Technical Science

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DEEP LEARNING PROCESSING CNN MODEL IN SEIZURE DETECTION

Summary. *Visualize EEG signal through CNN based deep learning processing to detect seizure as pre-scanning in epilepsy.*

Key words: *epilepsy, EEG, Seizure, EfficientNet.*

More than 1% of the population in the world have been suffered from epilepsy and more than 50 million individuals have been suffered and living under the condition (Fisher et al, 2005). To detect epilepsy, electroencephalography (EEG) is most common and plays a major role in detection of it. The aim of this research was to test and improve the possibility to seizure detection with deep learning system and to identify and compare the possible method of EEG detection by the deep learning process to apply it effectively for professional field and confirm the designed system with confusion matrix score. 30 patients scalp EEG data MHG (Mediclub Hospital in Georgia) was used for CNN based Convolutional Neural Networks conducted in EfficientNet with conducted STFT (Shor Time Fourier Transform) Spectrogram to visualize EEG segment signal. EfficientNet showed high correlation between EEG signal and designed deep learning system.

Introduction. The most effective and accurate method to detect epilepsy have been found was EEG (Electroencephalography). Through electric signals in certain parts of the brain, abnormal frequency, peak, wave length could be detected between -100µV and 100µV brainwaves within Delta, Theta, Alpha, Beta, Gamma frequency from the low to high. Seizure signal often divided three stages, Pre-ictal, Ictal, and Post-ictal and normal stage as an epilepsy are called Inter-ictal. Alma et al developed the difference of EEG signal between Inter-ictal(a) and Ictal stage in 2019.

Koatas et al developed PSM (Patient-Specific Method) by conducting STFT (Short time Fourier Transform) and classified CNN model in 2018 and in 2020, Zhang et al used CHP-MIT scalp EEG dataset to transform raw EEG to visualize image with SFTF spectrogram to improve accuracy which could be used with deep learning to detect and predict chronic seizure prediction. With deep learning technology and methods, Explanation Artificial Intelligence(XAi) developed to model behavior and interpret Ai generated results. Tan et al, developed EfficientNet to improve model performance by balancing the relationship between depth, width, and resolution, providing a clear justification for model scaling. In this study, EEG data set by MGH identified and processed by CNN based deep learning to identify correlation between EEG and EfficientNet in seizure detection.

Main part. Each patient have variation of locating of electrodes but followed by most common EEG locating method by Roger, 2018, Scalp EEG data used in this study collected at 30 pediatric patients in MGH (Table 1). Composed recorded signal with sampling rate was 256Hz and 196, 20 common channels were used for electrodes among 40. (FP1, F7, T3, T5, O1, FP2, F8, T4, T6, T7, O2, F3, C3, P3, F4, C4, P4, Fz, Cz, and Pz).

Table 1

EEG dataset information

Dataset	MHG
EEG type	Scalp EEG
Number of Patients	30
Number of channels	20 selected channels among over 40 channels
Selected channels	3

Number of seizures	192
Sampling rate	240

Source: by author's development

Collected signals transformed by STFT method which can maintain time information axis. STFT is an algorithm that converts EEG signals into frequency power spectrograms. 3 channels selected to conduct machine learning training and STFT spectrogram was used to convert raw EEG to visualize EEG signal as images. The power value of the corresponding frequency band at a specific time is calculated with the original signal input. Selected 3 channels were used to multiple channel data training with EfficientNet model. Brief diagram of processing to detect seizure when selected channels are input as multiple channel model (Fig 1.).

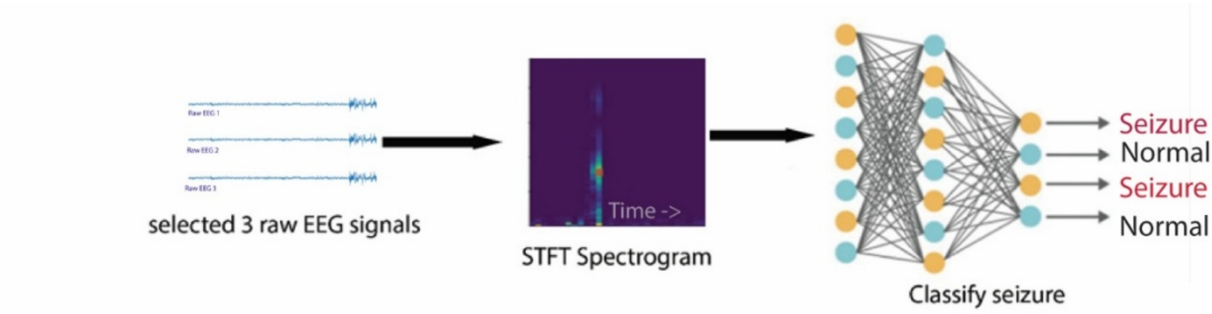

Fig. 1. Diagram of multiple channel model deep learning processing for seizure detection

Source: by author's development

To evaluate detection rate, Confusion Matrix Index was used for identifying and scoring designed machine learning models. T and F indicated seizure or non-seizure among the EEG sample data and N and P indicated each of result as negative or positive (Table 2).

Table 2

Confusion Matrix Index scoring in EfficientNet

Index	Description	Calculation
Accuracy	Correct diagnosis rate	TP+TN / TP+TN+FP+FN
Sensitivity	Correct seizure detection rate	TP / TP+FN

Specificity	Correct non-seizure detection rate	TN / TN+FP
False Positive Rate	Wrong seizure detection rate	FP / TN + FP

Source: by author’s development

In conclusion of this research, channels 2, 5, and 19 were collected as their sensitivity and specificity were relatively significant than other channels. 30 patient EEG data with 20 channels can be converted with STFT method in Matlab. Channel(F7-T3) was selected for machine learning process to identify reliable multiple channels. Though it was short window size with 10 sec STFT model in EfficientNet models, it shows that both models are able to applied to initial scanning of seizure in raw EEG signal data.

Mingxing Tan and Quoc V, in 2020 conducted EEG signal was used to develop EfficientNet model to identify seizure detection with single channel which was similar result in this research of multiple channels, deep learning process was practiced and the result of EfficientNet in Specificity indicated in 13.36, sensitivity increased in 10.96, and accuracy increased in 11.14 (Table 3).

Table 3

EfficientNet score of sensitivity, specificity, and accuracy in multiple channels

Channel	Specificity	Sensitivity	Accuracy	Channel	Specificity	Sensitivity	Accuracy
1	85.9	85.9	88.4	11	92.8	87.5	81.8
2	94.1	93.1	94.8	12	88.8	89.4	88.3
3	80.8	89.8	89.5	13	91.8	85.8	87.7
4	90.7	80.2	92.9	14	91.5	89	83.8
5	95.8	97.4	97.9	15	89.7	86.4	92
6	87.4	87.8	80.9	16	88.7	86.5	86.1
7	92.6	84	84.9	17	90.7	89.6	86.2
8	92.7	84.8	89.9	18	90.3	89.7	87.9
9	91.7	86.8	88.3	19	89.5	98.8	98
10	92.5	85.8	86.9	20	86.9	90.8	89

Source: by author’s development

It is remarkable with high average score in EfficientNet with 30 patients raw EEG data set; 90.24 in specificity, 88.35 in sensitivity, and 88.89 in accuracy, it is highly desired to be applied initial scanning for seizure detection in epilepsy. Moreover, most of the scores were quite reliable for most patients indicates that EfficientNet model is more reliable in this research which considered to be used as pre-scan to seizure detection in raw EEG by using conducted STFT. Further research and experiments are considered to various models in near future for predicting seizure based on this study process.

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