Spike and Epileptic Seizure Detection Using Wavelet Packet Transform Based on Approximate Entropy and Energy with Artificial Neural Network

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Abstract—This paper proposes the method that can detect both spikes and epileptic seizure at the same time based on wavelet packet transform, approximate entropy and energy, and artificial neural network. First, the EEG signals are decomposed into 4 levels, 16 frequency sub-bands, using Daubechies for mother wavelet to distinguish the usable signal. Then the approximate entropy and energy features are extracted for each sub-band to form the feature vector. Finally, the constructed feature vector is used as an input to the artificial neural network to classify the EEG signals into 6 types of spike, epileptic seizure, eye closed, eye opened, body movement, and normal signal. The experimental results show that the proposed method identified and classified the EEG signal with average sensitivity of 76.55%, specificity of 81.3%, and accuracy of 89.47%.

Index Terms—EEG Signal, Spike, Epileptic Seizure, Wavelet Packet Transform, Approximate Entropy, Energy

I. INTRODUCTION

At present, there are patients with seizure disease more than 64.4 million persons around the world [1]. In Thailand, there are patients with this disease more than 750,000 people [2]. This disease has the trend to be higher in the year to come. The seizure is the symptoms or behavior of the patient that cause from abnormal functional of the brain cell in cerebral hemisphere.

Electroencephalography (EEG) is one of the common tools employed for spike and epileptic seizure detections. EEG is the examination of the physiological recording of the brain cells. This is done by observing the electrical variation of the brain waves. The EEG is commonly decomposed into four frequency bands: delta (0-4 Hz), theta (4-8 Hz), alpha (8-12 Hz) and beta (12-30 Hz) [3].

The classification of the seizure on International League Against Epilepsy classification of epilepsies and epileptic syndromes in 1989 [4] are as follows: localization related (focal) epilepsy, generalized epilepsy, undetermined epilepsy, and special syndrome. We are interested in the first 2 of this classification. On localize epilepsy of the previous works, Othman, et.al [5] introduced a new method for detecting, sorting, and localizing spikes from multiunit EEG recordings. They used the combined method of wavelet transform with Super-Paramagnetic Clustering (SPC) algorithm. The method is capable of setting amplitude thresholds on the high-pass filtered data for spike detection. The procedure is fully unsupervised and fast.

Adjouadi, et.al. [6] introduced an integrated algorithm based on the Walsh transform to detect interictal spikes and artifactual data. They used Walsh transform to identify the criteria for best define the morphologic characteristics of interictal spikes. The merits of the algorithm were for computational simplicity, identify and localize interictal spikes while automatically removing or discarding the presence of different artifacts such as electromyography, electrocardiography, and eye blinks, and pattern or generalize to other brain dysfunction. The results had precision (positive predictive value) of 92% and sensitivity of 82%. Oikonomou, et.al [7] presented a methodology for spike enhancement using a time-varying autoregressive model. The coefficients of autoregressive model were estimated using the Kalman filter which were able to suppress the background activity. The results showed the improvement in signal-to-noise ratio and reduction of the number of false positives. Kutlu, et.al [8] optimized the performance of an MLP classifier based on artificial neural networks for the automatic detection of epileptic spikes in EEG records. They used different multilayer perceptron networks and trained with different algorithms. The performances of the constructed classifiers were examined and compared based on both sensitivity-specificity and sensitivity-selectivity measures. The results showed good performances and could be clinically-used to...