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APPLICATION OF KNN METHOD FOR CLASSIFICATION OF ARRHYTHMIA TYPES BASED ON ECG DATA

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ABSTRACT

World Health Organization (WHO) data from June 2024 shows that 31% of adults worldwide or 1.8 billion people do not do physical activity. With that, adults are at higher risk of developing cardiovascular disease and causing an economic and social burden on people with heart disease. K-Nearest Neighbor (KNN) is a machine learning method that can be used to classify or predict heart disease conditions. KNN works by finding the closest data point in the training dataset and then using the class labels of those neighbors to classify new data points. In the context of heart disease, this can be used to predict the likelihood of someone having heart disease. Recording the electrical activity of the heart using a 3-led ECG to determine heart health as well as being material for classification. Exploring the use in the diagnosis of heart disease by focusing on screening and classification of heart disease. By utilizing the KNN method, it has the potential to produce a model that can assist in clinical decision making. Improving the prevention of heart disease and accelerating diagnosis through more sophisticated and technology-based analysis of patient health data.

Keywords: Arrhythmia, KNN, ECG, Classification

INTRODUCTION

Based on data from the World Health Organization (WHO), the number one cause of death in the world is heart disease at 31% or 17.9 million people. This disease is a challenge in every country because this disease increases every year. This disease is not only suffered by the elderly but also productive age. This disease can occur suddenly and unexpectedly [1]. Therefore, early detection is needed especially in knowing heart health or problems that occur in the heart so that prevention or monitoring can be carried out earlier. Based on statistics from the Ministry of Health of the Republic of Indonesia, the number one cause of death in Indonesia is heart disease which reaches 650,000 people per year. There are several factors that cause heart disease, including heredity, age, obesity, lack of activity, alcohol and so on [2]. There are several types of heart disease that can be grouped, namely coronary heart disease, congenital heart disease, arrhythmia and endocarditis [3].

Electrocardiogram (ECG) is a medical test used to record the electrical activity of the heart [4]. It is commonly used to identify various heart diseases such as arrhythmia, cardiomyopathy, coronary heart disease, cardiovascular heart disease and other diseases [5]. The examination process is always carried out by doctors and clinically is a procedure that requires significant time and human resources (medical) to process large amounts of data [6]. On the other hand, due to the diversity of signals, many problems can arise, making the ECG examination process more challenging. For example, data from two healthy people do not provide completely similar results. In addition, two patients suffering from the same heart disease can show different signs in their data [7]. One of the most common problems is the presence of interference or noise in the recorded electrical signal caused by patient movement and electrodes that are not attached properly or shifted [8].

Making an android-based heart disease classification application using artificial neural networks on medical data. Explaining the creation of a heart disease classification method to predict the type of disease experienced by patients. Using PTB diagnostic database data from physionet, the data acts as input for the Artificial Neutral Network (ANN) model to predict heart disease suffered by patients. The benefit is to provide a classification system to researchers to develop an automatic diagnosis system so that it can be implemented in the world of health, especially in Indonesia. The creation of an android application aims to make it easier for users to access and diagnose heart disease using mobile devices. In addition, it provides solutions to health workers in Indonesia in carrying out fast and responsive

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diagnostic responses so that they can help patients with heart disease [9].

Innovation in engineering and technology to meet the needs of medical personnel in handling heart disease continues to grow. One of them is the development of an intelligent computing system that can help medical personnel to diagnose a person's disease. In this study, a prototype design of a web-based application is proposed which is intended to identify early heart disease. The inference engine is built using the Case Base Reasoning (CBR) method. The application that is built is assisted by data security features using QR Code. The application that is built is intended to be able to help health facilities that do not yet have experts (heart specialists) to be able to provide early detection services to a person [10].

Classification of ECG signals with Support Vector machine method to detect arrhythmia. This method has been tested on data recorded from ten healthy volunteers aged around 25 ± 3 years and functioning normally. Classification of heart disease using the ANN method is a method that imitates the way biological neural networks work. By carrying out the learning process, artificial neural networks can organize themselves to produce a consistent response to a series of inputs [11]. The method of identifying heart disease using Machine Learning classification in E-Healthcare. This technique uses patient data and uses machine learning methods to categorize individuals as people who have or do not have heart disease [12]. The application of data mining for the classification of coronary heart disease uses the Naive Bayes (NB) method. The NB classifier is easy to implement and is computationally fast and performs well on large data sets that have high dimensions [13]. Classification of Heart Disease Using Comparison of Decision Tree and NB Methods. Decision Tree is a series of sequence-based processes starting from the root that involves evaluating features and branching between two choices. While NB is a probabilistic classification method derived from Bayes' theorem. This method predicts future probability based on past experience, so it is often referred to as Thomas Bayes [14]. Classification of arrhythmias in ECG signals using Deep Neural Network. Shows that the method used gets a very good accuracy value of 99.62% and sensitivity of about 97.18% [15].

Development of SVM method to improve the accuracy of heart disease diagnosis classification. The results show an increase in accuracy from 87.65% to 96.56%. In addition, the features used in the system are reduced from 14 to 8 features which means the computational load is reduced from 100% to around 32% [16]. Electrocardiogram signal classification in heart disease diagnosis based on RBF artificial neural network. The classifier trains the electrical signal features and the final classification accuracy can reach 98.9%. Experiments show that this method can effectively detect signal abnormalities and apply it to heart disease diagnosis [17]. Classification of heart disease based on imbalanced signals using ensemble machine learning techniques. All proposed methods for HD detection use two imbalanced recordings because the subjects show consistent performance following the imbalanced number of inputs during both training and testing phases [18]. Improving heart disease diagnosis through ECG image vectorization-based classification. The results show that the use of image vectorization techniques improves the performance of machine learning methods compared to the use of conventional feature extraction methods such as CNN and VGG16 [19].

Classification of the risk level of heart disease attacks using the KNN method. Early detection is needed to prevent the occurrence and worst heart disease that can be experienced by someone. The method that can be implemented into data to detect the risk level of heart disease attacks is KNN. Classifying based on training data by looking at the closest distance with the Eucledian Distance formula to class objects as many as K values. Based on the analysis and testing data in this study, it is known that the results of the influence of the amount of training data on accuracy starting from the amount of training data as much as 21 to 210, the value of K = 5 and the test data as much as 60 obtained the highest accuracy of 88.333% produced when the training data used was 126. And the results of the analysis on the influence of the K value on accuracy starting from the K value of 3 to 91, the training data as much as 126 and the test data as much as 60 obtained the highest accuracy of 96.667 which was produced when K was 57 and 59 [20].

Classification of heart failure disease using the KNN method. The conclusion obtained in the application of this method to heart failure disease data is carried out by testing the accuracy carried out using the rapidminer application. The dataset used was 918 data and 12 attributes. Then the results of the implementation of the KNN method in the rapidminer application were carried out using the replacement of the k value, and the highest accuracy results were obtained at a value of k = 9 with an accuracy of 70.65%, the precession value was 75%, while the recall produced 70.73% [2 1]. The KNN method is one of the classification methods that utilizes data patterns in the dataset to classify categories or classes of an unknown sample. The results of the training data classification showed an accuracy of 85.49%, with a precision of 84.43%, a recall of 87.04%, and an f1-score of 85.71%. Through trials using KNN, results were obtained with an accuracy of 91% and a precision value of 90%, a recall of 93%, and an f1-score of 92%. The conclusion of this study is that the KNN method has good results for classifying cardiovascular diseases, namely an accuracy of 91% [22].

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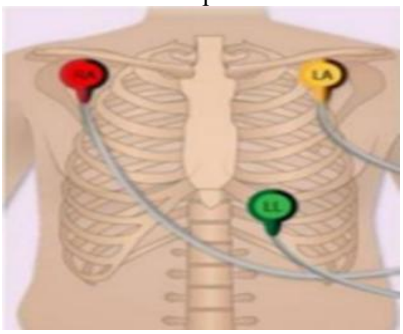
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Previous studies have focused on the specification of the types of heart disease classified and the scope of the proposed study. Focusing on heart failure clearly states that the study will focus only on heart failure disease. Heart failure is a medical condition in which the heart is unable to pump blood efficiently which can be caused by many factors such as heart muscle damage, hypertension, or coronary artery disease. The aim is to analyze and classify individuals based on medical data to detect whether they are suffering from heart failure or not. This method will classify patients into categories such as indicated heart failure or not heart failure. This method classifies heart failure as a type of heart disease, excluding other types of heart disease such as arrhythmia or coronary heart disease.

Focus on heart disease in general covers all types of heart disease. Heart disease covers a wide range of conditions, including heart failure, coronary artery disease, arrhythmia, heart valve disease, and others. The use of KNN for Heart Disease aims to use the KNN method to diagnose and classify various types of heart disease that a person may suffer from. This system will compare the patient's medical data (eg data, blood tests and medical history) with other heart disease case data to identify possible heart conditions. This step will classify a person based on various types of heart disease, not just heart failure. For example, coronary heart disease, arrhythmia, heart failure, or heart valve disease.

METHODOLOGY

The research was conducted at SMK Sandi Putra Telkom 2 and in collaboration with Padjadjaran University. The tool used to process the data is a 3-lead ECG which is a tool for recording the electrical activity of the heart. This method uses 3 electrodes (leads) to measure electrical signals from the heart which are used to analyze heart conditions and identify abnormalities or problems that occur in the heartbeat. The 3 electrodes used are red, yellow, and green. The red electrode is installed in the right shoulder area under the collarbone and functions as a negative electrode in measuring leads I and II. The yellow electrode is placed next to the left collarbone in the left shoulder area and functions as a positive electrode for lead I and negative for lead III. While the green electrode is installed at the base of the left rib just below the chest muscle and functions as a positive electrode for leads II and III, as shown in Fig 1.



(Fig. 1 Lead 3 ECG installation position)

The KNN method is a method used for data classification. In this study, this method is used to classify the recording results with the aim of identifying whether someone has heart disease based on the patterns found in the signal. The subject is someone who is the object of research or whose results will be analyzed. This subject can be a patient who has or is at risk of heart disease or an individual who is part of the dataset for research. This subject is usually a person who has a history of heart problems or someone who wants to check their heart condition. The object of research is heart disease which will be classified using 3 led data. Focusing on analyzing and classifying the types of heart disease that a person may suffer from based on data obtained from the recording. The objects can include various heart conditions such as heart failure, coronary heart disease, arrhythmia, and other heart conditions that are detected through electrical signals.

ECG is a medical device used to record the electrical activity of the heart in the form of a graph. The data generated from the recording can be used to diagnose various heart diseases. This step refers to the use of three electrodes to record the electrical signals of the heart. In this system, electrodes are attached to certain parts of the body (usually on the hands and feet) to record the P, QRS, and T waves that indicate electrical activity in the atria and ventricles of the heart. The data obtained from the recording will include information about the heart rhythm, time intervals, and wave patterns that can indicate abnormalities or heart disorders such as arrhythmias, myocardial infarction, or other heart conditions. This data collection can be obtained through an ECG medical device installed on a patient in a hospital or clinic. If this research is conducted experimentally, it is necessary to collect data from patients with a history of heart disease and patients without a history of heart disease. Public datasets can also use existing recording datasets such as

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Physionet's MIT-BIH Arrhythmia Database which contains recordings from patients with various heart disorders. Although this dataset is more complex, you can choose a subset of data that only involves 3 Leads. Consent to obtain patient data must ensure that the research is conducted in accordance with medical ethics guidelines including obtaining informed consent from the patient and maintaining data confidentiality (as regulated in HIPAA or GDPR regulations). The installation of 3 Lead electrodes on the patient's body is in accordance with medical standards for recording heart signals. These electrodes will record the electrical activity of the heart and produce signals in the form of waves. The recording results are usually in the form of time signals with amplitude values that indicate the strength and duration of the heart's electrical activity at each interval. Data retrieval can be taken in a certain time period ranging from 10 seconds to 60 seconds and then converted into a format that can be analyzed such as digital data in the form of a matrix or array. The data obtained often contains noise or interference such as body movement or electrical interference. Therefore, it is necessary to carry out a cleaning or filtering process to eliminate this noise, such as using a bandpass filter. Data normalization has variations in amplitude and wave duration. Data normalization is very important to avoid the dominance of certain features in the analysis using the KNN method. Normalization can be done by changing the range of signal values to a standard such as between 0 and 1. To classify recorded data using the KNN method, it is necessary to extract relevant features. Some commonly extracted features include: RR Interval duration the time between two consecutive R waves used to measure heart rate. PR interval is the duration between the P wave and the QRS wave indicating the time it takes for an electrical impulse to travel from the atria to the ventricles. P, QRS, and T Wave Amplitude measures the height of the waves which can provide clues to abnormalities. The speed at which electrical impulses are transmitted throughout the heart. Heart Rate Variability (HRV) measures the fluctuation of the RR interval as an indicator of heart health. Training and testing data after the features are extracted the dataset will be divided into two parts, namely the training data (training set) and the testing data (testing set). Usually this division is done with a ratio of 70:30 or 80:20. The training data is used to train the KNN method while the testing data is used to evaluate the accuracy of the model. Determine the optimal K value (number of nearest neighbors) for the KNN method. This can be achieved using the cross-validation method. Use the KNN method to classify data based on the extracted features. Each new data will be classified based on the majority of classes (e.g., with heart disease or without heart disease) from the K nearest neighbors. Performance measurement after the method is trained using metrics such as accuracy, precision, recall, F1-score, and confusion matrix. Perform cross-validation to check whether the resulting KNN method is general enough for unseen data. Analyze the classification results to find out whether the KNN method can accurately classify heart disease based on 3 Lead ECG data. Feature importance to identify which features are most influential in classification (for example, whether the duration of the RR interval or the amplitude of the T wave is more significant). In this scenario, data collection using 3 Lead ECG is done by recording the electrical activity signals of the heart from the patient and then pre-processing is carried out to prepare the data ready for analysis. Important features from the signal are extracted and used in the KNN method to classify heart disease. The KNN method is tested and evaluated to measure its accuracy and effectiveness in detecting heart abnormalities based on data limited to 3 leads.

K-Nearest Neighbor is one of the methods in machine learning that is used for classification and regression. This method is based on instance-based learning which means that KNN does not go through an explicit training stage (as in other methods such as Decision Tree or Neural Network). Instead, it uses existing training data to determine the class of new data to be predicted. Defining K KNN works by finding the "K" nearest neighbors of the data to be predicted. The value of K is a predetermined parameter and is usually chosen based on experiments or cross-validation. For example, if K = 3, then the method will find the 3 closest data points to the data to be predicted. To find the nearest neighbor, KNN calculates the distance between the data to be predicted and the training data. The distance commonly used is the Euclidean distance but other distances such as Manhattan or Minkowski can also be used depending on the needs and nature of the data. After the distance is calculated, KNN selects the K closest data points and classifies the new data based on the majority class of the nearest neighbors. If more than half of the nearest neighbors fall into a certain class, then the data to be predicted will be predicted to fall into that class. The results are usually based on majority voting, namely the class that appears most often among the K nearest neighbors. While for prediction regression, it can be the average of the values in the nearest neighbors. Euclidean between two points ($\chi1$, $\gamma1$) and ($\chi2$, $\gamma2$).

$$\text{Distance} = \sqrt{((\chi1-\chi2)\text{^}2+(\gamma1-\gamma2))^2} \quad (1)$$

Euclidean distance is a way to calculate the straight line distance between two points in a 2-dimensional plane. ($\chi1$, $\gamma1$) and ($\chi2$, $\gamma2$) are the coordinates of two points in the 2D plane. ($\chi1$-$\chi2$)^2 is the square of the difference between the x coordinates (in this case called χ). ($\gamma1$-$\gamma2$)² is the square of the difference between the y coordinates (γ). The sum

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of the two squares is then taken the square root to produce the actual distance between the two points. The KNN method will collect historical patient data with information such as age, blood pressure, cholesterol levels and history of heart disease. For new patients or patients whose health status is unknown, the KNN method will search for the k nearest neighbors in the existing patient data. Based on the nearest neighbors, KNN will provide a high-risk or "low-risk" classification based on the majority of classifications in the k neighbors. The collected data will be sent to Raspberry Pi via Bluetooth and ESP32 which functions as an intermediary. The data processing system uses Python with two main principles, namely filtration and extraction. Before using KNN, it is necessary to prepare data as training that has been labeled. This data contains features relevant to heart disease (eg, age, blood pressure, cholesterol levels, and other medical test results), as well as labels indicating whether the patient is at high risk or not at risk of heart disease. The test result data is sent to the cloud system via a WiFi connection where the data can be accessed by users as in Fig 2.

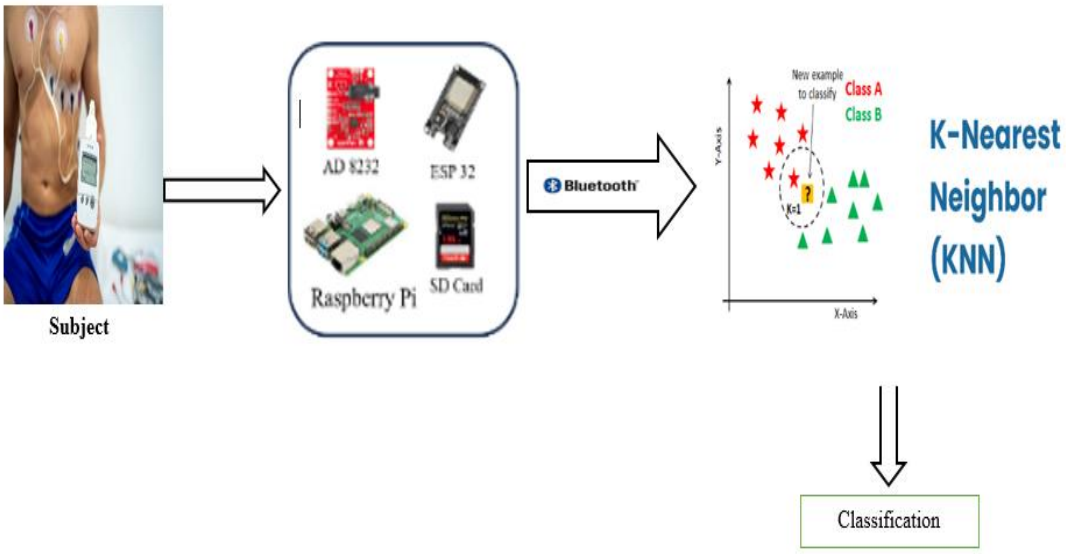


Fig. 1 Block diagram

RESULT

ECG or electrocardiogram is a diagnostic tool that is very much needed, especially in detecting various heart diseases. This tool will measure the electrical speed of the heart, thus helping doctors determine heart health. The KNN method can be used to classify patients into certain risk categories based on the medical data they have. Collect patient data whose condition is known, whether they have heart disease or not. This data will be used as training data. When there is new data (for example, patient data whose condition is not yet known), KNN will look for k data that are closest or similar to that data. This proximity is measured using a distance metric, such as Euclidean distance. The patient will be classified into the category that appears most often from the k nearest neighbors.

The average data of the experimental results from the ECG signal will be displayed clearly according to the results carried out. In this study there were 30 subjects who participated in the thin, medium and fat experiments. Each experiment will provide different wave results according to the method used. In Fig 3 there are 5 data points or data colors, namely abnormal (blue), normal (yellow), potential for arrhythmia (purple), quite potential for arrhythmia (orange) and very potential for arrhythmia (green). Fig 3 (A) explains the Respiratory Rate (RR) graph and RR interval including the distance between two waves measured at the same time. The RR interval ranges from 250-4800ms. Fig 3 (B) explains the Pulse Rate (PR) PR interval graph and duration from the beginning.

In Fig 3 (A), the scatter diagram explains the experimental results between PR and RR 500 to 5000 according to the ECG data taken in recording the electrical activity of the heart. The blue dots explain the normal PR data of 100-1100 and RR 500-5000. The QS scatter diagram with values 50-400 and RR 500-5000. This explains that the PR interval is lower than the RR interval. In Fig 3 (A), the green dots indicate "very potential for arrhythmia" more spread out and many data points. This data explains that there is a very potential for arrhythmia with an RR value of 600-

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1600 and a PR value of 80-300. In Fig 3 (B) explains that the fairly potential for arrhythmia is in the orange dots. The magnitude of the QS value is 40-105 and the PR value is 300-900.

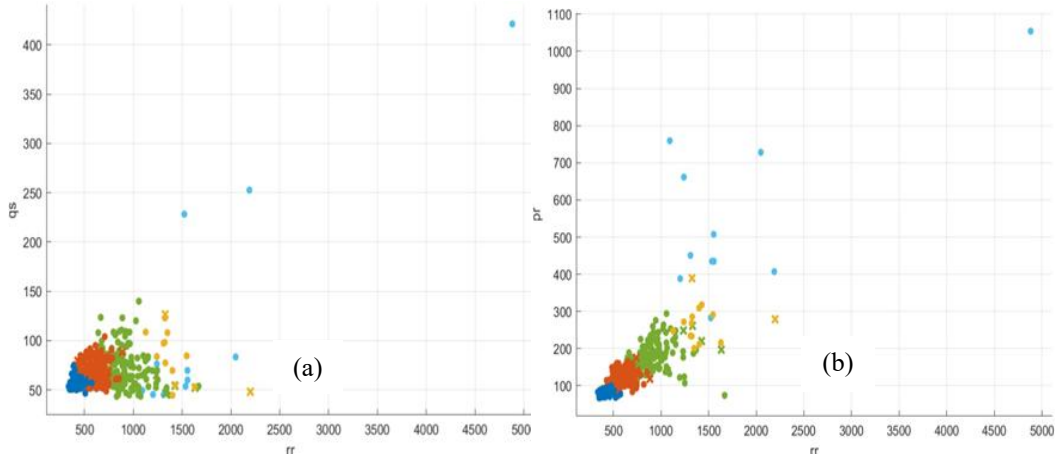
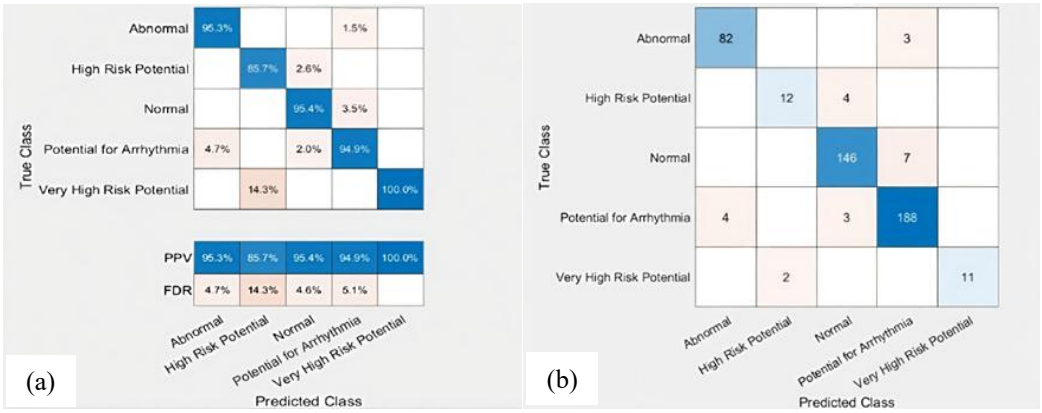


Fig. 2(a) RR-PR scatter (b) RR-QS scatter

The height of the ECG data wave explains the positive and good results that can be used in analyzing the rhythm that occurs in the heart such as arrhythmia and others. The KNN method is used to determine the possibility of someone having arrhythmia according to the experiments applied. In processing, attribute normalization, noise and other problems are needed. This step explains how the KNN method can run well and provide satisfactory results. After this step is carried out, KNN will carry out its special task in grouping data. Testing is carried out using various K parameter values. The performance of the method is measured using evaluation metrics such as accuracy, precision, recall, and F1 score. Evaluation is carried out using cross-validation techniques to avoid noise. This ensures that this method has the ability to conclude.

All lines in the image have their own characteristics and describe the RR value. Among thin, medium and fat, fat shows the most significant wave listed in the RR value with a wave exceeding 1000. Thus indicating that fat or obesity tends to have a higher heart rate because the heart has to work harder to pump blood throughout the body. Medium (more than thin) shows moderate variation with a lower RR value than running. While thin shows more stability with less variation in RR values.



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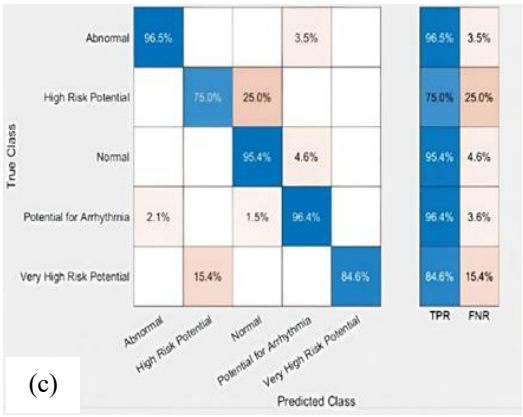
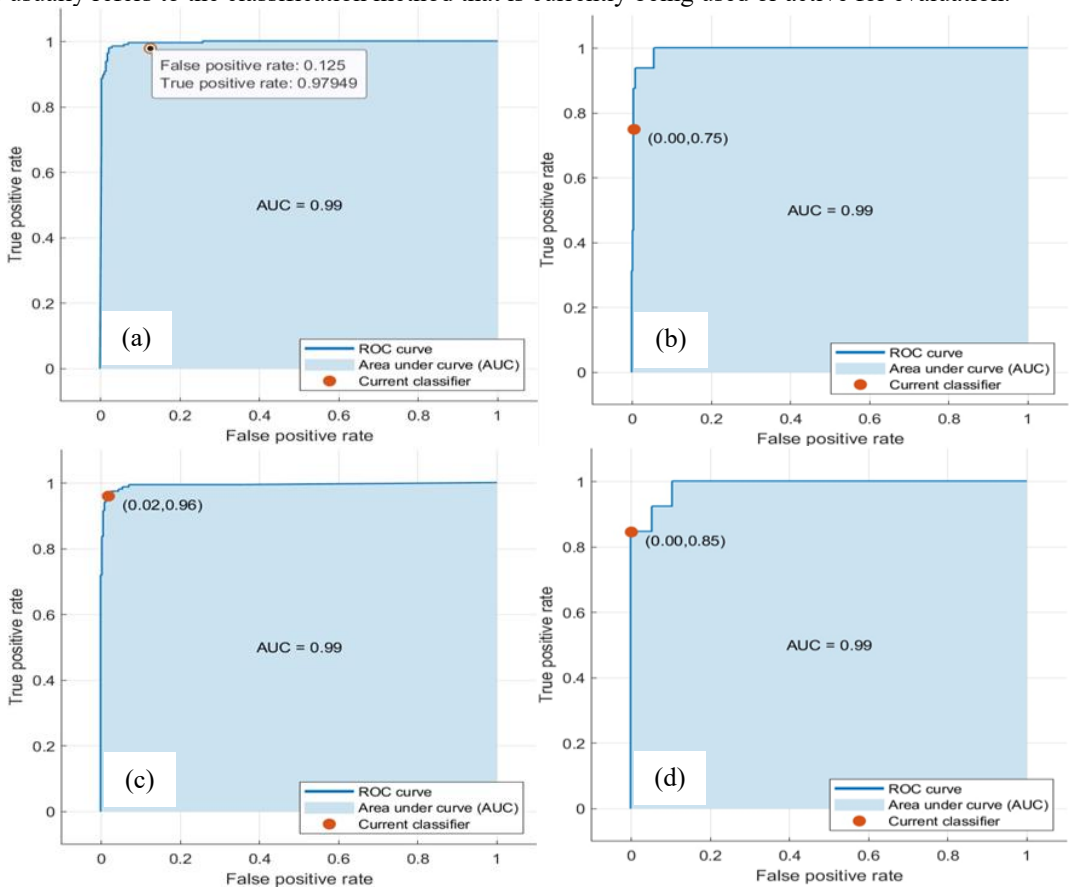


Fig. 3(a) Number of Observations (b) TPR & FNR (c) PPV & FDR

ROC Curve (Receiver Operating Characteristic Curve) is a graph used to evaluate the performance of a binary classification model. This graph shows the relationship between True Positive Rate (TPR) or Sensitivity = TP / (TP + FN) and False Positive Rate (FPR) = FP / (FP + TN) On the Y-axis: TPR and on the X-axis: FPR. The closer to the upper left corner of the graph, the better the model. ROC curve shows the trade-off between sensitivity and specificity. AUC (Area Under Curve) is a numeric value that shows the area under the ROC curve. The AUC value is between 0 and 1. AUC = 1.0: perfect classification, AUC = 0.5: random classification (random guess) and AUC < 0.5: the model is worse than random guess (biased towards the negative class). In the context of MATLAB applications, Current Classifier usually refers to the classification method that is currently being used or active for evaluation.



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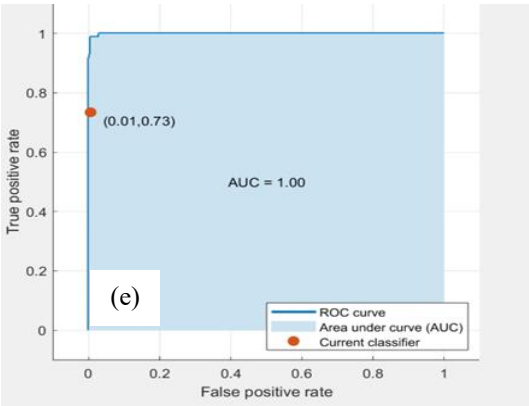


Fig. 4(a) Normal Average (b) Abnormal Average (c) Potentially Arrhythmic Average (d) Moderately Arrhythmic Average (e) Highly Arrhythmic Average

CONCLUSION

This study has been successful and that the use of the KNN method is very effective in classifying the potential for Normal, Abnormal, Potential for Arrhythmia, Quite Potential for Arrhythmia, Very Potential for Arrhythmia. These results were obtained from research data when using a 3 Lead ECG. The evaluation results showed above average, namely 95.0% so that it can be concluded that the KNN method is very accurate in classifying especially in this study. This method is very helpful for medical personnel, especially in heart surgery and in predicting the risk of heart disease. The benefits of detecting heart disease are very important because they can provide great benefits including preventing the development of the disease, reducing serious complications, increasing the effectiveness of treatment and providing time for lifestyle changes.

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