, the modeling of musculoskeletal properties in people with SCI is significantly challenging for researchers due to the complexity of the system. The complexities are due to the complex structural anatomy, complicated movement and dynamics, as well as indeterminate muscle function. Although there are some models have been developed, the complexities of the system resulting mathematical representation that have a large number of parameters which make the model identification process even more difficult. Therefore, a new approach of modeling has been presented which is comparatively less burdened compared with mathematical representations. Hence this musculoskeletal model can be used for FES control system development.

Keywords

Functional electrical stimulation (FES), spinal cord injury (SCI), rehabilitation, framework, musculoskeletal.

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For restoring lower limb functions, the hybrid FES system, which uses an orthosis with FES, has been accepted as one of practical methods [4, 5]. In the recent years, powered orthotic devices or robotic exoskeletons have been focused on an assist or rehabilitation of lower limb functions [6, 7]. Therefore, the hybrid FES system is also expected to be realized with powered orthotic devices. In such system, cooperative control between FES and powered orthosis will be necessary. For computer simulation tests of learning the ISM and the IDM and of control performance, a musculoskeletal model of the upper limb was developed. In brief, muscle force. The musculoskeletal system that is the controlled object of FES has nonlinear, time variant characteristics. Those characteristics are different between persons. In addition, there is redundancy in stimulation intensity determination because the number of stimulated muscles is generally larger than that of controlled movements (joint angles). The FEL controller for FES (FEL-FES controller) is examined in computer simulation and experiments with subjects. Multi-joint control of lower limbs with fuzzy FES controller. Walking is a complex multi-joint movement of the lower limbs. In the movement, three joints (hip, knee and ankle joints) are influenced each other.