Design of Fuzzy Controller of the Cycle-to-Cycle Control for Swing Phase of Hemiplegic Gait Induced by FES

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Abstract

The goal of this study was to design a practical fuzzy controller of the cycle-to-cycle control for multi-joint movements of swing phase of functional electrical stimulation (FES) induced gait. First, we designed three fuzzy controllers (a fixed fuzzy controller, a fuzzy controller with parameter adjustment based on the gradient descent method, and a fuzzy controller with parameter adjustment based on a fuzzy model) and two PID controllers (a fixed PID and an adaptive PID controllers) for controlling two-joint (knee and ankle) movements. Control capabilities of the designed controllers were tested in automatic generation of stimulation burst duration and in compensation of muscle fatigue through computer simulations using a musculo-skeletal model. The fuzzy controllers showed better responses than the PID controllers in both control capabilities. The parameter adjustment based on the fuzzy model was shown to be effective when oscillating response was caused due to the inter-subject variability. Based on these results, we designed the fuzzy controller with the parameter adjustment realized using the fuzzy model for controlling three-joint (hip, knee, and ankle) movements. The controlled gait pattern obtained by computer simulation was not significantly different from the normal gait pattern and it could be qualitatively accepted in clinical FES gait control. The fuzzy controller designed for the cycle-to-cycle control for multi-joint movements during the swing phase of the FES gait was expected to be examined clinically.

Keywords: cycle-to-cycle control, FES-induced gait, multi-joint control, fuzzy controller, adaptive fuzzy controller

References

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