A Review on Machine Learning Approaches For Heart Disease Classificaiton Using PCG Data

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Abstract- *Heart disease or cardiovascular disease (CVD) is the leading cause of death in the world. Around 17.9 million people die prematurely because of heart disorders. Much of the deaths occur in low and middle-income countries [1]. CVD relates to a collection of heart or blood vessel malfunction such as coronary heart disease, congenital heart disease, and peripheral arterial disease. Diagnosis of these cardiac problems often involves listening to the heart sounds through the phenomenon of cardiac auscultation [2]. One of the common methods to perform cardiac auscultation electronically is through Phonocardiograph. This paper presents a comprehensive review on automated classification of PCG data using machine learing. The contemporary techniques along with the salinet features of the apprapches used.*

Keywords- Machine Learning, Heart Diseases, PCG-Phonocardiogram, Automated Classification.

I. INTRODUCTION

Our heart forms one of the precious and crucial organs for living. Since a long time demises because of heart diseases have cropped up on a large scale. So any kind of such ailment that is related and linked to the heart holds strong reason for concern. The link between the pressure, blood flow and its volume forms a major componenent for proper functioning of the cardiac vessels. When the heart valves of the heart close, it produces normal sounds of the heart. Also the sound that originate from inside the heart related to the flow of flood also constitute the sounds coming from heart and its vessels.[4] These kind of sounds generally get produced from the myocardial walls inside the heart and also due o the actions of opening and closing of the heart valves and also the blood flow in the heart chambers. It is quite a wonder how amazingly the human body works in sync. There are two major and main components of the sounds from heart that come out. During a single cardiac cycle, the sound that comes out from the heart comprise of two main types. One is the first heat sound S1 and there is another heart sound S2. Different categorizations have been done on the various cardiac regions for better classification of the heart sounds.

There exist various cardiac regions and areas according to the chief funtions they perform. They are namely tricuspid, mitrel, aortic and pulmonary areas. Generally these areas represent direction of the flow blood flow into anf from the heart valves. Mainly the classification of the sounds from the heart can be done specific to each region. The sounds coming from a particular region, the adjacent areas or the problem region have to be properly identified and analysed. The different regions can provide clue for different features of the originating sound that can come from mitral , pulmonary and other regions. The crucial thing to be noted is that any kind of abnormality and problem in the cardiac region gets reflected in the nature of heart sounds.

So as a part of analysing and identifying the abnormalities related to the heart, the health experts generally consider evaluating the sounds from mitral, tricuspid, pulmonary, and aortic sections. These days the most general method used by the heath physicians is diagnosing cardiac diseases by listening via stethoscope.Hearing the sounds from different cardiac sections via a stethoscope aids in the process of properly understanding the origin of the sounds from the cardiac region and gives hint about any possible problem in the heart.

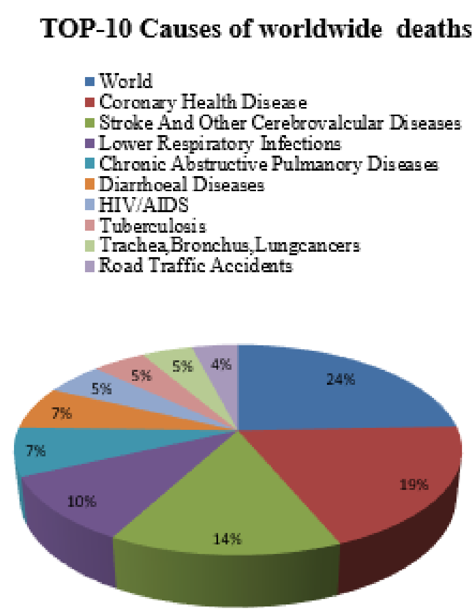

Fig.1 Leading causes of deaths worldwide

These details and facts signify how the cardio vascular diseases pose a serious health issue worldwide. So any improvement in this field of the proper identification and classification of the heart sounds can prove to be of significant help for millions of people globally. Proper early diagnosis of the cardiac problem has to done to keep the situation from getting serious and complex. Physicians need more innovative tools and methods for the better recognition of the heart associated problems.

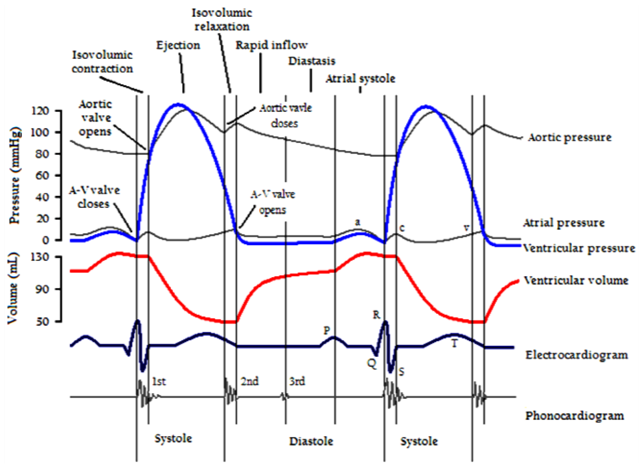

Fig.2 The cardiac cycle and origin of PCG

The phasor representation of the heart activity is oftn helpful in analyzing the activity of the heart and the generation of teh various sounds of the heart. The explanation of the above is given subsequently.

Phase 1: Atrial Contraction: It represents the contraction of the heart muscles therby not allowing or barring the entry of the blood in the heart chamber.

Phase 2: Isovolumetric Contraction: This can be seen as the occurrence of the 'QRS' complex wave and is termed as the ventricular depolarization. The valves are closed in this duration.

Phase 3: Rapid Ejection: This is the phase in which blood is ejected from the heart into the following sections:

A) Pulmonary artery
B) Aorta

During thariers phase, there are generally no substantial heart sounds which are generated for a normal functioning heart. The systematic illustration of the processes above are given below. The diagram clearly superimposes the electrocardiogram and the phonocardiogram sections of the heart signals.

Phase 4: Reduced Ejection: Ventricular re-polarization marks the occurrence of the 'T' wave of the ECG after 'QRS' Aortic valves can be seen to be closed at this stage.

Phase 5: Isovolumetric Relaxation: The valves named aortic and pulmonic valves are seen to close off in one go as the intra-ventricular pressures plummets at the culmination of

phase 4. This is teh origin of the second heart sound and the beginning of isovolumetric relaxation. All valves are closed at this point of time.

Phase 6: Rapid Filling: The intra-ventricular pressure becomes less with respect to the atrial pressure when the ventricles continue to relax. This generally occurs at the end of phase 5. This is the original cuase of ventricular filling. This is normally silent phase and the herat sound with a third peak si generally not detected in this phase.

Phase 7: Reduced Filling: At this condition occurrence, the filling rate of blood in the chambers is less compared to the average rate and hence a low fourth sound may be detected at this phase.

II. RELATED WORK

This section presents the contemporary work in the domain.

Krishnan et al. proposed a Feed-forward Neural Network model with five hidden layers provided a better overall accuracy of 0.8565 with a sensitivity of 0.8673, and specificity of 0.8475. The balanced accuracy of the model was found to be 0.8574. The performance of the model was also studied using the Receiver Operating Characteristic (ROC) plot, which produced an Area Under the Curve (AUC) value of 0.857. The classification accuracy of the proposed models was compared to the related works on PCG signal analysis for cardiovascular disease detection. The DNN models studied in this study provided comparable performance in heart sound classification without the requirement of feature engineering and segmentation of heart sound signals.

Zhao Ren et al., proposed a method for Learning Image-based Representations for Heart Sound Classification,In this work the author has come up with a novel approach consisting of learning method. It comprises of image graphics that are to be studied and analysed that depict the varied classifications of the heart sounds. Equal number of cardiac cycles were utilized for the categorization of the sounds of the heart. As the image is used and is to learnt it is an effective approach for the sound classification. But the Image is subject to noise and changes from compression and noise effects.The representations were robust and could be extended further for improvements. Segmentation method was also a part which is an arduous process.

TE Chen et al. proposed a method of "S1 and S2 heart sound recognition using deep neural networks" . The author here has used the S1 and S2 classification of the heart sounds done using the artificial intelligene backed deep neural network. As artificial intelligence has already been aiding in efficiency of various work systems across a large number of domains. It can certainly help in accurate classification of the heart sounds using the neural networks. The rigorous training and testing mechanisms can help in deciding aptly about the type of the sound tht gets originated in the heart.Deep neural networks work very efficiently for the recognition of the sounds. Initially if the data that is fed to the neural network is good enough, it can learn to better classsifiy the sounds and it can do it very quickly as well. This system not only yielded good performance but it also saved a lot of time as well. But one flipside of this system was that there was an error probability. Also sound distortions could not be properly analysed by the system effectively.

MN Homsi et al, proposed "Automatic heart sound recording classification using a nested set of ensemble algorithms" was put forth by the author which is a most widely used approach for obtaining all the pertinent data to recognize the various cardiovascular diseases. But one of main limitations of such an approach is the interference between different signals. The sounds can originate internally or externallyBy using any sound proof systm the external sounds interference can be prevented. But the problem is with the internal sounds. The sounds originating from other internal organs such as the muscle contraction etc are difficult to be separated during the PCG signal recording. It will be difficult to be differentiated.The wavelet method helps in this regard to suucessfully separate the signals out. In this work, a method of nested set of ensemble algorithms have been used for better and improved classification without the problem of interference of the signals. The wavelet thresholding can separate out the other sounds from the internal organs and single out the heart sounds for accurate diagnosis of the disease. This forms a very useful approach as this study investigated the various ongoing parameters of the PCG signal for different wavelets. Likewise the wavelet yields the exact value for the ensemble nested set implementing the efficient algorithm.

SK Randhava et. al. suggested "Classification of heart sound signals using multi-modal features". In this system the author proposed the concept of heart sound catgorization using various multi modal characteristics. As there can exist various features of the sounds that are produced in the cardiovascular region, this characteristic can be very well made use of. The multi modal features can be like the extent of the frequency of the sound, the amplitude that can differentiate between different sounds, the level of vibration elements and various other miscellaneous components. So systematic approach can be carried out for the beetr analysis of the procedures entailed in this domain. The classification done using this method gives high precision and accuracy but the main demerit is the nature of the multi modal features of the sound that is to be collected in the database. There exists various variations in the heart sounds so it is important that the grouping of the sounds is done properly and is carried out very well and it adheres to the standards that can be followed by the physician. In this aspect, there is scope of good improvement of this proposed system of work by the author. The overall performance of this system of feature classification is very useful and beneficial.

Joao Pedrosa et al. proposed "Automatic heart sound segmentation and murmur detection in paediatric phonocardiograms" which is a novel method to determine the features of heart sounds using the process of segmentation and detecting the murmurs by use of the phonocardiogram. This was an efficient method that made use of the feature vectors and wavelet detail classification. The decision making wa followed in the four major steps including segmentation, feature extraction and then finally using the phonocardiogram in the paediatric approach for the final impelemntation. It resulted in good diagnostic approach and process for the sound classification.

Anita Devi, et al. proposed A Survey on Classifiers Used in Heart Valve Disease Detection. This method proposed mainly focussed on the different classifiers that were used for the heart disease.Mainly the classification of the sounds from the heart can be done specific to each region. The sounds coming from a particular region, the adjacent areas or the problem region have to be properly identified and analyse classification that consisted of affected valves by the problems in cardiac region. An expert system based on the joint analysis of frequency and amplitude characteristics related to PCG signal has been presented for detecting and recognizing existing sounds In one of such studies some experts developed SVM classifier and they kind of determined the data sets which were many in number of the heart sound signals. They were composed of both normal case of medical health and also those from unsual cardiac related health issues.

Abhishek Misal , et. al. proposed Separation of Lung Sound from PCG Signals Using Wavelet Transform which incorporated various classification methods based on the PCG signal and the wavelet transform was utilized for this purpose. It is an algorithm for frequency and amplitude which are two determinative features for detecting and identifying various cardiac sound types. WT is one of the most promising methods to extract features from the biomedical signals . Wavelt transforms offers very high accuracy and is a very good way for separation other sound signals from a particular kind of signal in this context.

Harun Uguz proposed Adaptive Neuro-fuzzy Inference System for Diagnosis of the Heart Valve Diseases Using Wavelet Transform with Entropy that suggested that an approach of neuro fuzzy adaprive method is used for the inference system for the accurate heart valve disease diagnosis and dietection that makes use of the wavelet transform along with the entropy. This is quite an effective and good approach that used the feature of adaptability that provided flexibility.normal and abnormal heart sounds depends on the physician's ability of listening, experience, and skill. Such limitations may be reduced by developing biomedical-based decision support systems.There is this process of exracting the features of the different characteristic sounds of the heart that are acquired from five sections with normal, aortic stenosis, mitral stenosis, aortic regurgitation & mitral regurgitation heart valve diseases. This implemtation usually consists of four ways namely the collection of data, extraction of the features , lessening the dimension and then the comparison. at the similar time interval, all the heart sound features are compared with the wavelet that is required. It is performed at the apt level of decomposition of the particular wavelet. This can lead to numbers of the inputs enhancing at a rapid rate that will make the process time conuming and computionally complex.

III. CONCLUSION

It can be concluded from previous discussions that phonocardiograph provides a way to record, store, and analyze the heart sounds for a thorough medical examination. Given the patient to doctor ratio of 50,000:1 in low income and middle-income countries, there is a need for automated heart sound classification system that can screen. the PCG records in real time. These automated systems can be used as an aiding tool for the physician as it reduces the time to analyze the data. The automated heart sound classification system is one of the widely researched topics in computer-aided diagnosis of heart disease over many decades. Many methods and techniques have been developed to study the PCG signal and diagnose heart problems. A plethora of these methods involves feature engineering that uses pre-defined features for the classification of heart sounds. This paper presents a comprehensive review on the same and it is expected that the paper would render insights into the development of accurate and automated tehcniques based on machine learing for heart disease classification.

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