Chapter 16
ECG Image Classification Using Deep Learning Approach

Pratik Kanani
https://orcid.org/0000-0002-6848-2507
Dwarkadas J. Sanghvi College of Engineering, India

Mamta Chandraprakash Padole
https://orcid.org/0000-0002-0695-5970
The Maharaja Sayajirao University of Baroda, India

ABSTRACT

Cardiovascular diseases are a major cause of death worldwide. Cardiologists detect arrhythmias (i.e., abnormal heart beat) with the help of an ECG graph, which serves as an important tool to recognize and detect any erratic heart activity along with important insights like skipping a beat, a flutter in a wave, and a fast beat. The proposed methodology does ECG arrhythmias classification by CNN, trained on grayscale images of R-R interval of ECG signals. Outputs are strictly in the terms of a label that classify the beat as normal or abnormal with which abnormality. For training purpose, around one lakh ECG signals are plotted for different categories, and out of these signal images, noisy signal images are removed, then deep learning model is trained. An image-based classification is done which makes the ECG arrhythmia system independent of recording device types and sampling frequency. A novel idea is proposed that helps cardiologists worldwide, although a lot of improvements can be done which would foster a "wearable ECG Arrhythmia Detection device" and can be used by a common man.

INTRODUCTION

With the current advancements and explosion of Artificial Intelligence in HealthCare Organizations, medical experts are constantly figuring out ways to narrow the gap between technology and healthcare so as to provide better services to patients.

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Deep Learning in medical domain can unearth hidden opportunities and delve patterns from medical data, helping doctors to blend their expertise and technology to treat patients faster. Deep Learning is a vital subset of Machine Learning that uses neural networks to improve computational efficiency and accuracy and can solve problems where Machine Learning algorithms do not perform up to the mark.

Arrhythmias are classified into different types namely Atrial Fibrillations, supraventricular tachycardia, Premature Ventricular Contractions (PVCs), Atrial Premature Beat. Prolonged Atrial Fibrillations can increase the risk of getting a stroke. Continuous PVCs are major indications of a more dangerous heart behavior in the near future that may lead to heart failure. Patients having a paced ECG beat need to be precariously monitored as it may arrest the blood flow and cause serious life-threatening complications.

Before processing the ECG signal, one has to make sure that they obtain accurate ECG signal. The accurate signal means that the sampling frequency should be kept such that it should not miss out the natural ECG characteristics. For different sub waves in ECG the frequency ranges are different (Larisa & Mark, 2005), e.g., T wave ranges from 0–10 Hz, P wave 5-30 Hz and the QRS complex is within 8-50 Hz. The highest ECG frequency is around 50 Hz, so one has to keep it more than 100 Hz while sampling it, according to Nyquist rate (Mamta, 2014). The other aspect is that the obtained ECG signal should be noise free. As ECG signals are of low frequency, they include more low frequency corrupted signals. Noise suppresses the natural characteristics of ECG signal, which makes it more difficult to analyze in computing realm. To make an ECG signal noise free, there are many preprocessing techniques (Kanani, 2018). The pre-processing techniques are explained in further sections. The noised and pre-processed denoised (noise free) signals are presented in Figure 5 and Figure 6.

The main function of a Cardiologist is to master the analysis procedures, to analyze complex heart behavior, make accurate clinical decisions and that help treat patients for CVDs. As disease detection is of paramount importance, deep learning approach can help detect abnormalities faster, rather than sifting through large amounts of ECG datasets manually. Cardiologists can thus, focus on developing intensive care programs for patients. There is no definite assurance that these tools can completely supplant the expertise of cardiologists, but the aim is to facilitate cardiologists to take faster and better decisions.

Multiple numerical based mathematical techniques (Bilal et al., 2014) do exist to analyze the ECG signals and to get its standard PQRST point intervals. But as machine learning techniques outperform other techniques, Deep Learning Approach has been used to identify the ECG Arrhythmias. Currently five types of arrhythmias are being classified.

Firstly, ECG wave from the dataset are plotted and then converted to grayscale images. Two dimensional CNN is performed to achieve a workable accuracy. Then the ECG Heartbeat Categorization dataset is fed as training data and validated on testing data which is also collected from acclaimed MIT-BIH database and PhysioNet database. The trained model predicts whether the Wave rhythm is normal or abnormal and also it classifies the disease as defined in the standard database. The proposed model has also been tested for Mendeley ECG Signals (1000 fragments) and the model is able to successfully classify and label them.

Problem Definition

The concept of Deep Learning which is an important asset in the AI umbrella is of paramount importance in the Health Care sector. Deep Learning is a self-learning model which can learn from training data, improve quality, reduce response time and improve the ability to interpret results from clinical data. Given such a diagnosis problem especially in the field of Cardiology, deep learning and its high computational