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IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE MODEL USING DEEP LEARNING METHODS FOR PREDICTION OF HEART ATTACK

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Abstract — This paper mainly focus on health care monitoring and prediction of heart attack using Artificial intelligence (AI) model using Deep (D) Learning (L) methods. Artificial intelligence has been increasing fast in recent years in terms of software algorithms, hardware implementation, and applications in a wide areas. This research shows that our original model's accuracy is about 0.98, and that using Deep Learning Methods can boost accurateness and open up current research possibilities. The AUC of the rhythm classes is shown in the results, and we can see that the accuracy is higher than the annotations. It is realized, there is a possibility for a more complete end-to-end methodology to be developed that employs deep learning using CNN methods and other neural network methods. ECG is a breakthrough concept in the field of cardiology and has paved way for lot of advanced techniques to expedite the diagnosis cardiological issues ensuring in-time treatment. With the beginning of High performance computing (HPC) and easy access to such infrastructure it has opened new doors to integrate new computational paradigm with ECG where we can implement various Machine Learning and Deep Learning Techniques to understand and analyze ECG in a better way. One of the challenges were the complexity of the data, the peak detection in the waveform and learning the patterns. Our current work, emphasizes on these aspects and we have proposed a Deep Learning based algorithm which can predict / classify arrhythmia with a greater accuracy.
Key Words : Healthcare, deep learning, artificial intelligence, machine learning, ECG, arrhythmia

I. INTRODUCTION

Artificial intelligence (AI) is defined as the intelligence of machines, as opposed to the intelligence of humans or other living species. AI can also be defined as the study of ‘‘intelligentagents”— that is, any agent or device that can perceive and understand its surroundings and accordingly take appropriate action to maximize its chances of achieving its objectives. AI also refers to situations wherein machines can simulate human minds in learning and analysis, and thus can work in problem solving. This kind of intelligence is also referred to as machine learning (ML). Typically, AI involves a system that consists of both software and hardware. From a software perspective, AI is particularly concerned with algorithms.

a. Deep Learning

DL is a subset of machine learning, which originally resulted from a multi-layer Artificial Neural Network (ANN). Strictly speaking, DL has a wider meaning, but in its present state, when talking about DL, we just think of a large deep neural network, that is, deep neural networks.

(i) Advantages Of Deep Learning Are –

- Deep learning gives better performance, and its overcomes the limitation of machine learning.
- For adopting new type of problems in upcoming days deep learning architecture performs well.
- Robustness to natural variations in the data is automatically learned.

(ii) Importance Of Deep Learning –

- Managing high dimensional data wherever input & output is relatively large.
- Sufficient power for managing the high dimensional data.
- Deep learning can do better than traditional methods.

b. History of Cardiovascular Diseases

Cardiovascular diseases (CVDs) are the largest cause of death in humans, claiming the lives of about 17 million people each year. According to the World Heart Federation, the middle and low-income segments of society account for three-quarters of all CVD deaths. There are many reasons for the heart to fail and most of those have been explored by the medical fraternity.

For our research we must understand the nature of heart and nature of the scans that are used to analyze the heart and the procedures that are used to access the conditions of the heart. This research majorly uses single graphical representation of the physical functions ofthe heart that is electrocardiogram (ECG). One of the most often used signals in the diagnosis and prediction of cardiovascular disorders is the electrocardiogram (ECG) (CVDs). The ECG readings can detect rhythmic anomalies in the heart, oftenknown as arrhythmias. For accurate diagnoses of patients' acute and chronic heart problems, detailed analysis of ECG signals is required. The intent of this research is to develop a model using Deep (D) Learning (L) Methods automate the detection of arrhythmias and develop an end-to-end clinical setup.

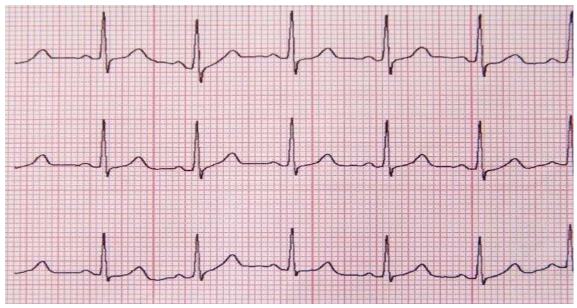
C. The Arrhythmia

An arrhythmia is characterized by an irregular or unexpected heartbeat. An individual's heart may beat too quickly, too slowly, too soon, or with an unpredictable/irregular rhythm if they have this ailment.

Arrhythmias occur when the electrical signals that regulate heartbeats do not function properly. An irregular heartbeat can feel like a fluttering heart or a dashing heart.

Cardiac arrhythmia refers to a range of conditions that cause the human heart tobeat in a regular or irregular manner, either too slowly or too fast. There are several categories of arrhythmia, including:

- A sluggish human heartbeat is known as bradycardia.tachycardia, or a rapid heartbeat in humans.



- A flutter or fibrillation is a unidirectional or irregular human heartbeat.
- A premature decline in human heartbeat or a premature reduction in human pulse

The vast majority of arrhythmias are harmless and do not cause concerns. It can, however, raise the chance of a stroke or heart failure. Some people may hear the term "dysrhythmia" used by doctors to describe their irregular or erratic heartbeat. Although the terms arrhythmia and dysrhythmia are interchangeable, arrhythmia is becoming more widely used.

Symptoms of Arrhythmia -

Arrhythmia can be undetected for a long time. A doctor or surgeon, on the other hand, may detect an arrhythmia during a regular checkup or after ordering an ECG (EKG). Even if a person detects symptoms, it does not always mean they have a serious arrhythmia. Some patients with life-threatening arrhythmias have no symptoms, whereas others with symptoms don't always have a severe arrhythmia.

II. RESEARCH IN ARRHYTHMIA CLASSIFICATION

It intended to develop a deep learning-based algorithm for classifying single-lead ECG recordings into four categories: normal rhythm (N), atrial fibrillation (A),other rhythm (O), and noise ().

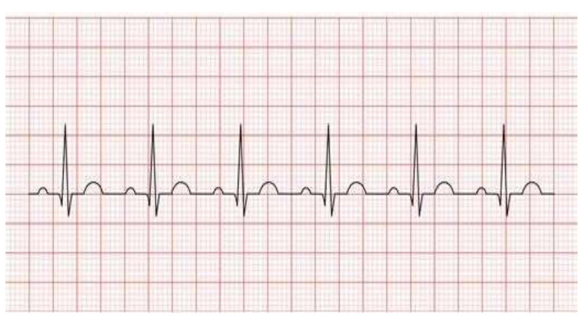


Figure 1 : Normal Rhythm

Figure 2 : Atrial Fibrillation

Figure 3 : Other Rhythm in ECG

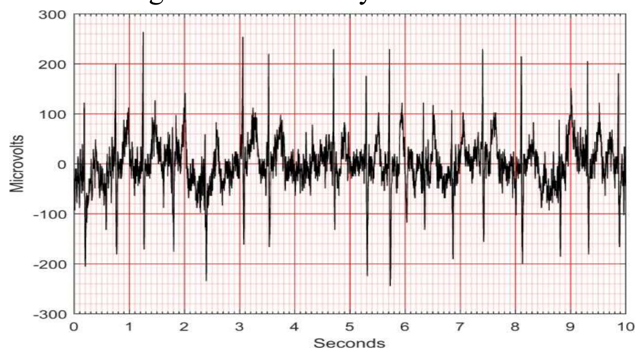
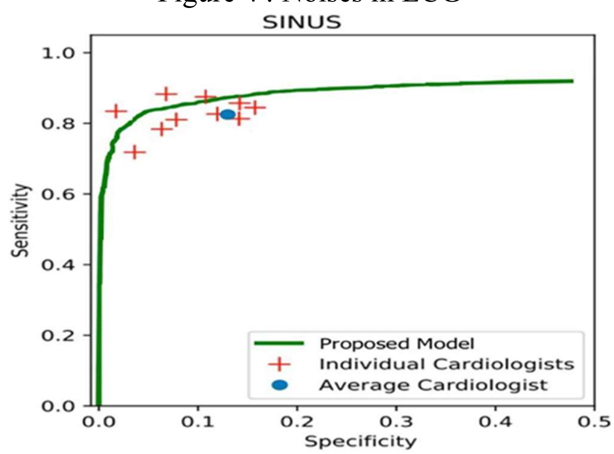


Figure 4 : Noises in ECG



III. TEST RESULTS AND ANALYSIS

As seen in Figures 5 to 16, the red cross reflects the cardiologist's individualperformance, while the blue dot represents the cardiologist's average performance. The ROC curve depicts the line's model performance, while the AUC curve depicts the model's performance below the ROC curve. AVB – Atrio Ventricular (AV) Block (B); AF – Atrial (A) Fibrillation (F) / Atrial (A) Flutter (F).

The graph shows the training accuracy and loss against number of iterations. The visible results indicate that the learning process has been a success. The loss in the graph indicates the errors encountered in the learning due to errors indata or errors in human prediction fed as the knowledge to the system. Sensitivity for each case is plotted against learning instances and shows that the system can discern between patterns exhibited by the ECGs of hearts with various classes of arrhythmia. The noise in the graphs shows the minor disturbance in the accuracy as it doesn’t affect the same much. This is due to the unsupervised nature of learning.

The graphs show that the system can predict the possibility of arrhythmia and its variants with a considerable probability of success. However, any hypothesis needs to be assessed against its converses to be successful. Hence the data from the modelis fed into another learning system as transfer learning. This stacking up of deep learning models ensures higher accuracy even though the second layer consumes higher time.

Figure 5 : Parameter for Different classes of Arrhythmia. (JunctionalRhythm)

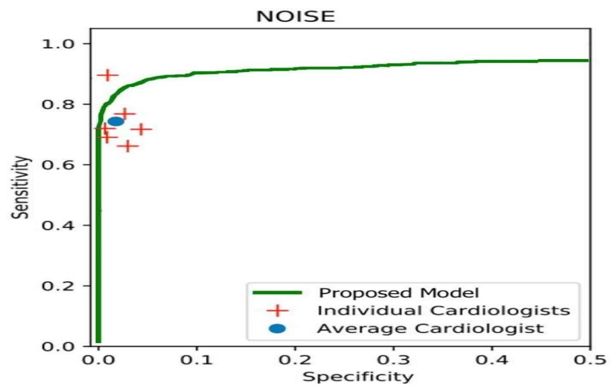


Figure 6 : Parameter for Different classes of Arrhythmia. (Noise)

Figure 7 : Parameter for Different classes of Arrhythmia. (Sinus Rhythm)

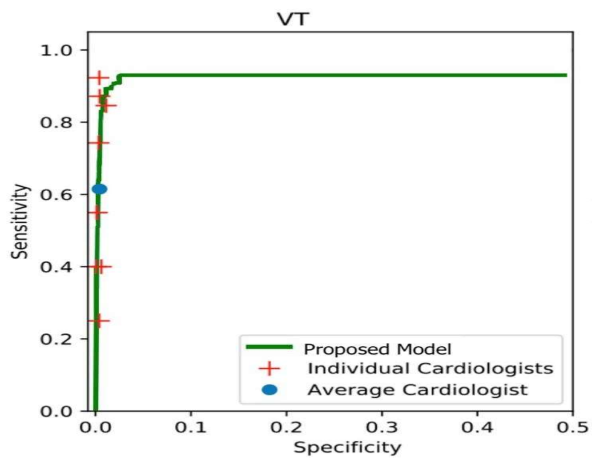
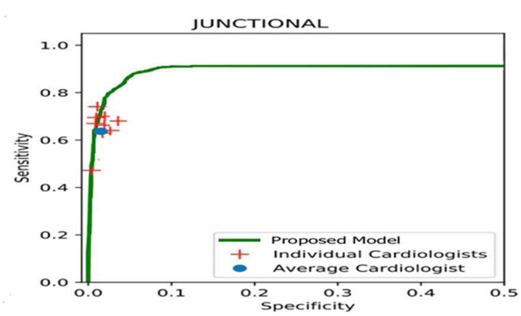


Figure 8 : Parameter for Different classes of Arrhythmia. (VT)



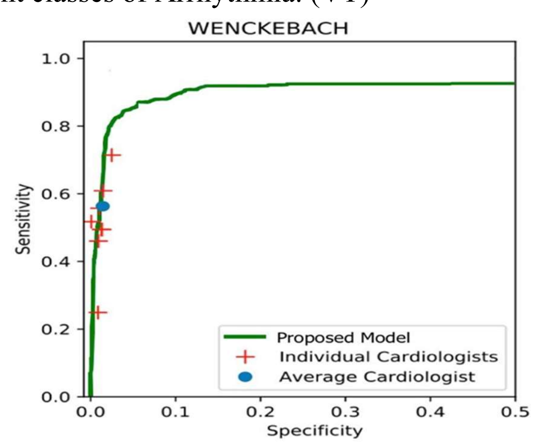


Figure 9 : Parameter for Different classes of Arrhythmia. (Wenckebach)

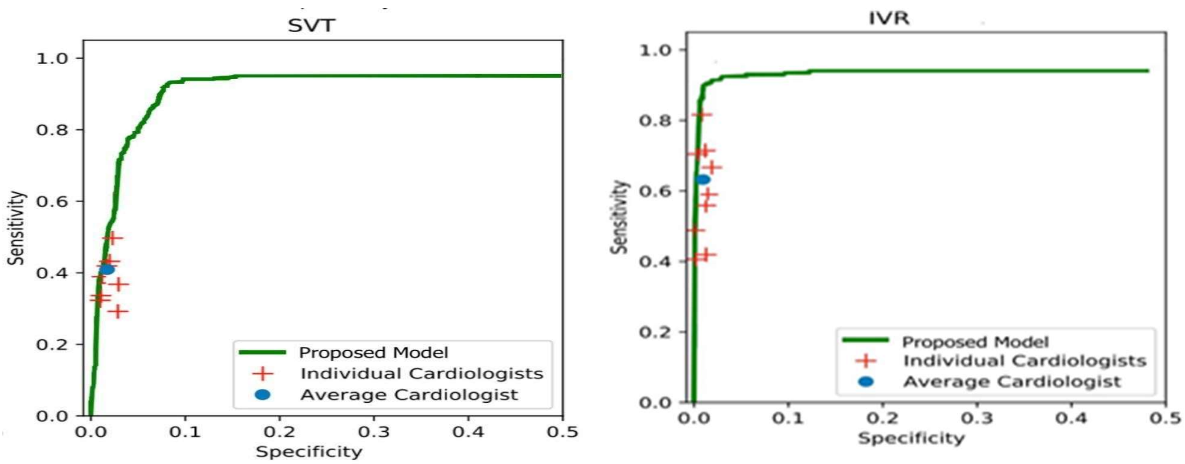


Figure 10 : Parameter for Different classes of Arrhythmia. (SVT)

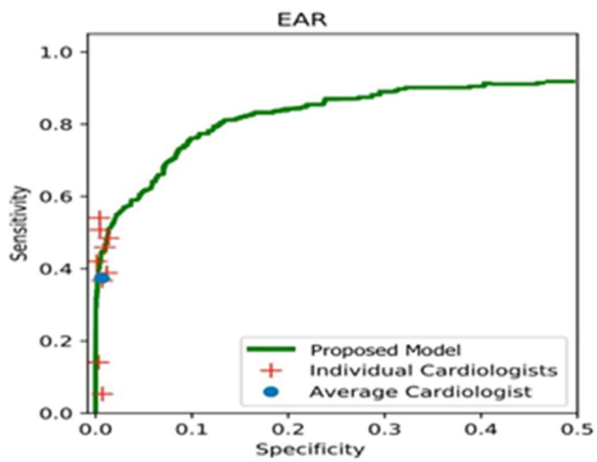


Figure 11 : Parameter for Different classes of Arrhythmia. (EAR)

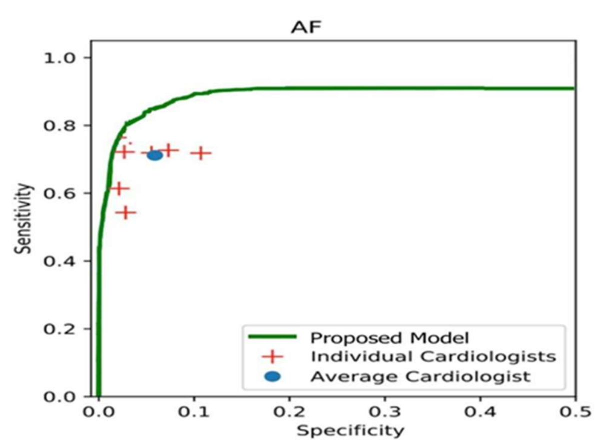


Figure 12 : Parameter for Different classes of Arrhythmia. (AF)

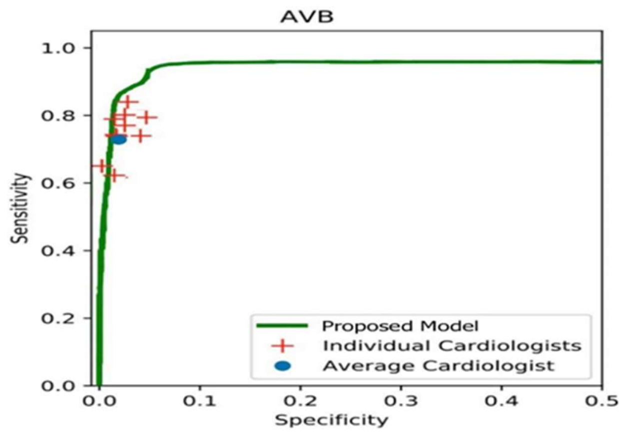


Figure 13 : Parameter for Different classes of Arrhythmia. (IVR)

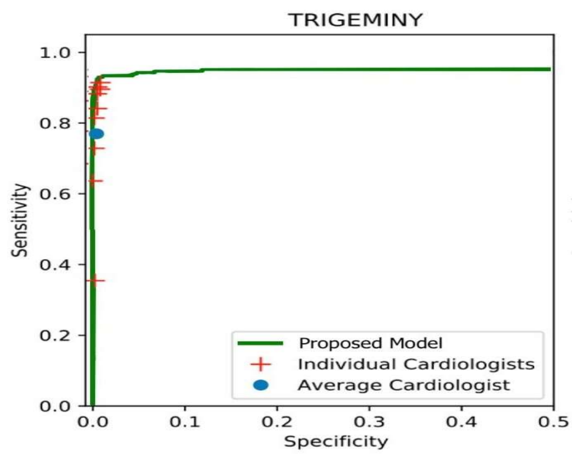


Figure 14 : Parameter for Different classes of Arrhythmia. (TRIGEMINY)

Figure 15 : Parameter for Different classes of Arrhythmia. (AVB)

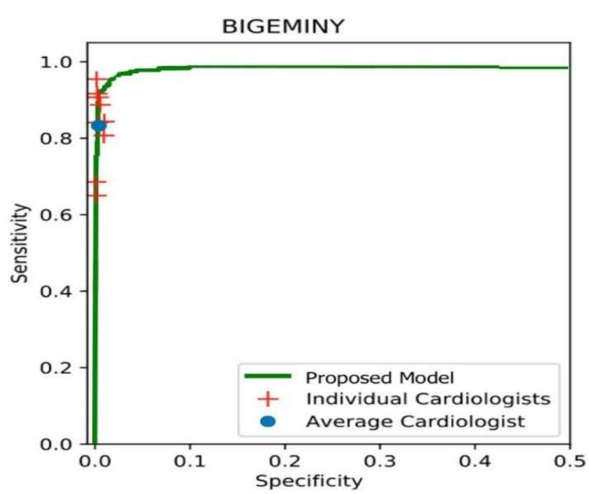


Figure 16 : Parameter for Different classes of Arrhythmia. (Bigeminy)

Figures 5 to 16 also show ROCs for various types of arrhythmias. The model's performance for all rhythmic classes met and exceeded the averaged cardiologist performance. Setting the specificity to the level obtained by expert cardiologists, theDNN's sensitivity outperformed the average cardiologist's and the rhythm classes for all sensitivity and the overall accuracy of the model (AUC) is around 0.972 as shownin Figure 17.

Arrhythmic Classes(AC)	Specificity(S)	Average Cardiologist Sensitivity (ACS)	Proposed Model's Sensitivity
Junctional Rhythm	0.96	0.64	0.81
Noise	0.97	0.78	0.84
Sinus Rhythm	0.90	0.81	0.86
Ventricular Tachycardia	0.97	0.62	0.84
Wenckebach	0.93	0.59	0.79
SVT	0.99	0.51	0.78
EAR	0.95	0.40	0.65
Atrial fibrillation and flutter	0.92	0.71	0.91
IVR	0.99	0.64	0.89
Trigeminy	0.98	0.79	0.98
AVB	0.97	0.77	0.89
Bigeminy	0.98	0.82	0.94

Table 1 : Sensitivity Comparison of our Model vs. Average Cardiologist

As it is evident from Table 2, on introduction of back propagation, the accuracy increases in an almost linear fashion before stabilizing at 97.10% in the 08th epoch.

Epoch	1	2	3	4	5	6	7	8	9	10	11
Back prop	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Accuracy	93.10	93.61	94.13	94.64	94.94	95.15	95.47	95.93	93.39	93.85	97.20

Table 2 : Back propagation improves on efficiency

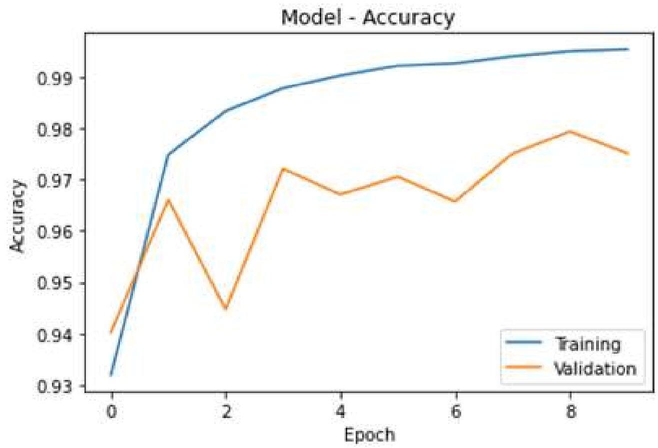


Figure 17 : Model Performance

The results in this research validates that the average accuracy of this model is around 0.98. The training determines how we used Deep Learning Methods i.e., DNN can do better the efficiency and exposed new paths for research. The AUC of all rhythmic classes is shown in Figures 5 to 16, and we can see that the accuracy is higher than the annotations.

IV. CONCLUSIONS

Current sensitivity is shown as declared by the cardiologists through statistical inference. It shows the average sensitivity for various arrhythmia classes. Our model's sensitivity is obtained by the result analysis of the deep learning method. To obtain the correlation we have plotted all the parameters as a radar graph. From the graph it can be seen clearly that our model out-performs the statisticalaverage. To validate Least Mean Square distance was computed for current and our model data. A distance more than zero (0.39) indicates that the model is faring well againstexisting methods. The model utilizes deep learning to predict the type of arrhythmia one might suffer from. Deep learning requires error correction throughout the learning phase. Our model uses SoftMax function to predict the final class label. In each learning epoch we have used back propagation as the error correction to increase the accuracy of prediction.

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