

EPILEPTIC SEIZURE PREDICTION AND DETECTION USING MACHINE LEARNING TECHNIQUES

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EPILEPTIC SEIZURE PREDICTION AND DETECTION USING MACHINE LEARNING TECHNIQUES

by

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Dedicated
To
My ALMIGHTY

CERTIFICATE

It is certified that the thesis entitled “**Epileptic Seizure Prediction and Detection Using Machine Learning Techniques**”, submitted by **Indrani Bhattacharjee**, to the Indian Institute of Technology, New Delhi, for the fulfilment of the requirements for the award of the degree of **Doctor of Philosophy (PhD)**, is a bonafide work of research carried out by her under my supervision. The submission of this thesis has not been made to any other institute or university to award any degree or diploma.



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Abstract

Epileptic seizures are singularly characterized as a chronic neurological disorder triggering recurrent seizures due to hypersynchronous discharge of abnormal neural networks. Epilepsy manifests in various forms and types and affects people of all ages. Uncontrolled seizures can result in depression, suicidal tendencies, impairing of memory and even sudden death. Due to the poor quality of life, patients have difficulty having gainful employment due to the complications attached to the disease.

The most adopted technique for diagnosing epilepsy is by manual detection of signal patterns of Electroencephalogram (EEG) which is a cumbersome, time-consuming process. Moreover, the epileptic symptoms getting overlapped with other disorders often contaminate the results, rendering them inefficient. Delayed or flawed effects can be very damaging, leading to severe impairment to the patient.

Accurate predictive processes help understand the prior onset of seizures and address the abnormal brain activity to reduce the severity of seizures. An easily affordable device for precise prediction of the pre-ictal brain state of epilepsy was mooted. To this end, an 8-channel indigenous and portable device was developed by the researcher for research purpose only by adopting automated techniques like Heart Rate and EEG Signals to predict epileptic seizures.

The classification of the epileptic patients' dataset and healthy persons' dataset was acquired from the leading hospital under the supervision of an expert. The acquired EEG data were further classified into a seizure (ictal state), inter-ictal state and normal states.

The epileptic seizure detection and classification of the University of Bonn dataset was applied to machine learning techniques. The human activity recognition method was used to classify the activities like "Seizure Patient", "Seizure Free", "Healthy -Eye Open", and "Healthy-Eye Closed" by using machine learning techniques.

The statistical features were computed over wavelet coefficients, and power spectrum calculations were done for each frequency band of the EEG signals. It led to the utilization of CNN with the multicolumn approach for determining the wavelet-based features. It resulted in a Multicolumn Convolutional Neural Networks (MCCNN) classifier of the EEG signals, which provides high efficiency and accuracy in detecting epileptic seizures.

Combined with utilizing the indigenous device developed during the research work and applying different machine learning techniques, this thesis enables accurate prediction and detection of epileptic seizures. It also provides promising computational tools in clinical and home settings with substantial future scope in further automating the techniques using cloud-based patients' data record management. Patients will surely benefit from having faster access to medical attention through remote diagnosis and medication.

सार

मिर्गी के दौर को असामान्य तंत्रिका नेटवर्क के हाइपरसिंक्रोनस डिस्चार्ज के कारण बार-बार होने वाले दौर को ट्रिगर करने वाले क्रोनिक न्यूरोलॉजिकल डिसऑर्डर के रूप में जाना जाता है। मिर्गी विभिन्न रूपों और प्रकारों में प्रकट होती है और सभी उम्र के लोगों को प्रभावित करती है। अनियंत्रित दौर के परिणामस्वरूप अवसाद, आत्महत्या की प्रवृत्ति, स्मृति क्षीणता और यहां तक कि अचानक मृत्यु भी हो सकती है। जीवन की खराब गुणवत्ता के कारण, रोग से जुड़ी जटिलताओं के कारण रोगियों को लाभकारी रोजगार प्राप्त करने में कठिनाई होती है।

मिर्गी के निदान के लिए सबसे अधिक अपनाई जाने वाली तकनीक इलेक्ट्रोएन्सेफेलोग्राम (ईईजी) के सिग्नल पैटर्न का मैनुअल रूप से पता लगाना है जो एक बोझिल, समय लेने वाली प्रक्रिया है। इसके अलावा, लक्षणों के अन्य विकारों के साथ ओवरलैप होने की संभावना अक्सर परिणामों को दूषित कर देती है, जिससे यह एक अक्षम प्रक्रिया बन जाती है। विलंबित या त्रुटिपूर्ण परिणाम बहुत हानिकारक हो सकते हैं जिससे रोगी को गंभीर हानि हो सकती है।

सटीक भविष्य कहनेवाला प्रक्रियाएं दौर की शुरुआत को समझने में मदद करती हैं और दौर की गंभीरता को कम करने के लिए असामान्य मस्तिष्क गतिविधि को संबोधित करती हैं। मिर्गी की प्री-इक्टल मस्तिष्क स्थिति की सटीक भविष्यवाणी के लिए एक आसानी से किफायती उपकरण पर विचार किया गया था। इसके लिए, एक 8-चैनल स्वदेशी, कम लागत वाला और पोर्टेबल डिवाइस विकसित किया गया था, जो कि मशीन लर्निंग तकनीकों के साथ-साथ हृदय गति और ईईजी सिग्नल जैसी स्वचालित तकनीकों को अपनाकर नैदानिक और साथ ही घरेलू सेटिंग्स में उपयोग के लिए मिर्गी के दौर की भविष्यवाणी करने के लिए विकसित किया गया था।

मिर्गी के रोगियों के डेटासेट और स्वस्थ व्यक्तियों के डेटासेट का वर्गीकरण किया गया था। अधिग्रहीत ईईजी डेटा को आगे एक जब्ती (इक्टल अवस्था), इंटर-इक्टल अवस्था और सामान्य में वर्गीकृत किया गया था।

बॉन डाटासेट विश्वविद्यालय के मिर्गी के दौरों का पता लगाने और वर्गीकरण को मशीन लर्निंग तकनीकों पर लागू किया गया था। मानव गतिविधि पहचान पद्धति का उपयोग मशीन लर्निंग तकनीकों का उपयोग करके "जब्ती रोगी", "जब्ती मुक्त", "स्वस्थ-आंखों का खुला", "स्वस्थ-आंख बंद" जैसी गतिविधियों को वर्गीकृत करने के लिए किया जाता है।

सांख्यिकीय विशेषताओं की गणना तरंगिका गुणांकों पर की गई और ईईजी संकेतों के प्रत्येक आवृत्ति बैंड के लिए पावर स्पेक्ट्रम गणना की गई। इसने तरंग-आधारित विशेषताओं को निर्धारित करने के लिए बहु-स्तंभ दृष्टिकोण के साथ सीएनएन का उपयोग किया। इसके परिणामस्वरूप ईईजी संकेतों का एक मल्टी-कॉलम कन्वोल्यूशनल न्यूरल नेटवर्क (एमसीसीएनएन) क्लासिफायर बना जो मिर्गी के दौरों का पता लगाने की उच्च दक्षता और सटीकता दर प्रदान करता है।

शोध कार्य के दौरान विकसित उपकरण के उपयोग और विभिन्न मशीन लर्निंग तकनीकों को लागू करने के साथ, यह थीसिस सटीक भविष्यवाणी और मिर्गी के दौरों का पता लगाने में सक्षम बनाता है। यह क्लाउड-आधारित रोगियों के डेटा रिकॉर्ड प्रबंधन का उपयोग करके तकनीकों को और स्वचालित करने में भविष्य की पर्याप्त गुंजाइश के साथ नैदानिक और घरेलू सेटिंग्स में आशाजनक कम्प्यूटेशनल उपकरण भी प्रदान करता है। मरीजों को निश्चित रूप से दूरस्थ निदान और दवा के माध्यम से चिकित्सा सहायता प्राप्त करने में लाभ होगा।

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