1-INTRODUCTION

1.1 Epilepsy

1.1.1 General definition, and etiology

Epilepsy is one of the most common neurological disorders affecting 70 million worldwide [1]. It was first defined by Jackson in 1873 as “an occasional sudden and excessive discharge of grey matter”. This definition lasted for a long period of time, during which, investigations have given more insights into the characterization and mechanisms of this medical disorder on several levels. The fundamental elements of epilepsy are unprovoked, recurrent seizures [2] resulting from abnormal excessive hypersynchronous neuronal discharges. Seizure manifestations vary greatly depending on the site, intensity and propagation of the seizure discharge. In between seizures, brief (milliseconds) asymptomatic discharges called interictal epileptiform discharges (also known as spikes) may occur [3]. Although epilepsy can appear at any age, its incidence is higher in children and elderly (after the age of 65) [4]. The main causes of epilepsy include genetic mutations, gliosis from acquired brain insults (hypoxia, ischemia/stroke, trauma, and infection), malformations of cortical development, vascular malformations, brain tumours and degenerative disorders.

1.1.2 Epileptic seizures

A seizure is defined as a transient disturbance of brain functions due to an abnormal electrical synchronization of groups of neurons. Epileptic seizures can be divided into two main categories: focal and generalized [5]. Seizures are said to be focal when they start from a restricted area of the brain (thus in one hemisphere) while generalized seizures involved the whole of both hemispheres [6]. Focal seizures can be further classified into frontal, temporal, insular, parietal, and occipital, depending on the lobe involved at seizure onset. In generalized seizures, there is impaired consciousness from the onset as the excessive electrical discharge is widespread from the beginning. With focal seizures, earliest symptoms depend on the lobe of seizure onset (ex. visual symptoms with occipital lobe seizures, sensory symptoms in parietal lobe seizures, motor symptoms in frontal lobe seizures etc.). Consciousness is frequently not impaired at the onset of a focal seizure but such impairment may occur as the discharge spreads to larger areas of the brain 2 and even manifest as bilateral tonic-clonic seizures if the discharge spreads to the whole brain [6].

1.1.3 Electroencephalography

Because epilepsy is fundamentally the result of abnormal neuronal discharges, EEG is the single most important investigative technique for the study of epilepsy. EEG consists in an electrophysiological recording of the brain’s electrical activity. The electroencephalogram (recorded signal) displays spatial and temporal voltage variations due to ionic currents flowing 3 within brain neurons. It is characterized by a high temporal resolution (order of ms), allowing the evaluation of dynamic cerebral functions [7]. EEG displays neuronal electrical activity resulting from the summation of inhibitory and excitatory postsynaptic potentials of large group of neurons. It is considered to be mainly produced by pyramidal cortical neurons, which are arranged in parallel, perpendicularly to the surface of the brain, and have their cell bodies mainly in layers III and V of the cerebral cortex [8].

1.1.4 The EEG in focal epilepsy

Patients with focal epilepsy exhibit focal epileptiform abnormalities. These are usually divided into a) ‘interictal’ discharges (‘spikes’) which are brief (20-200ms) asymptomatic paroxysmal EEG transients clearly distinguished from background; and b) ‘ictal’ discharges which are sudden focal rhythmic activity with characteristic pattern of evolution (with respect to amplitude, frequency and spatial distribution) lasting at least several seconds to minutes. These ictal discharges are generally associated with clinical seizure manifestations (electroclinical seizures) but can sometimes be clinically silent (electrical seizures) [9]. With a routine 30- min EEG, interictal spikes can be found in approximately 50% of epileptic patients (and in up to 84% by the third serial EEG).

1.1.5 seizure detection

Due to the time-limited observation period, the patient’s antiepileptic medication is sometimes reduced for facilitating the occurrence of epileptic events within the observation period [10], where the seizures may not be representative of natural conditions. In many cases, patients are asked to keep seizure diaries, as seizure monitoring is crucial for therapeutic decisions. Patient-reported seizure counts and measures derived from these reports, such as reduction in seizure frequency over a defined period, represent the primary endpoint for most clinical trials in epileptology [11].

However, it is well known that most epileptic seizure go unnoticed by the patients and their caregivers, which may affect treatment decisions. Seizure tracking is dependent on a subjective patient and family recall and may be influenced by the capacity of remembering details post seizure, by the level of awareness during the seizure and by the ability to identify seizures [12].

1.1.6 seizure prediction

Besides seizure detection, accurately predicting seizures a few minutes before their onset would enable patients to take precautions against injury, and could open the door for development of treatments to prevent or control the incoming seizure. For instance, neurostimulation systems can act quickly as a way of suppressing a high portion of seizures [13]. This prediction should have sufficient precision, specificity and sensitivity to minimize the interruptions on the patient’s life, having minimal unpredicted seizures and false alarms.

1.2 Problem statement

People who suffer from epilepsy cannot lead their normal lives because they may be exposed to a sudden seizure that endangers their lives, such as falling in a public place, their workplaces or while sleeping, and damage the parts of their body often leads to death, which makes their lifestyle limited. Some methods which used in epileptic seizures classification and detection varying at accuracy and time of work.

1.3 Objectives

The general objective is to design EEG-Based Epileptic Seizure Detection and Prediction Machine/Deep learning models.

The specific objectives are to

1. Achieve accurate classification for epileptic seizures.

2. Achieve high accuracy, less time predicting the occurrence of a seizure.

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