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Detection of Arrhythmia Using Machine Learning

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ABSTRACT: This study proposes an artificial intelligence of things (AIoT) system for electrocardiogram (ECG) analysis and detection of Arrhythmia (Cardiac distress). The system includes a front-end IoT-based hardware, a user interface on smart device's application (APP), a cloud database, and an AI platform for cardiac disease detection. The front-end IoT-based hardware, a wearable ECG patch that includes an analog front-end circuit and a Bluetooth module, can detect ECG signals. The APP on smart devices can not only display users' real-time ECG signals but also label unusual signals instantly and reach real-time disease detection. These ECG signals will be uploaded to the cloud database. The cloud database is used to store each user's ECG signals, which forms a big-data database for AI algorithm to detect cardiac disease. The algorithm proposed by this study is based on convolutional neural network and the average accuracy is 94.96%. The ECG dataset applied in this study is collected from patients in Tainan Hospital, Ministry of Health and Welfare. Moreover, signal verification was also performed by a cardiologist.

KEYWORDS: Artificial Intelligence; Arrythmia; electrocardiogram; ECG signals

I. INTRODUCTION

A "Cardiac Arrhythmia" is any abnormal heart rate or rhythm. In normal adults, the heart beats regularly at a rate of 60 to 100 times per minute. And the pulse (felt at the wrist, neck or elsewhere) matches the contractions of the heart's two powerful lower chambers, called the ventricles. The heart's two upper chambers, called the atria, also contract to help fill the ventricles.

This convincingly shows that a medical chatbot can diagnose patients accurately utilizing basic symptom screening and a conversational approach based on regular language preparation. According to WHO estimates, arrhythmias are responsible for around 15% of all cardiac-related fatalities globally. Cardiovascular diseases, on the other hand, account for more than 80% of all sudden deaths. Arrhythmia is the major cause of death in patients with cardiovascular disease.

According to a study published in The Lancet, heart disease mortality among rural Indians has surpassed that of urban Indians in India. According to the study, which will be published in the August edition, obesity, unlike in the West, may not be a major cause of such deaths in India. Coronary heart disease caused 0.9 million deaths (68.4%) and stroke caused 0.4 million deaths (28.0%).

Data analytics (AI) is the process of analysing raw data in order to derive conclusions from it. Different approaches are employed in this procedure, such as grouping the data, collecting the data, organising the data, and cleaning it before the analysis. The data is first grouped and then collected, which is accomplished through the use of various sources. The data is then saved as a result of this procedure.

Machine Learning is an artificial intelligence (AI) application that allows computers to automatically learn and improve from experience without having to be explicitly designed. Machine learning is concerned with the creation of computer programmes that can access data and learn on their own.

The convolutional neural network aids in the project helps us analyze the graphical 2D data and process them by running through a filter and get the refined structured data for the model to analyze and alert the user. ECG offers the information required to diagnose issues, making it crucial in the development of improved diagnostic systems. An ECG signal can detect an abnormal heartbeat, or arrhythmia, which can be used to predict whether a person will have cardiovascular problems in the future.

Frameworks for experimentation that employ machine learning approaches to forecast an illness and provide cures for the defined disease have been developed in the past. This research relies heavily on Neural Networks and SVM.

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II. RELATED WORK

To develop a method to robustly classify an ECG trace into one of 13 broad arrhythmia classes. The main objective of this project is to design an efficient and accurate algorithm that would detect the early Signs of Cardiac distress or irregularities in ECG pattern alerting the user about the same For the Analysis to work efficiently, we need to first have a base line graph against which we analyse the ECG pattern of the user and train the model to detect irregularities..

The data was collected from the MIT-BIH database which had a collection of arrhythmia-based samples. There are 3 components in the file namely .dat, ars and. xsws which are different formats in which the ECG data is available. These files can be read as an array and plotted with time to get ECG signals. ECG signals have power line interferences at 50Hz, to remove that a notch filter of 50Hz cut-off frequency is used. The bandstop filter has a small bandwidth through which the signal will be attenuated. The ECG signals were filtered using a Butterworth high pass filter to remove noise. The files were plotted in the time domain and the visual differences were noted. The signals are normalized within the range of -1 and 1. The filtered signals are split into four seconds. The R-R peaks are detected by calculating the moving average of the signal and then maxima at each interval specified in the sampling rate are determined. The features that are required for detecting arrhythmia are peak to peak intervals and beats per minute.

The Project 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 mat lab feature selection package named mRMR This technique selects the features which have both maximum correlation with the output labels and minimum correlation among themselves.

III. MODULES

Data Extraction: From the ECG, a mathematical and organised dataset was extracted. Heart rate, R-R interval, number of deflections, sex, age, height, and other factors are all taken into account. This project's dataset comes from the UCI Machine Learning Repository. The data is then saved as a csv file.

Preprocessing: The dataset are not ready to get processed in classification process because there are missing values and inconsistent data. Several values are removed because it contained the same value in each patient. Invariant attributes are checked with variance or standard deviation value. The rest missing values are replaced by average values. Feature Selection: Two approaches to feature selection are Principal Component Analysis (PCA) and Random Forest. There are a lot of features in the preprocessed data, and the categorization method we picked is a time-consuming process. Feature selection is essential to save time and extract the most important features that are most closely related to the output class. The selected attributes are then used as input for the five classifications that follow. Each algorithm's accuracy is assessed and displayed. System modelling is the process of creating abstract models of a system, each of which gives a different view or perspective on that system. The phrase "system modelling" has come to mean "modelling the system with some form of graphical notation," which is almost always based on the Unified Modelling Language's notations (UML). You can create models for both the present system and the new system: Formal (mathematical) models of a system, on the other hand, can be created, usually in the form of a detailed system specification. Models are used to help define a system's needs during the requirements engineering process, to describe the system to engineers who will be implementing it during the design phase, and to document the system's structure and operation once it has been implemented.

Principal component analysis is a method of identifying the aspects that have the most impact on the final decision and supply the most data. The PCA approach is simple and effective. In contrast to simplicity and economy, data compression is accomplished by describing subspaces in lower-dimensional space. In addition to dimensionality reduction, it's employed in image processing for statistical density estimation. Principal Component Analysis (PCA) can be applied to nearly any dataset or scenario, such as reducing the number of iris-related characteristics extracted.

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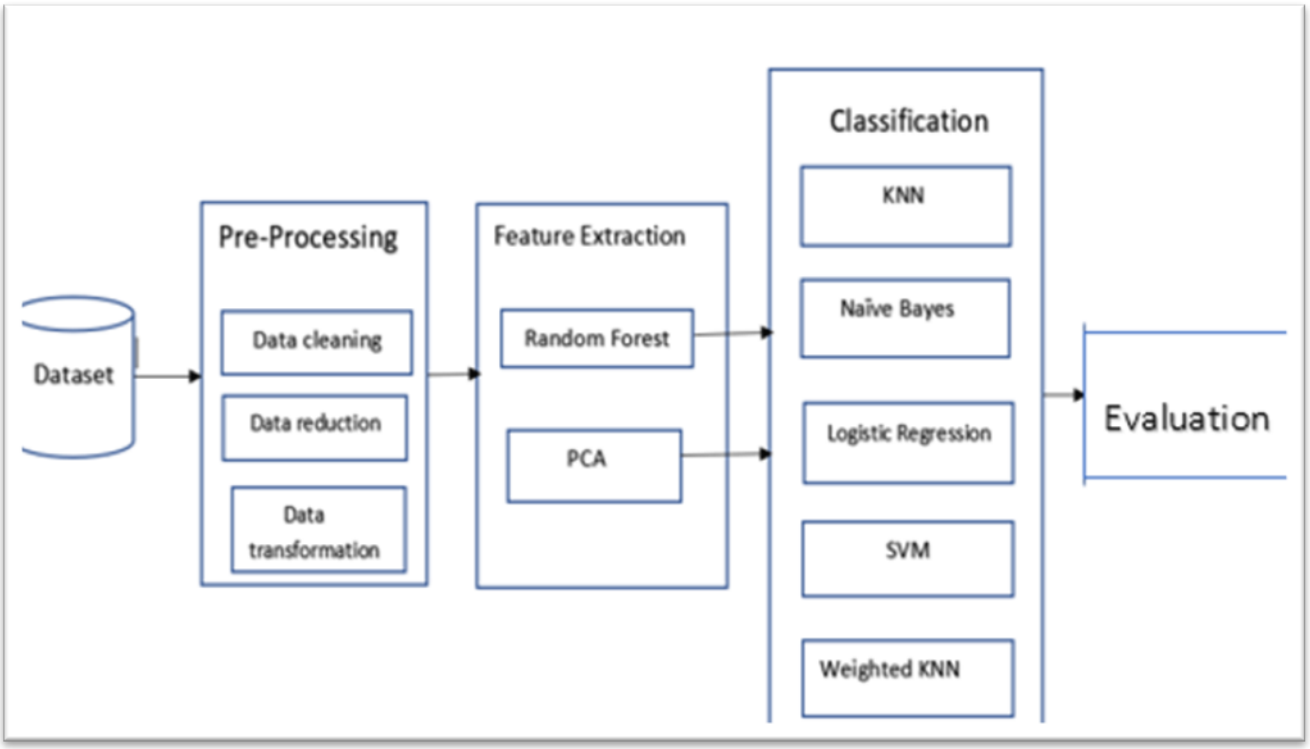
IV. DESIGN AND METHODOLOGY

A formal description and representation of a system arranged in a way that facilitates reasoning about the system's structures and behaviours is known as an architecture description. A system architecture can be made up of system components as well as designed sub-systems that will work together to achieve the overall system. There have been attempts to codify languages for describing system architecture, which are referred to that as architecture description languages collectively (ADLs).

The underlying organisation of a system, as embodied in its components, their interactions with one another and with the environment, and the design and evolution principles. A system model that encompasses a mapping of functionality to hardware and software components, a mapping of software architecture to hardware architecture, and human interaction with these components. An assigned arrangement of physical pieces that gives a design solution for a consumer product or life-cycle process that exceeds the functional architecture's and requirements baseline's needs.

The most important, omnipresent, top-level strategic inventions, decisions, and linked rationales about the overall structure (i.e., fundamental elements and their linkages) and associated features and conduct are referred to as architecture.



A description of a computer software's design and contents. It may include information like a complete inventory of current hardware, software, and networking capabilities; a description of long-term strategies and priorities for future purchases; and a plan for updating and/or replacing aged equipment and software, if it is recorded. The required to build abstract models of a system, each of which presents a different view or perspective of that system, is known as system modelling. The term "system modelling" has come to denote "representing the system using some type of graphical notation," which is nearly invariably based on notations from the Unified Modelling Language (UML). However, formal (mathematical) models of a system can be established, usually as a detailed system specification. Models are used in the requirements engineering process to assist define a system's needs, throughout the design process to describe the system to engineers who will be implementing it, and after implementation to document the system's structure and operation. You can create models for both the previous system and the new system.

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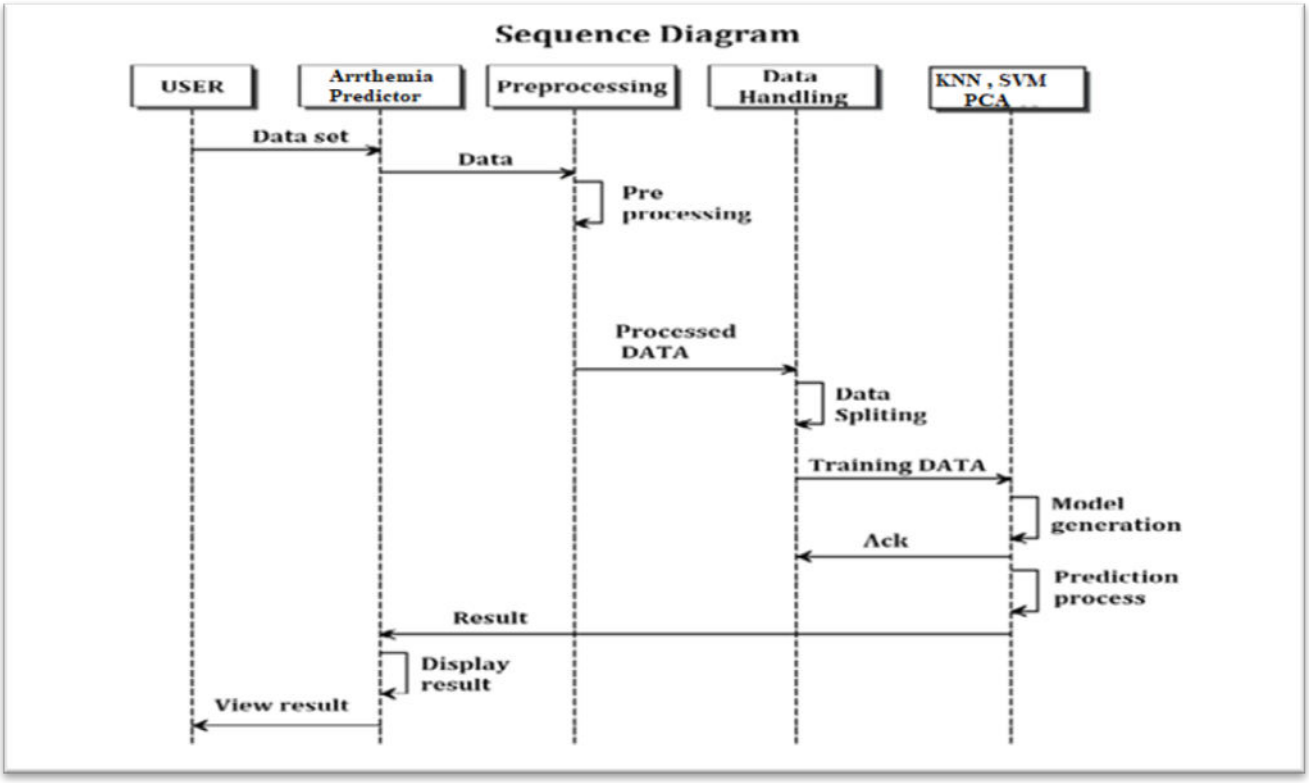

During requirements engineering, existing system models are employed. They can be used to clarify what the existing system delivers and to discuss its merits and drawbacks. As a result, requirements for the new system emerge.

During requirements engineering, models of the new system are used to help explain the proposed requirements to other system stakeholders. Engineers use these models to talk about design ideas and documenting the system for later usage.

It is possible to generate a whole or partial system implementation from a system model via a model-driven engineering approach. The most significant feature of a system model is that it can not include all of the details. A model is a simplified version of the system being researched rather than a different representation of it. A representation of a system should, in essence, keep all of the information about the entity it represents. An abstraction simplifies and highlights the most crucial elements.

V. EXPERIMENTS AND RESULTS

Software testing is an activity that checks if the actual results match the expected results and ensures that the software system is free of vulnerabilities. It entails running an application or system component in order to evaluate one or more properties of interest.

The library, which has been loaded from Python, was used to create a model with nave bayes. The model will be trained and tested when it has been produced. Seventy-five percent of the dataset was used for training, and twenty-five percent for testing. When the model was applied to new data from the test set, it accurately predicted the disease. To attain the best accuracy, the decision tree method is compared to the nave bayes algorithm.

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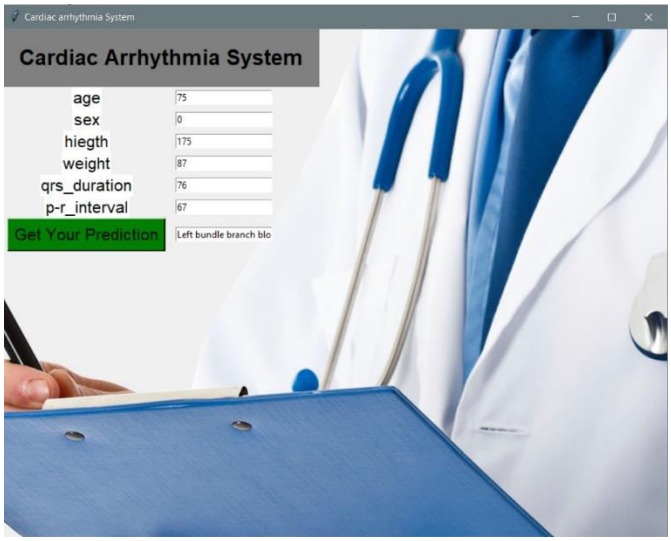
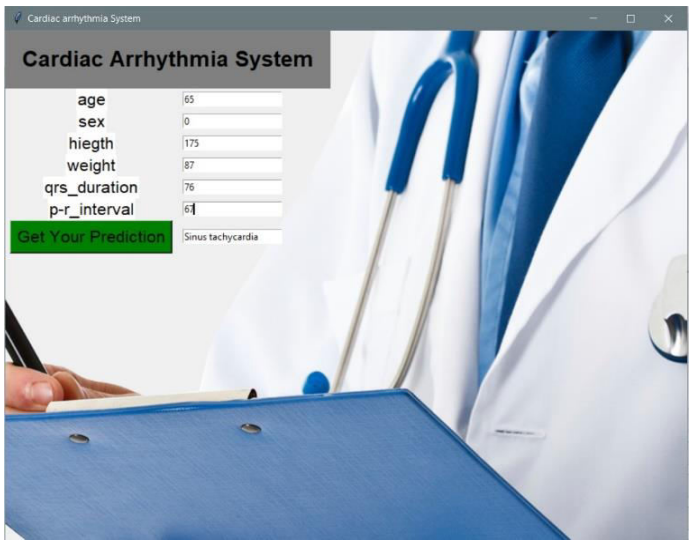
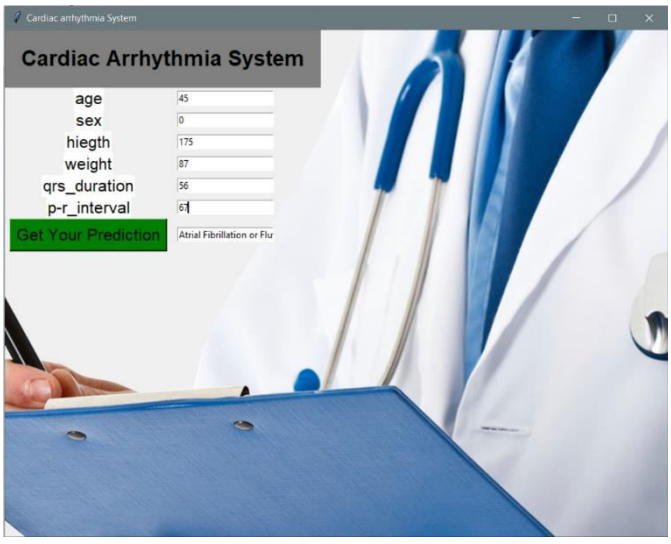




The first testing was performed in the first module, Data Preprocessing, to confirm that the dataset was free of missing or unknown values. Data cleansing is successfully conducted through using original CSV file as input.

To lower the dimensionality of the dataset, the second and third testing is performed in the second module, Feature Extraction.

To get the reduced feature dataset, we take the preprocessed csv file and apply PCA and random forest sequentially.



To forecast and characterize the class of cardiac arrhythmia, the last four tests are done for each classifier, namely KNN, weighted KNN, logistic regression, SVM, and naive-bayes.
The proper diagnosis was predicted based on the user's symptoms, making it dependable and valuable for health tracking. In today's fast-paced world, consumers demand a system that would be dependable. If the proper findings are presented, people will trust this new procedure.

VI. Conclusion and Future Work

The findings strongly suggest that machine learning can help with cardiac arrhythmia diagnosis. It aids in the early detection and identification of cardiac arrhythmias.

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a) Atrial Fibrillation Prediction: Congestive heart failure (CHF) is a chronic, progressive disorder that weakens your heart's pumping power.
b) Congestive Heart Failure Prediction: Atrial fibrillation arises when the heart chambers do not work together properly due to incorrect electrical signals.

As a result of big data breakthroughs in the biomedical and healthcare communities, accurate medical data analysis supports early illness identification, clinical services, and community services. The precision of a study degrades when medical data is of poor quality. A new region has been brought into play. The idea can be implemented in hospitals and evaluated and verified on a regular basis with new patient datasets. By adding the functionality that the doctor may demand in the near future, the project may have become more user friendly.

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