F. Widjaja, C.Y. Shee, D. Zhang, W.T. Ang, P. Poignet, A. Bo, D. Guiraud. Current progress on pathological tremor modelling and active compensation using functional electrical stimulation. Gerontechnology 2008; 7(2):240. Pathological tremor is an involuntary and roughly periodic movement of a body part. It is the most common movement disorder and its incidence increases with ageing. Upper limb tremor causes difficulties in performing activities of daily living like buttoning, inserting a key into a keyhole and writing[1]. The active tremor compensation method involves 3 stages: sensing, filtering and actuation. Tremor and intended motion are observed by means of motion and neuromuscular sensors and a filtering algorithm is applied to separate such movements. The corresponding muscle is actuated in anti-phase with respect to the tremor signal using Functional Electrical Stimulation (FES). The long term goal is to provide a wearable tremor suppression orthosis for the upper limb. **Sensing** We developed a sensing system for quantification of tremor based on accelerometers and sEMG system[2]. An optical tracking system is used as a reference. The system concepts has been implemented and tested successfully. The next step involves miniaturization of sensing, filtering and actuation systems into a single wearable device. Data from normal subjects and patients (Parkinson disease, essential tremor, psychogenic tremor, Holmes tremor and stroke) with tremor have been recorded. Data obtained by the sensing system may be used to model and estimate tremor. A Kalman Filter (KF) fused the data from both sensors to estimate joints angles of the affected limb. This approach provided promising results for further exploration[3]. For instance, when tested with data collected from a Parkinson patient, the developed KF could estimate the wrist angle with an RMS error of 8.1% of the tremor peak-to-peak amplitude. **Filtering** The key technical challenge in tremor filtering is the real-time criterion of the application. Tremor frequency lies in different band from voluntary movement. However most classical frequency selective filters produce phase shift in the filtered signal, which means the filtered pathological motion is a time-delayed version of the physical motion. Therefore adaptive zero-phase filtering algorithms are studied and proposed to overcome this barrier. An improvement of the Weighted-Fourier Linear Combiner (WFLC), the Bandwidth-Limited FLC, has been implemented[4]. This improved algorithm is able to track modulated signals with multiple frequency components and it has been tested in real physiological tremor signal. **Actuation** Only simulation studies have been carried out. As to the control architecture, model-based control schemes are preferred, although a model-free fuzzy logic control approach has been evaluated to control joint angle. Two different musculoskeletal models have been used. The first approach is based on a simplified mechanical model actuated by an antagonist pair of muscles derived from Hill or Huxley model. The second combines a pair of linearized Hill-type muscle models with a virtual spring-damper system. The main advantage of using this last approach is the simplification of the identification procedure. Some algorithms, like a Smith Controller and a Generalized Predictive Controller were evaluated under simulation on this second model. Within this activity, we employed a filtering method to remove both FES artefacts and voluntary motion from the tremor signal[5].

References

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