Chapter VIII

Artificial Neural Networks in EEG Analysis

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Abstract

The artificial neural networks (ANNs) are regularly employed in EEG signal processing because of their effectiveness as pattern classifiers. In this chapter, four specific applications will be studied: On a day to day basis, ANNs can assist in identifying abnormal EEG activity in patients with neurological diseases such as epilepsy, Huntington’s disease, and Alzheimer’s disease. The ANNs can reduce the time taken for interpretation of physiological signals such as EEG, respiration, and ECG recorded during sleep. During an invasive surgical procedure, the ANNs can provide...
objective parameters derived from the EEG to help determine the depth of anesthesia. The ANNs have made significant contributions toward extracting embedded signals within the EEG which can be used to control external devices. This rapidly developing field, which is called brain-computer interface, has a large number of applications in empowering handicapped individuals to independently operate appliances, neuroprosthesis, or orthosis.

Introduction

The electroencephalogram (EEG), generally recorded on the scalp from a number of electrodes, is the result of asynchronous firing of billions of neurons within the nervous system. Digital signal processing of the EEG has been a major domain of research in biomedical engineering for many years. Development of artificial neural networks for EEG analysis is a natural evolution of bringing better engineering and analytical methods to medicine in general and to neurology in particular. Artificial neural networks (ANNs) can be used as part of a primary pattern recognition system to assist the physician. In the 1970s and 1980s when computers were centrally located, applications were based on understanding the frequency composition of EEG. Specifically, the frequency analysis of the EEG into delta (0-4 Hz), theta (5-7 Hz), alpha (8-13 Hz), and beta (13-18 Hz) bands was the most widely used tool as a source of critical information for diagnosis.

With widespread use of personal computers, analysis of EEG signals has been approached by both linear and non-linear (chaos) methods. If the data can be structured suitably, then ANNs can potentially enhance the quality of pattern identification and assist the user. The ANNs also learn from experience, have fault tolerance capabilities, and can create complex decision surfaces for classification. The ANNs provide a greater depth of technological innovation and have generated novel paradigms of pattern recognition. For example, the brain-computer interface (BCI) can enable physically disabled subjects to interact with the computer and consequently the external environment. The BCI has given rise to a number of technologies which can make life easier for such individuals. In this chapter, we summarize the state-of-the-art of applying ANNs in EEG analysis during neurological diagnosis, monitoring the depth of anesthesia, automated sleep scoring, and toward enhancing the BCI, among a myriad of applications of ANNs.