Identification of EMG Stretch Reflex Dynamics Using Hammerstein SVM Mode

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Nonlinear systems identification techniques have been used to study the stretch reflex dynamics of the muscles of the human ankle. Kearney and Hunter (Annals of Biomed. Eng., 1988) suggested a Hammerstein structure consisting of a static nonlinearity followed by a dynamic linear system to model the relationship between the angular velocity of the ankle and the electromyogram (EMG) measured over the Gactrocnemius-Soleus (GS) muscle. Furthermore, they showed that the static nonlinearity resembled a half-wave rectifier. However, such nonlinearity is not well approximated using polynomials. Cubic splines have been used to overcome this difficulty, but the problem became non-convex and hence difficult to solve. Recently, support vector machines (SVMs) have shown powerful abilities in approximating hard nonlinearities. In this work, a SVM and an autoregressive exogenous input (ARX) model have been used to represent the nonlinearity and the linear element respectively. The model parameters have been identified by minimizing epsilon insensitive cost functions based on either the sum of absolute residuals or the sum of squared residuals. Both approaches result in convex problems. Large scale implementations of these techniques are used to identify models of the stretch reflex EMG from experimental data recorded from a spinal cord injured patient. Even with non-Gaussian and nonwhite input signal, no numerical problems were encountered. The effects of the various cost functions and tuning parameters are demonstrated. It is clear from the results that the SVM based approach provides better predictions of the reflex EMG than the polynomial and cubic spline based models.