

# Chapter 26

## Multi-Channel Template Extraction for Automatic EEG Spike Detection

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### **ABSTRACT**

*Automatic electroencephalogram (EEG) spike detection plays an important role in epilepsy diagnoses, but there is no currently accepted method to detect spikes accurately. The template method is considered to be an effective method but is rarely studied. Template making is difficult because the morphology of spike waveforms can vary dramatically. Different patients have different EEG patterns, and for a single patient, different patterns may be observed at different sites on the scalp. The current study proposed a template extraction method. Without prior information, extracted templates could be adapted not only to individual patients but also to individual focus channels. The method was evaluated using the recordings from two epileptic patients. The results suggest that the proposed template extraction method is effective and that templates for spike detection should include multiple channels. In addition, this template method could be easily adapted for real-time applications.*

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## **INTRODUCTION**

### **Epileptic Spikes**

Epilepsy is one of the most common neurological diseases. Electroencephalogram (EEG) testing is the most frequently used epilepsy diagnostic tool. Epileptic patients often have unusual waveform patterns, even when they are not having a seizure. The EEG test typically lasts 1 hour, but 24-hour recordings are occasionally warranted. Because approximately half of the people who have had an epileptic seizure have normal EEG recordings, additional diagnostic tests may be necessary.

The waveform patterns in EEG recordings of epileptic patients were defined as spikes or sharp waves by Chatrian et al. in 1974. A spike is “a transient, clearly distinguished from background activity, with pointed peak at conventional paper speeds and a duration from 20 to under 70 ms, i.e., 1/50 to 1/14 s, approximately. Main component is generally negative relative to other areas. Amplitude is variable.” (Chatrian et al., 1974). A sharp wave has a duration of between 70 and 200 ms. However, the identification of spikes and sharp waves can vary between individual experts. A spike declared by one expert may be identified as a normal wave by another expert. Experts do not routinely achieve average sensitivities of 80-90% (Wilson & Emerson, 2002).

### **Common Montages**

EEGs can be derived from various montages. The most popular montages used by doctors for the identification of epileptic spikes are the bipolar (BP) montage and the common average referential (AV) montage. Both montages have advantages and disadvantages.

In the BP montage, adjacent electrodes are connected. This montage is popular in clinical diagnoses, particularly in the visual detection of spikes, as phase reversals can be easily observed between the channels near the focus during

spike activity, while channels distant from the focus will not be affected. BP montages provide precise localization information. However, there are three major disadvantages to this technique. First, both positive and negative polarities must be considered, and it may be difficult to recognize the polarity correctly, even upon visual inspection. Second, to confirm a spike event during automatic spike detection, multiple phase reversal possibilities must be considered. Third, the BP derivation is a subtraction between adjacent electrodes; therefore, the amplitude is decreased, and the waveforms may be distorted.

In AV montages, each electrode is referenced to the AV potential (the average potential of all scalp electrodes). This reference can accurately reflect the activity at actual electrodes because the AV potential is considered to be zero (Indiradevi, Elias, Sathidevi, Nayak, & Radhakrishnan, 2008). However, this assumption is not always correct. If large spikes appear, the AV potential will be negative, the amplitude of the true spikes will decrease, and channels without spikes will show positive sharp transients (STs). If large positive STs appear, the channels at the opposite site will show negative STs, which can be mistaken for spikes. However, spike events can be easily detected by AV montages, due to their larger amplitudes. Moreover, because only negative peaks need to be considered, the number of candidates can be significantly reduced. For artifact identification, AV montages show better performance.

Therefore, we recommend the use of both AV and BP montages for the accurate identification of spike activity.

### **Automatic EEG Spike Detection**

Automatic spike detection has been studied since the 1970s, and a number of methods have been developed. However, there are no currently well-accepted algorithms to aid the clinician because of the high number of false detections produced by the current methods (Halford, 2009). The major

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