

Classification of Epileptic and Non-Epileptic EEG Events

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Abstract— In this paper, the classification of epileptic and non-epileptic events from multi-channel EEG data is investigated using a large number of time and frequency domain features. In contrast to most of the evaluations found in the literature, in this paper the non-epileptic class consists of two types of paroxysmal episodes of loss of consciousness namely the psychogenic non epileptic seizure (PNES) and the vasovagal syncope (VVS). For the classification, several classification algorithms were explored. The classification models were evaluated on EEG epochs from 11 subjects in an inter-subject cross-validation setting and the best among them achieved classification accuracies of 86% (Bayesian Network), 83% (Random Committee) and 74% (Random Forest).

Keywords: *epileptic seizures; PNES; vasovagal syncope; classification; machine learning*

I. INTRODUCTION

One of the most common and challenging medical cases in everyday clinical practice is that of patients reporting one or more episodes of paroxysmal loss of consciousness or altered awareness. The management of these medical cases may be proven to be demanding, time consuming and expensive and finally, in spite of the extensive and exhaustive investigation, the underlying diagnosis may remain elusive [11]. The differential diagnosis that a clinician usually faces is mainly that of an epileptic seizure, a possible psychogenic non epileptic seizure (PNES) and a probable vasovagal syncope (VVS).

Epileptic seizures are brief episodes of abnormal excessive or synchronous neuronal activity in the brain of patients suffering from epilepsy [16]. During an epileptic seizure there are several specific changes recorded in the electroencephalogram (EEG) which is a sensitive and important test used to evaluate patients with suspected epilepsy. There are certain characteristic ictal neurophysiological patterns that support the identification and detection of epileptic events and postictal and/or interictal abnormalities that can provide supplementary information. Psychogenic non-epileptic seizures (PNES) are sudden paroxysmal changes in behavior or consciousness, that resemble epilepsy but are not accompanied by the

electrophysiological changes that characterize an epileptic seizure [23]. Although the clinical history can help differentiate these episodes, it is not unlikely to have inconclusive and insufficient event description by the patient and witnesses, not being able to confidently exclude and underlying epileptic disorder. In these cases the diagnosis of PNES can be supported by video-EEG monitoring, especially if a psychogenic event is captured, since in the case of PNES there are no specific EEG changes. Vasovagal or vasodepressor syncope is a common type of syncope and various mechanisms have been postulated for explaining the characteristic association of hypotension and bradycardia. The term "vasovagal" was introduced by Lewis [10] to indicate that both blood vessels and heart were implicated and since atropine reversed the bradycardia but not the hypotension he considered vasodilatation as the primary responsible factor. During a vasovagal syncopal attack there may be some characteristic EEG changes starting with progressive generalized theta slowing of background rhythms, followed by sometimes hypersynchronous delta activity of high voltage (beta / alpha → theta → delta) and appearance of progressively lower voltage rhythms until isoelectric suppression [2, 12]. This pattern is progressively reversed after the patient's fall, during his/her recovery. These changes do not include any ictal activity.

Several methods have been proposed for the classification of EEG captured events into epileptic or normal [7, 13, 21, 22, 24]. However, only a few studies deal with the differentiation between epileptic and other paroxysmal episodes of loss of consciousness such as PNES and vasovagal syncope. It is worth to note that the discrimination between different types of non-epileptic events is considerably more useful in diagnostic procedure given the semiological resemblance between the aforementioned paroxysmal attacks. Furthermore, according to [23] the one third of PNES patients may have clinical convincing GrandMal like seizures. This makes discrimination between PNES and epileptic seizures a challenging task, especially in an online monitoring system for automatic detection of epileptic events, such as [3], where false alarms caused by events similar to epilepsy are undesired.