Features Extraction from a Second-Order Black Box Model Matched to the Veltink Model for a System Identification of Knee Extension for Control Law and Formulations of Close-Loop Controller Rehabilitation Using Functional Electrical Stimulation(Book Chapter)

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Abstract:
Real-world functional electrical stimulation (FES) encounters nonlinear effects of fatigue and time delay that cause the FES controller to under-perform or sometimes fail. Nonlinearities cause the system to change, but it is not possible to re-tune the controller once its parameters are set. System representation using an observer can allow the patient's knee extension to be represented in a numerical computation algorithm and can exist, run, or be executed in an embedded system. This enables the closed-loop controller to be tuned to the system being imitated. The second-order black box model can be matched to the Veltink model to represent the knee extension in which the model is transformed into a linear differential equation, and then into a physical-based model. The numerical computation using Taylor series is then used to convert the physics-based model using a computational algorithm that represents the knee extension system in a discrete-time linear system. Prior to the conversion of the numerical model, certain parameters need to be extracted from the actual system response of the patient knee angle trajectory upon receiving an open-loop signal from FES. This paper focuses on the control algorithm technique for extracting the second-order black box model parameters matched the actual knee extension system response. MATLAB/Simulink is used to test the parameter extraction algorithms. The results indicate that the extraction algorithms succeeded in extracting the actual system parameters that are similar to the ones obtained by extracting the parameters representing the knee extension model.

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