

## Chapter 32

# Hand Tremor Prediction and Classification Using Electromyogram Signals to Control Neuro–Motor Instability

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### ABSTRACT

*This chapter provides a prototype design of a hand tremor compensator/controller to reduce the effect of the tremor to an external device/ apparatus, such as a magnetic pen for the patients suffering from Parkinson and similar diseases. It would also be effective for busy surgeons suffering from hand tremor due to muscle fatigue. Main emphasis in this chapter is given on the prediction of the tremor signal from the discrete samples of electromyogram data and tremor. The predicted signal is inverted in sign and added to the main tremor signal through a specially designed magnetic actuator carrying the external device, such as a magnetically driven pen or surgical instrument. Two different prediction algorithms, one based on neural nets and the other based on Kalman Filter have been designed, tested, and validated for the proposed application. A prototype model of the complete system was developed on an embedded platform. Further development on the basic model would be appropriate for field applications in controlling tremors of the subjects suffering from Parkinson and the like diseases.*

DOI: 10.4018/978-1-61350-429-1.ch032

## INTRODUCTION

McCarthy coined the name Artificial Intelligence (AI) in the famous 1956 Darmouth conference (Konar, 2000). Since its foundation the subject of AI has evolved through many phases. The early research in AI was confined in toy problems; but with the passage of time, AI has gradually been enriched with new theories, which found interesting applications in different spheres of human life and civilization.

Machine learning is one of the fundamental areas of research of the modern AI. Late 1980's has seen significant contribution of research in machine learning. The main stream research in machine learning gradually merged with statistical learning and pattern recognition algorithms over the last two decades.

People suffering from Parkinson's and the like diseases face difficulty in performing common tasks, such as writing, taking food etc. because of uncontrolled shaking of their hands and body parts. This chapter provides an interesting solution to this problem using the principles and techniques of AI and pattern recognition.

Hand motion control has always been an area of interest of the modern bio-mimetic robotics, bio-robotics and smart rehabilitation engineering. Hand motion in a sense can be classified into many types of actions depending upon their appearance. Origin of different type of movements also varies extensively, but grossly the movements are always classified into two types, intended or desired motion and other is tremor. One novel approach to control hand tremor is to predict the amplitude of the tremor around the principal plane of vibration, and add the predicted signal to the original tremor signal to reduce or nullify its effect.

The performance of the tremor compensation system mainly depends on the quality of prediction of tremor signal. Prediction of the compensatory signal at time  $t$  in general is considered as a linear combination of its  $n$  previous samples at time  $(t-T)$ ,  $(t-2T)$ , ..... $(t-nT)$ , where  $T$  is the sampling

interval. Thus apparently, the compensatory signal can be predicted from the last  $n$  previous samples of the tremor signal. Any standard linear prediction algorithm can be employed to estimate the compensatory signal from its previous  $n$  samples. Alternatively, a supervised neural learning algorithm can also be used to aid the linear estimation process.

Measurement of the tremor signal thus indeed is a fundamental step for the prediction process. An accelerometer is a device that senses acceleration and produces an output according to the linear displacement, it experiences. Thus measurement of tremor signal can be performed by an accelerometer. Recent research however demonstrate that Electromyogram (EMG), which is a simultaneous manifestation of neural control signal over muscle fibers (Wolf et al., 1996; De Luca et al., 1997; Haig et al., 1996; Pullman et al., 2000; Rechten et al., 1999) is also a good source for tremor prediction (Lippold et al., 1970; Fox et al., 1970; Cameron et al., 1998; Widjaja et al., 2003; Veluvolu et al., 2007). In this chapter, we employed both accelerometer and the EMG signal for prediction of tremor signal.

Controlling the movement of an external device, such as a magnetic pen for people suffering from Parkinson's like diseases, is the primary problem addressed in this chapter. This needs an actuator to control the motion of the pen. We design magnetic actuator and a specialized device holder which can be controlled by a changing magnetic field in the desired direction of motion of the pen.

Finally realization of the complete tremor control system on an embedded platform would be an added problem to be undertaken here. The input of the embedded system would be the digitized previous  $n$  samples of EMG and tremor signals. The output of the embedded system would be the compensatory tremor signal, which would be transferred to the actuator through an actuator circuit.

The objective of this study is two fold. First, we examine the viability of the proposed tremor compensatory system. Second, we study the rela-

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