Evolving Fuzzy and Neural Network Models of Finger Dynamics for Prosthetic Hand Myoelectric-based Control

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ABSTRACT

The development of myoelectric-based control systems for prosthetic hands includes several control techniques as on-off, proportional, direct, finite state machine, pattern recognition-based, posture and regression. These techniques are applied in the model-based control design framework, which requires accurate models of the human hand in order to tune the controllers. The human hand in such systems is a challenging biomedical process, namely a Multi Input-Multi Output (MIMO) nonlinear dynamical system, with the inputs represented by the myoelectric signals (MESs) and the outputs by several finger angles.

The presentation starts with giving the prosthetic hand myoelectric-based control system structure. A set of evolving Takagi-Sugeno-Kang (TSK) fuzzy models, neural network models and simple linear models of the human hand dynamics, i.e. the finger dynamics, is next offered. These models will be used as reference models in myoelectric-based control systems. The inputs of this MIMO nonlinear system are the MESs obtained from eight sensors placed on human subject’s arm, and the outputs are the flexion percentages that correspond to the midcarpal joint angles.

Proportional-Integral (PI) and cost-effective PI fuzzy controllers are designed and tuned. On the other-hand, since the process modeling might be difficult and also expensive for certain applications, data-driven model-free controllers became popular during the last two decades. The tuning of these controllers does not make use of process models. Some popular data-driven model-free controllers are discussed and exemplified for this biomedical process. Both data-driven model-free control (in terms of the controller parameter update laws) and evolving fuzzy modeling (in terms of incremental online identification algorithms) can be viewed as machine learning techniques.

The models and the controllers were tested on a dataset that covers approximately 450 s and the results are encouraging. The structure, the models, the controllers and the experimental results illustrated in this presentation belong to a relatively wide range of applications focused on the development of evolving TSK fuzzy models, Tensor Product-based model transformation, neural network models, model-based and data-driven model-free controllers, with different degrees of intelligence and learning included, obtained by the Process Control group of the Politehnica University Timisoara, Romania.