A Review on Diagnosis and Management of Arrhythmia Using ML

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***Abstract*: Cardiac arrhythmia refers to a variety of heart rhythm disorders in which the heartbeat is irregular, rapid, or sluggish. Arrhythmias come in a variety of forms, some of which have no symptoms. When symptoms are present, palpitations or a sense of a pause between heartbeats may be noticeable. In more extreme instances, lightheadedness, fainting, shortness of breath, or chest discomfort may develop. While most arrhythmias are harmless, some can cause serious complications such as stroke or heart failure. Others might lead to cardiac arrest. Arrhythmia affects millions of individuals throughout the world. Nearly half of all deaths due by cardiovascular disease, or roughly 15% of all deaths globally, are caused by sudden cardiac death. Ventricular arrhythmias account for approximately 80% of sudden cardiac death. Arrhythmias can affect people of any age, although they are more frequent as they get older.**

***Keywords*: Medical Imaging; Machine learning, Arrhythmia Diagnosis, KNN, SVM, Random Forest, Decision Tree**

I. INTRODUCTION

Cardiac arrhythmia is a group of conditions in which the heartbeat is irregular, too fast, or too slow. Many types of arrhythmia have no symptoms. When symptoms are present these may include palpitations or feeling a pause between heartbeats. In more serious cases there may be light headedness, passing out, shortness of breath, or chest pain. While most types of arrhythmia are not serious, some predispose a person to complications such as stroke or heart failure. Others may result in cardiac arrest. Arrhythmia affects millions of people. Sudden cardiac death is the cause of about half of deaths due to cardiovascular disease or about 15% of all deaths globally. About 80% of sudden cardiac death is the result of ventricular arrhythmias. Arrhythmias may occur at any age but are more common among older people. A healthy person will hardly ever suffer from long-term arrhythmia unless they have an external trigger, such as drug abuse or an electric shock. If there is an underlying problem, however, the electrical impulses may not be able to travel through the heart correctly, increasing the likelihood of arrhythmia. When it's normal, your heartbeat is nice and regular and has just the right rate. But when your heartbeat is too fast, too slow, or beats in an irregular rhythm, it's known as a cardiac arrhythmia (abnormal heart rhythm), which is among the most common of the heart disorders. Most people, in fact, have occasional cardiac arrhythmias. An arrhythmia is caused by a disruption of your heart's normal electrical system, which regulates your heart rate and heart rhythm. The severity of cardiac arrhythmias can vary tremendously. Most arrhythmias are completely benign and inconsequential, while others are extremely dangerous and life-threatening. And many of them, while not particularly dangerous, produce symptoms that can be quite disruptive to your life. The heart's electrical system triggers the heartbeat. Each beat of the heart is represented on the electrocardiogram (EKG or ECG) by a wave arm. The normal heart rhythm (normal sinus rhythm) shows the electrical activity in the heart is following the normal pathway. The rhythm is regular and the node is normal (about 50 to 100 beats per minute). Each heart beat originates as an electrical impulse from a small area of tissue in the right atrium of the heart called the sinus node or Sino-atrial node or SA node. The impulse initially causes both atria to contract, then activates the atrioventricular (or AV) node, which is normally the only electrical connection between the atria and the ventricles (main pumping chambers). The impulse then spreads through both ventricles via the Bundle of His and the Purkinje fibres causing a synchronised contraction of the heart muscle and, thus, the pulse. In adults the normal resting heart rate ranges from 60 to 90 beats per minute. The resting heart rate in children is much faster. In athletes, however, the resting heart rate can be as slow as 40 beats per minute, and be considered as normal. The term sinus arrhythmia refers to a normal phenomenon of alternating mild acceleration and slowing of the heart rate that occurs with breathing in and out respectively. It is usually quite pronounced in children and steadily decreases with age. This can also be present during meditation breathing exercises that involve deep inhaling and breath holding patterns. Normal sinus rhythm, with solid black arrows pointing to normal P waves representative of normal sinus node function, followed by a pause in sinus node activity (resulting in a transient loss of heart beats). Note that the P wave that disrupts the pause (indicated by the dashed arrow) does not look like the previous (normal) P waves — this last P wave is arising from a different part of the atrium, representing an escape rhythm.

2. MACHINE LEARNING

Machine learning (ML) is a research area concerned with understanding and creating "learning" techniques, or technologies that allow use of data to improve performance on some set of tasks. It's thought of as a part of machine intelligence. Machine learning techniques create a method of statistical inference, also referred to as training examples, in addition to making decisions or judgments with out being expressly programmed to do it anyway. These models are used in a variety of applications, including object recognition, spam filtering, pharmacy, and voice recognition. Programs that use machine learning can do work without having them specifically coded. Computers use available data to learn in order to do specific jobs. For straightforward jobs given to systems, it really is able to construct techniques that instruct the device how to carry out all the steps necessary to address the issue at hand; no learning is required on the part of the computer. Instead of considering human developers describe each necessary measure, it may prove to be more reliable and effective to assist the machine in creating on its strategy. Machine learning uses a variety of techniques to train computers to complete jobs for which there isn't a totally suitable solution. One strategy is to declare a few of the right answers as valid when there are many possible replies. The computer can then use this as practice data to refine the algorithm(s) that employs to decide the proper responses.

3. MACHINE LEARNING ALGORITHMS AND RELATED PERFORMANCE MATRICES.

Machine learning algorithms that are appropriate for estimating Arrhythmia Detection include Logistic regression, Naive Bayes, Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Weight KNN and Random Forest (RF).

A generalized linear regression analytic methodology for assessing a specific thing's probability is logistic regression [2] [7]. The objective of logistic regression is to identify the better model that explains the relationship among the variables as well as an array of independent variables. (2) Naïve Bayes [2] is based on the Bayes theory as well as assumes that the necessary features are independent of one another. (3) SVM uses supervised learning, a generalized linear classifier can categorizes data [12]. It is the popular one kernel learning techniques is the SVM, which can perform nonlinear classification. (4) The goal of the KNN [12] algorithm is to locate a sample's k closest neighbors. (5) The DT [13] is a a nonlinear trained classifier that may also create decision rules can be used from a data set with feature representation and it present these rules using the tree's structure to address classification and regression issues. (6) A classifier with several decision trees is called the Random forest [4] [12] [13]. The majority of decision trees' output categories determine this tree's output category.

Researchers created a number of evaluation measures to assess the effectiveness of machine learning systems. The following formula displays the point of comparison: Where, A model's ability to forecast the positive class is gauged by the statistic known as TP (True Positive). As a result, the model predicted a positive outcome, and the outcome was favourable. When a model predicts that an instance belongs to a class when it doesn't, this is known as a false positive (FP). False positives pose a danger since they could lead to poor decisions. The model predicts that certain outcomes will be negative, or TN (True Negative). One of the criteria used to assess a classification model's effectiveness is true negatives. False Negative (FN) results whenever a model predicts a negative outcome when the actual result is positive.

4. LITERATURE REVIEW

Vasu Gupta et.al [1] Irregularity in heart beat may be harmless or life threatening. Hence both accurate detection of presence as well as classification of arrhythmia are important. Arrhythmia can be diagnosed by measuring the heart activity using an instrument called ECG or electrocardiograph and then analysing the recorded data. Different parameter values can be extracted from the ECG waveforms and can be used along with other information about the patient like age, medical history, etc to detect arrythmia. However, sometimes it may be difficult for a doctor to look at these long duration ECG recordings and find minute irregularities. Therefore, using machine learning for automating arrhythmia diagnosis can be very helpful The paper aims at using different machine learning algorithms like Naive Bayes, SVM, Random Forests and Neural Networks for predicting and classifying arrhythmia into different categories. Experimented with two different filter feature selection techniques. One of the reasons for using fewer features was the limited number of data records(452) compared to 257 features. This helps in avoiding overfitting and also gives insight into the important features which have maximum correlation with the output labels but minimal correlation among themselves. In the first technique, we discretized all the continuous valued columns and then computed the mutual information I(Y,X) between each feature and the output label vector using the below formula. Our second approach was to use a matlab feature selection package named mRMR.

Thara Soman et.al [2] The motivation behind the research reported in this paper is the results obtained from extensions of an ongoing major effort. Some of the results of this effort have been partly reported .In the effort, we focused on the acquisition and (software) analysis of ECG signals for early diagnosis of Tachycardia heart disease. The work reported here builds on the initial work by developing an experimental framework using machine learning techniques to accurately predict the disease The algorithms selected to diagnose cardiac arrhythmia are OneR , Naïve Bayes , and J48 . OneR is a simple algorithm proposed by Holt. OneR induces classification rules based on the value of a single attribute. As its name suggests, this system learns one rule. Surprisingly, in some circumstances it is almost as powerful as sophisticated systems such as J48. OneR algorithm prefers the attribute that generates the lowest training error on the given dataset. In the event that two attributes generate the same training error, OneR makes a random choice between them. This algorithm is chosen to be a base algorithm for comparing the predictive accuracy with other algorithms. J48 algorithm is an implementation of the C4.5 decision tree learner. The algorithm uses the greedy technique to induce decision trees for classification. A decision-tree model is built by analyzing training data and the model is used to classify unseen data. An information-theoretic measure is used to select the attribute tested for each non-leaf node of the tree. Decision tree induction is an algorithm that normally learns a high accuracy.

Varun Kathuria et.al [3] The total number of deaths due to cardiovascular diseases read 17.3 million a year according to the WHO causes of death. Thus, how to predict cardiac arrhythmia in real life is of great significance. In this project, we plan to develop a machine learning system that can classify a patient into different cardiac arrhythmic classes. The diagnosis of cardiac arrhythmia can be classified into various classes based on the Electrocardiogram (ECG) readings and other attributes. First class will refer to the normal patient while other classes shall represent different classes of cardiac arrhythmia like Tachycardia, Bradycardia and Coronary artery diseases. If any training instance has a missing value for a given attribute, we set it as the mean of the value plus or minus the standard deviation for that attribute related to the class it belongs to. If for a given attribute majority of values are

missing, then we discard that attribute and remove it from our training set. We implement a Random Forest classifier. The model works by continually sampling with replacement a portion of the training dataset, and fitting a decision tree to it. The number of trees refer to the number of times the dataset is randomly sampled. Moreover, in each sampling iteration, a random set of features are selected. In decision trees, each node refers to one of the input variables, which has edges to children for all possible values that the input can take.
Mr. Jitendra Kumar et.al [4] Cardiac arrhythmia is a major kind of abnormal heart activity. An arrhythmia is a problem with the heartbeat rate or rhythm of the heartbeat. For the period of an arrhythmia, the heart may beat too fast or too slow, or with an irregular rhythm. Fast heartbeat is said to be tachycardia whereas slow is called Bradycardia. Most arrhythmias are not dangerous, but some can be and some can be even fatal[1],[3]. Classification of cardiac arrhythmia is a difficult task. One of the ways to detect cardiac arrhythmia is to use electrocardiogram (ECG) signals. The ECG is the most important biomedical-signal used by cardiologists for diagnostic purposes. The ECG signal provides all the required information about the electrical activity of the heart[1]. The early detection of the cardiac arrhythmias can save lives and enhance the quality of living through appreciates treatment. contraction and relaxation activity generated by the heart. [3], An ECG comprises of the P wave, QRS complex, T and U waves. They are denoted by the capital letters P, Q, R ,S, T and U. The P wave is the contraction of the atria, while the QRS complex is related with the contraction of the ventricles. The T wave is generated by relaxation of the ventricles. The P, Q, R, S, T and U waves of the ECG signal.

Yang Meng, et al., [5] has briefed that the People's life rhythms have accelerated in recent years as society and the economy have grown rapidly, and the increasing strain of survival has increased the prevalence of cardiovascular disease (CVD) year after year, posing a serious threat to human life and health. CVD is on the rise in China, according to the Chinese Report on Cardiovascular Health and Condition (2019), with an estimated 330 million people suffering from the disease. CVD-related mortality is currently the leading cause of death among both urban and rural residents. As a result, cardiovascular disease prevention and treatment are crucial. The vast majority of CVD patients have arrhythmia and chronic illnesses. The electrocardiogram (ECG) is a critical instrument for measuring the periodic activity of the heart and is commonly used in clinical practise. The ECG is still the most important tool for identifying arrhythmia. Traditional ECG analysis is mainly reliant on physicians' naked eye observations, and the analysis is based on personal experience and current theoretical understanding, which can lead to inaccurate conclusions with serious. Due to the scarcity of arrhythmia data, only four arrhythmia diseases were chosen for investigation in this study, which may result in some differences in the results. It will investigate the DCNN algorithm's usefulness in ECG and increase the types of arrhythmias that may be examined.

Senthil Kumar [5] Electronic Health Records (EHRs) are aggregated, combined and analyzed for suitable treatment planning and safe therapeutic procedures of patients. Integrated EHRs facilitate the examination, diagnosis and treatment of diseases. However, the existing EHRs models are centralized. There are several obstacles that limit the proliferation of centralized EHRs, such as data size, privacy and data ownership consideration. In this paper, we propose a novel methodology and algorithm to handle the mining of distributed medical data sources at different sites (hospitals and clinics) using Association Rules. These medical data resources cannot be moved to other network sites. Therefore, the desired global computation must be decomposed into local computations to match the distribution of data across the network. The capability to decompose computations must be general enough to handle different distributions of data and different participating nodes in each instance of the global computation. In the proposed methodology, each distributed data source is represented by an agent. The global association rule computation is then performed by the agent either exchanging some minimal summaries with other agents or travelling to all the sites and performing local tasks that can be done at each local site. The objective is to perform global tasks with a minimum of communication or travel by participating agents across the network, this will preserve the privacy and the security of the local data. The proposed association rule mining methodology will be used for heart disease prediction using real heart disease data. These real data exist at different clinics and cannot be moved to a central site. The proposed model protects the patient data privacy and achieves the same results as if the data are moved and joined at a central site. We also validate the extracted association rules from all the data providers using an independent test datasets. It would be desirable to have algorithms that let the individual databases reside at their own sites and work with an imagined implicit join of the databases by decomposing themselves into localized computations such that each localized computation can be performed locally within a single site using its physical database. A common constraint in these situations is that the data cannot be moved to other network sites due to security, size, privacy and data ownership considerations. An example of such situations is, we may need to compute decision trees, association rules, or some complex statistical quantities using data from a census database, a diseases database, a labor statistics database, and a few pollution databases located in ten different cities across the country. It is impossible to bring these databases together and join them for performing some computations.

Fahad Algarni [6] The IoT has applications in many areas such as manufacturing, healthcare, and agriculture, to name a few. Recently, wearable devices have become popular with wide applications in the health monitoring system which has stimulated the growth of the Internet of Medical Things (IoMT). The IoMT has an important role to play in reducing the mortality rate by the early detection of disease. The prediction of heart disease is a key issue in the analysis of clinical dataset. The aim of the proposed investigation is to identify the key characteristics of heart disease prediction using machine learning techniques. Many studies have focused on heart disease diagnosis, but the accuracy of the findings is low. Therefore, to improve prediction accuracy, an IoMT framework for the diagnosis of heart disease using modified salp swarm optimization (MSSO) and an adaptive neuro-fuzzy inference system (ANFIS) is proposed. The proposed MSSO-ANFIS improves the search capability using the Levy flight algorithm. The regular learning process in ANFIS is dependent on gradient-based learning and has a tendency to become trapped in local

minima. The learning parameters are optimized utilizing MSSO to provide better results for ANFIS. The following information is taken from medical records to predict the risk of heart disease: blood pressure (BP), age, sex, chest pain, cholesterol, blood sugar, etc. The heart condition is identified by classifying the received sensor data using MSSO-ANFIS. A simulation and analysis conducted to show that MSSA-ANFIS works well in relation to disease prediction. The results of the simulation demonstrate that the MSSO-ANFIS prediction model achieves better accuracy than the other approaches. The proposed MSSO-ANFIS prediction model obtains an accuracy of 99.45 with a precision of 96.54, which is higher than the other approaches.
A trained practitioner with the adequate experience and expertise can identify and diagnose heart disease. The term heart disease, also referred to as cardiac disease, incorporates various conditions, the symptoms of which include high blood pressure, arrhythmia, stroke, and heart attack. The challenge for healthcare institutions is to provide quality treatment at a reasonable price. An incorrect clinical diagnosis and low-quality treatment may lead to inadequate outcomes. Healthcare institutions may use decision support systems (DSSs) as a tool for cost reduction. Healthcare typically includes a large number of patient records, multiple disease diagnoses, and resource management, etc. The pervasive development of the Internet of Things (IoT) and its use in medical research has improved the effectiveness of remote health monitoring systems.

Wang Li [7] Coronary arteriongraphy (CAG) is an accurate invasive technique for the diagnosis of coronary heart disease (CHD). However, its invasive procedure is not appropriate for the detection of CHD in the annual physical examination. With the successful application of machine learning (ML) in various fields, our goal is to perform selective integration of multiple ML algorithms and verify the validity of feature selection methods with personal clinical information commonly seen in the annual physical examination. In this study, a two level stacking based model is designed in which level 1 is base-level and level 2 is metalevel. The predictions of base-level classifiers is selected as the input of meta-level. The pearson correlation coefficient and maximum information coefficient are first calculated to find the classifier with the lowest correlation. Then enumeration algorithm is used to find the best combining classifiers which acquire the best result in the end. The Z-Alizadeh Sani CHD dataset which we use consists of 303 cases verified by CAG. Experimental results demonstrate that the proposed model obtains an accuracy, sensitivity and specificity of 95.43%, 95.84%, 94.44%, respectively for the detection of CHD. The proposed method can effectively aid clinicians to detect those with normal coronary arteries from those with CHD. Coronary heart disease (CHD) remains one of the leading causes of cardiovascular death globally. At present, the diagnostic methods of CHD can be divided into invasive and non-invasive ways. Coronary angiography (CAG) is a relatively safe and reliable invasive diagnostic technique, which has been widely used in clinical practice as the gold standard for the CHD diagnosis . However, its invasive nature and relatively expensive operation cost makes it difficult to apply in the annual physical examination. Electrocardiogram (ECG) and echocardiography are non-invasive methods, but neither with reliable accuracy [2]. Therefore, it is necessary to find new non-invasive methods to detect CHD. In clinical cardiology, machine learning (ML) has been proved an effective method for prediction of all-cause mortality in patients with suspected CHD.
Ahamd Kamran Malik [8] A rapid increase in heart disease has occurred in recent years, which might be the result of unhealthy food, mental stress, genetic issues, and a sedentary lifestyle. There are many advanced automated diagnosis systems for heart disease prediction proposed in recent studies, but most of them focus only on feature preprocessing, some focus on feature selection, and some only on improving the predictive accuracy. In this study, we focus on every aspect that may have an influence on the final performance of the system, i.e., to avoid overfitting and underfitting problems or to solve network configuration issues and optimization problems. We introduce an optimally configured and improved deep belief network named OCI-DBN to solve these problems and improve the performance of the system. We used the Ruzzo-Tompa approach to remove those features that are not contributing enough to improve system performance. To find an optimal network configuration, we proposed a stacked genetic algorithm that stacks two genetic algorithms to give an optimally configured DBN. An analysis of a RBM and DBN trained is performed to give an insight how the system works. Six metrics were used to evaluate the proposed method, including accuracy, sensitivity, specificity, precision, F1 score, and Matthew's correlation coefficient. The experimental results are compared with other state-of-the-art methods, and OCI-DBN shows a better performance. The validation results assure that the proposed method can provide reliable recommendations to heart disease patients by improving the accuracy of heart disease predictions by up to 94.61%. Heart disease is mainly caused by risk factors categorized as changeable factors and non-changeable factors. Changeable factors include blood pressure, cholesterol level, etc., while non-changeable factors include a patient's history, age, and sex. There is a substantial amount of hidden information in a patient's medical data, but a major challenge in hospitals is that a large amount of this data is not being used adequately to support clinical decisions. This extensive information can also be used to predict heart disease accurately in the early stages. Although the diagnosing of heart diseases is done by invasive cardiology-based techniques like angiography, it relies on a patient's medical history and a high level of technical expertise to analyze the concerned symptoms. Additionally, it is a complex process with high costs, so noninvasive techniques like decision support systems based on machine learning and deep learning must be used to overcome these issues
Maraiam Eljamil [9] Electronic Health Records (EHRs) are aggregated, combined and analyzed for suitable treatment planning and safe therapeutic procedures of patients. Integrated EHRs facilitate the examination, diagnosis and treatment of diseases. However, the existing EHRs models are centralized. There are several obstacles that limit the proliferation of centralized EHRs, such as data size, privacy and data ownership consideration. In this paper, we propose a novel methodology and algorithm to handle the mining of distributed medical data sources at different sites (hospitals and clinics) using Association Rules. These medical data resources cannot be moved to other network sites. Therefore, the desired global computation must be decomposed into local computations to match the distribution of data across the network. The capability to decompose computations must be general enough to handle different distributions of data and different participating nodes in each instance of the global computation. In the proposed methodology, each distributed data source is represented by an agent. The global association rule computation is then performed by the agent either exchanging some minimal summaries with other agents or travelling to all the sites and performing local tasks

that can be done at each local site. The objective is to perform global tasks with a minimum of communication or travel by participating agents across the network, this will preserve the privacy and the security of the local data. The proposed association rule mining methodology will be used for heart disease prediction using real heart disease data. These real data exist at different clinics and cannot be moved to a central site. The proposed model protects the patient data privacy and achieves the same results as if the data are moved and joined at a central site. We also validate the extracted association rules from all the data providers using an independent test datasets. Electronic Health Care Records (EHRs) are widely used in various healthcare institutions, such as hospitals and clinics. EHR contains a great collection of medical and health care information on symptoms, diagnosis, laboratory tests, other diagnostic tests, and treatments and is therefore a potential source of data for pragmatic trials, evaluations of drug safety, epidemiologic studies, and various health care organization evaluations. Information recorded in the EHRs has to revolutionize a health care system through careful analysis and interpretation of data, feedback, and change implementation. Their utilities are not limited to supporting financial and administrative operations or maintaining patient records.

Simanta Shekhar sarmah [10] The leading causes of death worldwide are chronic illnesses suchlike diabetes, Heart Disease (HD), cancer as well as chronic respiratory malady. It is remarkably intricate to diagnose HD with disparate symptoms or features. With the augmentation in popularity of smart wearable gadgets, a chance to render an Internet of Things (IoT) solution has turned out to be more. Unfortunately, the survival rates are low for the people suffering from sudden heart attacks. Consequently, a patient monitoring scheme intended for heart patients utilizing IoT centered Deep Learning Modified Neural Network (DLMNN) is proposed to assist in the HD diagnosis, and medication is given accordingly. This proposed technique is executed via ‘3’ steps: I) Authentication, ii) Encryption, and iii) Classification. First, by utilizing the substitution cipher (SC) together with the SHA-512, the heart patient of the specific hospital is authenticated. Subsequently, the wearable IoT sensor device, which is fixed to the patient’s body, concurrently transmits the sensor data to the cloud. This sensor data is encrypted and securely transmitted to the cloud utilizing the PDH-AES technique. After that, the encrypted data is finally decrypted, and by employing the DLMNN classifier, the classification is done. The classified outcomes comprise ‘2’types of data: i) normal and ii) abnormal. It denotes the patient’s heart condition and if the outcome is abnormal, an alert text is passed to the physician for treating the patient. The investigational outcomes are estimated and the DLMNN for HD diagnosis shows improvement as compared to existing algorithms. Additionally, the proposed PDH-AES used in support of secure data transmission results in the highest level of security i.e. 95.87%, and it is achieved in the lowest time for encryption along with decryption when weighted against the existent AES. Studies conducted on heart failure patients show that around 30 percent of patients had been readmitted as a minimum of once within the timeframe of 90 days. Within 3-6 months, the readmission ranges had come athwart 25% to 54%. Therefore, the key to augment the HD performance of the healthcare (HC) and to decrease the death rate is changing the inert HC mode into an invasive one. The physicians should monitor the patient’s physical status and decide the time the HC services should well be delivered to them, which could be attained with the assist of IoT

Yongjun piao [12] This study proposes an efficient prediction method for coronary heart disease risk based on two deep neural networks trained on well-ordered training datasets. Most real datasets include an irregular subset with higher variance than most data, and predictive models do not learn well from these datasets. While most existing prediction models learned from the whole or randomly sampled training datasets, our suggested method draws up training datasets by separating regular and highly biased subsets to build accurate prediction models. We use a two-step approach to prepare the training dataset: (1) divide the initial training dataset into two groups, commonly distributed and highly biased using Principal Component Analysis, (2) enrich the highly biased group by Variational Autoencoders. Then, two deep neural network classifiers learn from the isolated training groups separately. The well-organized training groups enable a chance to build more accurate prediction models. When predicting the risk of coronary heart disease from the given input, only one appropriate model is selected based on the reconstruction error on the Principal Component Analysis model. Dataset used in this study was collected from the Korean National Health and Nutritional Examination Survey. We have conducted two types of experiments on the dataset. The first one proved how Principal Component Analysis and Variational Autoencoder models of the proposed method improves the performance of a single deep neural network. The second experiment compared the proposed method with existing machine learning algorithms, including Naïve Bayes, Random Forest, K-Nearest Neighbor, Decision Tree, Support Vector Machine, and Adaptive Boosting. The experimental results show that the proposed method outperformed conventional machine learning algorithms by giving the accuracy of 0.892, specificity of 0.840, precision of 0.911, recall of 0.920, f-measure of 0.915, and AUC of 0.882.

Yawar Rasheed [13] Cardiovascular diseases are considered as the most life-threatening syndromes with the highest mortality rate globally. Over a period of time, they have become very common and are now overstretching the healthcare systems of countries. The major factors of cardiovascular diseases are high blood pressure, family history, stress, age, gender, cholesterol, Body Mass Index (BMI), and unhealthy lifestyle. Based on these factors, researchers have proposed various approaches for early diagnosis. However, the accuracy of proposed techniques and approaches needs certain improvements due to the inherent criticality and life threatening risks of cardiovascular diseases. In this article, a MaLCaDD (Machine Learning based Cardiovascular Disease Diagnosis) framework is proposed for the effective prediction of cardiovascular diseases with high precision. Particularly, the framework first deals with the missing values (via mean replacement technique) and data imbalance (via Synthetic Minority Over-sampling Technique - SMOTE). Subsequently, Feature Importance technique is utilized for feature selection. Finally, an ensemble of Logistic Regression and K-Nearest Neighbor (KNN) classifiers is proposed for prediction with higher accuracy. The validation of framework is performed through three benchmark datasets (i.e. Framingham, Heart Disease and Cleveland) and the accuracies of 99.1%, 98.0% and 95.5 % are achieved respectively. Finally, the comparative analysis proves that MaLCaDD predictions are more accurate (with reduced set of features) as compared to the existing state-of-the-art approaches. Therefore, MaLCaDD is highly reliable and can be applied in real environment for the early diagnosis of cardiovascular diseases.

Liao Yongjian [13] Heart failure is considered one of the leading cause of death around the world. The diagnosis of heart failure is a challenging task especially in under-developed and developing countries where there is a paucity of human experts and equipments. Hence, different researchers have developed different intelligent systems for automated detection of heart failure. However, most of these methods are facing the problem of overfitting i.e. the recently proposed methods improved heart failure detection accuracy on testing data while compromising heart failure detection accuracy on training data. Consequently, the constructed models overfit to the testing data. In order, to come up with an intelligent system that would show good performance on both training and testing data, in this paper we develop a novel diagnostic system. The proposed diagnostic system uses random search algorithm (RSA) for features selection and random forest model for heart failure prediction. The proposed diagnostic system is optimized using grid search algorithm. Two types of experiments are performed to evaluate the precision of the proposed method. In the first experiment, only random forest model is developed while in the second experiment the proposed RSA based random forest model is developed. Experiments are performed using an online heart failure database namely Cleveland dataset. The proposed method is efficient and less complex than conventional random forest model as it produces 3.3% higher accuracy than conventional random forest model while using only 7 features. Moreover, the proposed method shows better performance than five other state of the art machine learning models. In addition, the proposed method achieved classification accuracy of 93.33% while improving the training accuracy as well. Finally, the proposed method shows better performance than eleven recently proposed methods for heart failure detection.

Mohammad Ayoub Khan [14] Nowadays, heart disease is the leading cause of death worldwide. Predicting heart disease is a complex task since it requires experience along with advanced knowledge. Internet of Things (IoT) technology has lately been adopted in healthcare systems to collect sensor values for heart disease diagnosis and prediction. Many researchers have focused on the diagnosis of heart disease, yet the accuracy of the diagnosis results is low. To address this issue, an IoT framework is proposed to evaluate heart disease more accurately using a Modified Deep Convolutional Neural Network (MDCNN). The smartwatch and heart monitor device that is attached to the patient monitors the blood pressure and electrocardiogram (ECG). The MDCNN is utilized for classifying the received sensor data into normal and abnormal. The performance of the system is analyzed by comparing the proposed MDCNN with existing deep learning neural networks and logistic regression. The results demonstrate that the proposed MDCNN based heart disease prediction system performs better than other methods. The proposed method shows that for the maximum number of records, the MDCNN achieves an accuracy of 98.2 which is better than existing classifiers.

M. Anwar Hossain [15] Cyber-Physical Systems (CPS) embed computation and communication capability into its core to regulate physical processes and seamlessly mediate between the cyber and the physical world for various control and monitoring tasks. Health CPS, a variant of CPS in the healthcare sector, acts as a health monitoring system to dynamically capture, process, and analyze health sensor data through integrated internet of things (IoT)-enabled cyber-physical processes. These systems can suitably support patients suffering from non-communicable diseases (NCDs) or who are at risk of suffering from those. Identifying the risk of NCDs, such as heart disease and diabetes, requires artificial intelligence (AI) techniques into the core of health CPS. Recently, there has been growing interest to incorporate machine learning into CPS, which can facilitate the disease classification, detection, monitoring, and prediction of several NCDs. However, there is a shortage of visible work that focus on early-stage risk prediction of these diseases. In this work, we propose a novel machine learning based health CPS framework that addresses the challenge of effectively processing the wearable IoT sensor data for early risk prediction of diabetes as an example of NCDs. In the experiment, a verified diabetic dataset has been used for training, while the testing has been performed on an artificially generated data collection from sensors. The experiment with several machine learning algorithms shows the effectiveness of the proposed approach in achieving the maximum precision from the Random Tree algorithm, which requires a minimum time of 0.01s to construct a model and obtains 94% accuracy to predict the probability of diabetes at an early point.

Mirjam Jonkman [16] Cardiovascular diseases (CVD) are among the most common serious illnesses affecting human health. CVDs may be prevented or mitigated by early diagnosis, and this may reduce mortality rates. Identifying risk factors using machine learning models is a promising approach. We would like to propose a model that incorporates different methods to achieve effective prediction of heart disease. For our proposed model to be successful, we have used efficient Data Collection, Data Pre-processing and Data Transformation methods to create accurate information for the training model. We have used a combined dataset (Cleveland, Long Beach VA, Switzerland, Hungarian and Stat log). Suitable features are selected by using the Relief, and Least Absolute Shrinkage and Selection Operator (LASSO) techniques. New hybrid classifiers like Decision Tree Bagging Method (DTBM), Random Forest Bagging Method (RFBM), K-Nearest Neighbors Bagging Method (KNNBM), AdaBoost Boosting Method (ABBM), and Gradient Boosting Boosting Method (GBBM) are developed by integrating the traditional classifiers with bagging and boosting methods, which are used in the training process. We have also instrumented some machine learning algorithms to calculate the Accuracy (ACC), Sensitivity (SEN), Error Rate, Precision (PRE) and F1 Score (F1) of our model, along with the Negative Predictive Value (NPR), False Positive Rate (FPR), and False Negative Rate (FNR). The results are shown separately to provide comparisons. Based on the result analysis, we can conclude that our proposed model produced the highest accuracy while using RFBM and Relief feature selection methods (99.05.

Muhammad Syafrudin [17] Heart disease, one of the major causes of mortality worldwide, can be mitigated by early heart disease diagnosis. A clinical decision support system (CDSS) can be used to diagnose the subjects' heart disease status earlier. This study proposes an effective heart disease prediction model (HDPM) for a CDSS which consists of Density-Based Spatial Clustering of

Applications with Noise (DBSCAN) to detect and eliminate the outliers, a hybrid Synthetic Minority Over-sampling Technique-Edited Nearest Neighbor (SMOTE-ENN) to balance the training data distribution and XGBoost to predict heart disease. Two publicly available datasets (Statlog and Cleveland) were used to build the model and compare the results with those of other models (naive bayes (NB), logistic regression (LR), multilayer perceptron (MLP), support vector machine (SVM), decision tree (DT), and random forest (RF)) and of previous study results. The results revealed that the proposed model outperformed other models and previous study results by achieving accuracies of 95.90% and 98.40% for Statlog and Cleveland datasets, respectively. In addition, we designed and developed the prototype of the Heart Disease CDSS (HDCDSS) to help doctors/clinicians diagnose the patients'/subjects' heart disease status based on their current condition. Therefore, early treatment could be conducted to prevent the deaths caused by late heart disease diagnosis

Jiabing Zhang [18] Nowadays, Heart disease is one of the crucial impacts of mortality in the country. In clinical data analysis, predicting cardiovascular disease is a primary challenge. Deep learning (DL) has been demonstrated to be effective in helping to determine and forecast a huge amount of data produced by the health industry. In this paper, the proposed Recursion enhanced random forest with an improved linear model (RFRF-ILM) to detect heart disease. This paper aims to find the key features of the prediction of cardiovascular diseases through the use of machine learning techniques. The prediction model is adding various combinations of features and various established methods of classification. it produces a better level of performance with precision through the heart disease prediction model. In this study, the factors leading to cardiovascular disease can be diagnosed. A comparison of important variables showed with the Internet of Medical Things (IoMT) platform, for data analysis. This indicates that coronary artery disease develops more often in older ages.

M. M. El-Gayar [19] Supervised machine learning algorithms are powerful classification techniques commonly used to build prediction models that help diagnose the disease early. However, some challenges like overfitting and underfitting need to be overcome while building the model. This paper introduces hybrid classifiers using the ensembled model with a majority voting technique to improve prediction accuracy. Furthermore, a proposed preprocessing technique and features selection based on a genetic algorithm is suggested to enhance prediction performance and overall time consumption. In addition, the 10-folds cross-validation technique is used to overcome the overfitting problem. Experiments were performed on a dataset for cardiovascular patients from the UCI Machine Learning Repository. Through a comparative analytical approach, the study results indicated that the proposed ensemble classifier model achieved a classification accuracy of 98.18% higher than the rest of the relevant developments in the study.
We used the UCI database of cardiology. It contains four datasets that have been previously used by ML researchers. The ''target'' attribute indicates the appearance or nonexistence of heart disease in the patient. This dataset contains 76 features. These features are smoking, body mass, physical activity, a healthy diet, cholesterol levels, blood pressure, fasting blood glucose, etc. These attributes are the same seven ideal measures that the American Heart Association has set to promote cardiovascular health and disease reduction. The four databases contain redundant and sometimes missing data.

Yimin Jiang [20] This paper is based on an improved three-dimensional U-net convolutional neural network deep learning algorithm for heart coronary artery segmentation for disease risk prediction, and it is practical with multiple data sets under two backgrounds without centerline and with the centerline. By using a new local feature to extract the ventricular information, and using the deep belief network to extract the features to regress the contour coordinates of the biventricular. Combining features and deep belief networks and training regression networks can not only extract high-level information but also accurately divide the left and right ventricles at a small computational cost. The performance of segmentation based on the dice coefficient compared between the two datasets. The results show that the model training effect of the centerline preprocessing is superior to the original data. The experimental results show that the best effect reaches the dice coefficient of 0.8291. In the experiment, it found that simple data expansion may be detrimental to the test data. From the training curve, it is believed that with the improvement of the quality of training data, the performance of coronary artery segmentation can be further improved, and it is of great significance to provide doctors and patients with more accurate and efficient opinions and suggestions in clinical practice to improve the quality of diagnosis and treatment. The purpose of assisting experts in real-time diagnosis and analysis achieved.

Salah Ud Din [21] Heart disease is one of the complex diseases and globally many people suffered from this disease. On time and efficient identification of heart disease plays a key role in healthcare, particularly in the field of cardiology. In this article, we proposed an efficient and accurate system to diagnosis heart disease and the system is based on machine learning techniques. The system is developed based on classification algorithms includes Support vector machine, Logistic regression, Artificial neural network, K-nearest neighbor, Naïve bays, and Decision tree while standard features selection algorithms have been used such as Relief, Minimal redundancy maximal relevance, Least absolute shrinkage selection operator and Local learning for removing irrelevant and redundant features. We also proposed novel fast conditional mutual information feature selection algorithm to solve feature selection problem. The features selection algorithms are used for features selection to increase the classification accuracy and reduce the execution time of classification system. Furthermore, the leave one subject out cross-validation method has been used for learning the best practices of model assessment and for hyperparameter tuning. The performance measuring metrics are used for assessment of the performances of the classifiers. The performances of the classifiers have been checked on the selected features as selected by features selection algorithms. The experimental results show that the proposed feature selection algorithm (FCMIM) is feasible with classifier support vector machine for designing a high-level intelligent system to identify heart disease. The suggested diagnosis system (FCMIM-SVM) achieved good accuracy as compared to previously proposed methods. Additionally, the proposed system can easily be implemented in healthcare for the identification of heart disease.

Biao Cheng [22] The diagnosis of heart disease has become a difficult medical task in the present medical research. This diagnosis depends on the detailed and precise analysis of the patient's clinical test data on an individual's health history. The enormous developments in the field of deep learning seek to create intelligent automated systems that help doctors both to predict and to determine the disease with the internet of things (IoT) assistance. Therefore, the Enhanced Deep learning assisted Convolutional Neural Network (EDCNN) has been proposed to assist and improve patient prognostics of heart disease. The EDCNN model is focused on a deeper architecture which covers multi-layer perceptron's model with regularization learning approaches. Furthermore, the system performance is validated with full features and minimized features. Hence, the reduction in the features affects the efficiency of classifiers in terms of processing time, and accuracy has been mathematically analyzed with test results. The EDCNN system has been implemented on the Internet of Medical Things Platform (IoMT) for decision support systems which helps doctors to effectively diagnose heart patient's information in cloud platforms anywhere in the world. The test results show compared to conventional approaches such as Artificial Neural Network (ANN), Deep Neural Network (DNN), Ensemble Deep Learning-based smart healthcare system (EDL-SHS), Recurrent neural network (RNN), Neural network ensemble method (NNE), based on the analysis the designed diagnostic system can efficiently determine the risk level of heart disease effectively. Test results show that a flexible design and subsequent tuning of EDCNN hyperparameters can achieve a precision of up to 99.1

Yenming J. Chen [23] Electrocardiography (ECG) is generally deemed the golden standard for diagnosing cardiovascular diseases and photoplethysmography (PPG) is unobtrusive, low-cost, and convenient for continuous monitoring. However, PPG contains insufficient information to diagnose diseases. In this study, we propose a novel method to accurately convert PPG to ECG. The banded kernel ensemble method converts a low-quality source (PPG) to a high-quality destination (ECG). Unlike neural network solutions, our algorithm requires no computation burden in the conversion task after a trained model is obtained. The proposed algorithm is then tested on a publicly available MIMIC III database. Our prediction shows excellent accuracy in the validation dataset. It offers the testing performance of under 0.314 and above 0.55 in rrmse (relative root mean squared error) and KGE (Kling–Gupta efficiency), respectively, under the scenarios of three prevalent heart diseases. The reconstructed ECG can be further used to perform heart disease detection and we obtained an average correctness rate of 81%. Our method can help a large population of high-risk, believed-healthy persons to walk into doctors' offices before the situation becomes irreversible. We concentrate on PPGs because the device is low-cost and ubiquitous. PPG has a wide range of applications, from human physiology to psychology, because of its low-cost, ubiquitous, and unobtrusive nature. For example, PPG has been applied to vital sign monitoring. In professional sports training, simple PPG devices are apt to record history and optimize performance in the field. In psychology, PPG can help humans outside laboratories understand stress responses and emotional communication. Despite the quality of the devices, recent advancement demonstrates a promising result in the accurate measurement of specific physiological parameters, e.g., estimating blood pressure from PPG based on specific haemodynamics.

Jiangong Li [24] Renal dysfunction, which is associated with bad clinical outcomes, is one of the most common complications of heart failure (HF). Timely prediction of renal dysfunction can help medical staffs intervene early to avoid catastrophic consequences. In this paper, we proposed a multi-task deep and wide neural network (MT-DWNN) for predicting fatal complications during hospitalization. The algorithm was tested on a dataset collected from Chinese PLA General Hospital, which contains 35,101 hospitalizations with HF diagnosis during the last 18 years, and 2,478 hospitalizations with a diagnosis of renal dysfunction. For the renal dysfunction task, the AUC of the proposed method is 0.9393, which is a significant improvement ($p < 0.01$) compared to that of conventional methods, while that of single task deep neural networks is 0.9370, that of random forest is 0.9360, and that of logistic regression is 0.9233. The experimental results show that the proposed MT-DWNN model achieves better prediction performance on renal dysfunction in HF patients than conventional models. the immediate symptom of heart failure is insufficient blood ejection from the heart. Insufficient blood supply can cause diseases in other organs, such as kidney. Many previous researches have reached the same conclusion that renal dysfunction has a great adverse impact the prognosis of patients with HF. Bibbins-Domingo et al. showed that renal insufficiency was a major predictor of mortality among women with HF. Forman et al. found that worsening renal function occurs frequently among hospitalized HF patients and is associated with significantly worse outcomes

Title of the Paper	Algorithm	Datatsets	Number of Samples	Metrics	Value in %
Predictive and Classification of cardiac arrhythmia	Naïve Byaes, SVM, Random Forest	Arrhythmia Dataset	5089	Accuracy	77.4
Classification of Arrhythmia Using Machine Learning Techniques	OneR , Naïve Bayes	Arrhythmia Dataset	8899	Accuracy	76.3
Prediction of Cardiac Arrhythmia	Random Forest, Decesion Tree	Arrhythmia Dataset	17000	Accuracy	70.03
Classification for Diagnosis of Heart Diseases	Logistic Regression	Heart Dataset	5600	Accuracy	56.04

Effective Heart Disease Prediction Using Hybrid Machine Learning Techniques	SVM	Heart Dataset	14000	Accuracy	78.04
A Healthcare Monitoring System for the Diagnosis of Heart Disease in the IoMT Cloud Environment Using MSSO-ANFIS	KNN, Naïve Byes	Heart Dataset	56000	Accuracy	73.56
A Stacking-Based Model for Non-Invasive Detection of Coronary Heart Disease	Levy flight algorithm	Heart Dataset	23000	Accuracy Precesion	85.56 82.10
An Optimally Configured and Improved Deep Belief Network (OCI-DBN) Approach for Heart Disease Prediction Based on Ruzzo–Tompa and Stacked Genetic Algorithm	SVM Naïve Bayes	Heart Dataset	56000	F1-score	2800
An Efficient Association Rule Mining From Distributed Medical Databases for Predicting Heart Diseases	KNN, SVM	Heart Dataset	14000	Accuracy	78.56
An Efficient IoT-Based Patient Monitoring and Heart Disease Prediction System Using Deep Learning Modified Neural Network	Naïve Bayes, Logistic Regression	Heart Dataset	23000	Accuracy	89.39
An Efficient Prediction Method for Coronary Heart Disease Risk Based on Two Deep Neural Networks Trained on Well Ordered Training Datasets	KNN, SVM	Heart dataset	12000	Recall	85.26
An Integrated Machine Learning Framework for Effective Prediction of Cardiovascular Diseases	Naïve Bayes, SVM	Heart dataset	23000	F1 - Score	73.48
An Intelligent Learning System Based on Random Search Algorithm and Optimized Random Forest Model for Improved Heart Disease Detection	Decision tree, Random Forest	Heart Dataset	24000	Accuracy, Precision	56.00 87.00
An IoT Framework for Heart Disease	Deep neural Networks	ECG Signals	42000	Accuracy	68.00

Prediction Based on MDCNN Classifier					
Early-Stage Risk Prediction of Non-Communicable Disease Using Machine Learning in Health CPS	Convolution neural network	ECG Signals	35200	Precision, Recall	85.00 75.00
Efficient Prediction of Cardiovascular Disease Using Machine Learning Algorithms With Relief and LASSO Feature Selection Techniques	Naïve Bayes, SVM	ECG Signals	26350	Accuracy, F1-score	65.23 78.21
HDPM: An Effective Heart Disease Prediction Model for a Clinical Decision Support System	KNN, Decision Tree	Heart Dataset	32500	Accuracy, Recall	92.83 87.00
Enhanced Random Forest With An Improved Linear Model for Heart Disease Detection on the Internet of Medical Things Platform	SVM, Convolution Neural Network	Heart Dataset	6600	Accuracy, F1-score	73.00 86.25
HDPF: Heart Disease Prediction Framework Based on Hybrid Classifiers and Genetic Algorithm	Logistic Regression, SVM	Heart Dataset	7560	F1-Score, Recall	85.78 83.21
Heart Coronary Artery Segmentation and Disease Risk Warning Based on a Deep Learning Algorithm	KNN, Logistic Regression	Heart Dataset	25333	Accuracy, F1-Score	96.85 85.45
Heart Disease Identification Method Using Machine Learning Classification in E-Healthcare	KNN, Decision Tree	Heart Dataset	23547	Accuracy, Recall	97.56 85.23
Enhanced Deep learning assisted Convolutional Neural Network for Heart Disease Prediction on the internet of medical things platform	Logistic Regression, SVM	Heart Dataset	32896	Accuracy, Recall, F1-score	78.00 93.00 85.25
Quickly Convert Photoplethysmography to Electrocardiogram Signals by a Banded Kernel Ensemble Learning Method for Heart Diseases Detection	Decision Tree, Logistic Regression	Heart Dataset	56892	Accuracy, Precision	86.23 75.00
A Multi-Task Neural Network Architecture for Renal Dysfunction Prediction in Heart	Random Forest, Logistic Regression	Heart Dataset	7400	Accuracy	95.00

Failure Patients With Electronic Health Records					

Table 1: Comparitive Study

5. CONCLUSION

The experiments give good results for predicting the arrhythmia disease. These algorithms use the ECG signals which is recorded and then used to remove the unwanted data along with the existing data. The Arrhythmia has its thirteen types of diseases by using the algorithms based on the literature survey the disease has been predicted with one of its diseases.

Future Work

As based on the comparative study we get to know that for all the papers they have used only two algorithms and accuracy recall precision f1-score has been calculated so for the future work we are implementing five algorithms by calculating the performance metrics.

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