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Ensemble model for Heart Disease Prediction

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ABSTRACT

For the identification and prediction of different diseases, machine learning techniques are commonly used in clinical decision support systems. Since heart disease is the leading cause of death for both men and women around the world. Heart is one of the essential parts of human body, therefore, it is one of the most critical concerns in the medical domain, and several researchers have developed intelligent medical devices to support the systems and further to enhance the ability to diagnose and predict heart diseases. However, there are few studies that look at the capabilities of ensemble methods in developing a heart disease detection and prediction model. In this study, the researchers assessed that how to use ensemble model, which proposes a more stable performance than the use of base learning algorithm and these leads to better results than other heart disease prediction models. The University of California, Irvine (UCI) Machine Learning Repository archive was used to extract patient heart disease data records. To achieve the aim of this study, the researcher developed the meta-algorithm. The ensemble model is a superior solution in terms of high predictive accuracy and diagnostics output reliability, as per the results of the experiments. An ensemble heart disease prediction model is also presented in this work as a valuable, cost-effective, and timely predictive option with a user-friendly graphical user interface that is scalable and expandable. From the finding, the researcher suggests that Bagging is the best ensemble classifier to be adopted as the extended algorithm that has the high prediction probability score in the implementation of heart disease prediction.

Keywords: Ensemble Model, Heart, Heart Disease, Classifiers and Dataset

INTRODUCTION

In a modern healthcare information system, detecting and predicting a solution model for heart diseases is extremely challenging. Any clinical attempt made through modern computing to provide

economical solutions and options is worth taking to medical experts. Therefore, the need for computerized models capable of performing various tasks such as data analysis, predictive and detective

analysis using effective data mining tools is vital. The application of such tools can assist medical practitioners to make a prompt and right medical decision. A lot of computation applications are designed purposely to assist physicians in making an effective decision about the various diseases in patients. Despite distinct soft computing innovative efforts in place, predicting and detecting heart diseases models stills remained an issue of grave medical concern. Data mining techniques provide a lot of algorithms to detect and predict disease but the challenges associated with each algorithm is still the matter that needs proper consideration.¹ Moreover, artificial intelligence plays a key role in every aspect of modern classified intelligence. From a medical perspective, artificial intelligence assist medical doctors and other health practitioners in performing expert diagnosis as well as detection or prediction of diseases in a patient more efficiently and accurately. Besides, artificial intelligence algorithms have great potential for exploring the hidden patterns in the datasets of the various disease-related subjects by adjusting the data mining model for utilizing such patterns for clinical diagnosis.²

This research work is proposed to develop an ensemble model for predicting heart disease using an object-oriented approach that would outline the whole models to be adapted in the processes. Also, the research intended to use some datasets from Adamawa State Specialist Hospital which was located in Yola North Local Government Area of Adamawa State. A sample of the patient database is needed to carry out the detection and prediction of the heart using common machine learning algorithms. This research will demonstrate the capability of computerizing three popular classifiers which are Support Vector Machine (SVM), Random Tree and Naïve Bayes of the collective dataset captured in the application. The model would also use Bagging as extended ensemble models or fuser's classifiers to finally perform decisive detection and prediction of heart diseases.

1. Research Motivation

The motivation for this study is the fact that human life is dependent on the efficient working of the heart because the heart is an essential part of our body, and heart disease has become a very common disease around us as the number one killer disease worldwide. Heart disease remains the leading cause of death in most countries worldwide. Early detection and treatment of Heart disease can set the stage for a lifetime of better heart health. From a medical perspective, artificial intelligence assist medical doctors and other health practitioners in performing expert diagnosis as well as detection or prediction of

diseases in a patient more efficiently and accurately. In addition, the motivation of this study is to improve the research works of scholars, who have contributed to the field of study.

2. Statement of the Problem

The World Health Organization has estimated that 12 million deaths occur worldwide, every year due to heart diseases.³ The continuous rising of this tragic loss of lives made it necessary for medical practitioners to find adaptive solutions to this epidemic. A conventional prediction method of heart disease is daunting especially in many developing countries where there are limited Doctors and voluminous data.⁴ The machine learning procedures are incorporated using data mining effective tools for identification and detection of diseases in patients. The need for a better approach to handling detection and prediction of heart diseases using different techniques to generate particular detection output is what our research aims to offer.

3. Aim and Objectives

This research work is aimed at developing an ensemble model for detecting heart disease using python. The specific objectives are:

- i. To Create the dataset
- ii. To design a model for heart disease prediction using python and MongoDB
- iii. To validate the proposed model using K-Fold Cross-Validation.
- iv. To develop a graphical user interface that captures the patient feature.
- v. To present the diagnosis analysis according to the probability score point of the patient data.

4. Related Works

A coronary illness forecast framework that may help specialists in anticipating coronary illness status addicted to the clinical information of patients? Thirteen significant clinical highlights, for instance, age, sex, chest torment type were chosen.⁵ The indecisive neural organize calculation was utilized for characterizing coronary illness hooked into these clinical features. Data was collected from the machine learning repository of the University of California, Irvine (UCI) Machine Learning repository. The unreal neural network model contained three layers i.e. the input layer, the hidden layer, and therefore the output layer has 13 neurons, 6 neurons, and a pair of neurons respectively. Learning Vector Quantization (LVQ) was utilized in this study. LVQ may be a special case of a synthetic neural network that applies a prototype-based supervised classification algorithm. C artificial language was used as a tool to implement cardio-vascular disease

classification and prediction trained via a synthetic neural network. They developed the system using C and C#. The accuracy of the proposed method for prediction is near 80%. However, proposed a cardiopathy prediction system supported Structural Equation Modeling (SEM) and Fuzzy Cognitive Map (FCM).⁶ Canadian Community Health Survey (CCHS) 2012 dataset was used in the utilization of their work. Here, twenty critical qualities were utilized. SEM is used to make the burden grid for the FCM model which at that time predicts the plausibility of cardiovascular infections. An SEM model is characterized with a relationship between CCC 121 (a variable that characterizes whether the respondent has coronary illness) alongside 20 traits. To make FCM a weight framework chatting with the standard of the causal connection between ideas must be developed first. The SEM characterized within the past area is presently utilized because the FCM in spite of the fact that they need to accomplish the required fixings (for example weight grid, ideas, and causality). 80% of the informational index was utilized for preparing the SEM model and therefore the remaining 20% for testing the FCM model. The precision got by utilizing this model was 74%. Many applications are wont to detect and predict heart diseases.⁷ However, the utilization of Radial Basis Function (RBF) to predict the medical prescription for cardiovascular disease, within the process of concluding the experiments, there have been about 300 patient's data collected from the Sahara Hospital, Aurangabad. RBFNN (Radial Basis Function–Neural Network) may be described as a three-layer feed-forward structure. The hidden layer consists of a variety of RBF units (NH) and bias (BK). Each neuron on the hidden layer uses a radial basis function as a nonlinear transfer function to control the computer file. The foremost often used RBF is sometimes a Gaussian function. Designing an RBFNN involves selecting centres, the number of hidden layer units, width, and weights. The various methods for selecting the focuses are arbitrary subset determination, k-implies bunching, and others. The technique was applied in MATLAB. Gotten results show that outspread premise capacity is effectively utilized (with an exactness of 90 to 97%) for recommending the medications for cardiovascular disease illness.

The research study discovered that the anticipated heart diseases are detected and predicted using the anticipated coronary illness utilizing changed k-implies and Guileless Bayes.⁸ The finding of coronary illness could be a mind-boggling task and requires extraordinary abilities. The dataset is gotten from Cleveland cardiopathy Database. The property "Infection" with a worth '1' shows the nearness of

coronary illness and a worth '0' demonstrates the nonattendance of coronary illness. Altered k-implies takes an effort at both straight out also, combinational information which we experience here. Utilizing two introductory centroids we get the 2 most remote groups. It, at last, gives an affordable number of bunches. Gullible Bayes' makes a model with prescient abilities. This indicator characterizes the category to which a particular tuple should have an area. This indicator has 93 % precision in anticipating a coronary illness and 89% exactness in situations where it recognized that a patient doesn't have a coronary illness.⁹ Have made comprehensive research worked on an intelligent attack prediction system using big data. In line with him, coronary failure has to be diagnosed timely and effectively due to its high prevalence. The target of this research article is to search out a prototype intelligent attack prediction system that uses big data and data processing modelling techniques. This technique can extract hidden knowledge (patterns and relationships) related to cardiopathy from a given historical cardiovascular disease database. This approach uses Hadoop which is an open-source software framework written in Java for distributed processing and storage of big datasets. Distributed or scalable machine learning algorithms can be implemented for free using Apache Mahout, a product of the Apache Software Foundation. Recordset with 13 attributes (age, sex, serum cholesterol, fasting blood glucose, etc.) was obtained from the Cleveland Heart Database which is obtainable online. The patterns were extracted using three techniques i.e. neural network, Naïve Bayes, and Decision tree. The long-run scope of this method aims at giving more sophisticated prediction models, risk calculation tools, and has extraction tools for other clinical risks.¹⁰ The centre illness expectation will be utilized using data processing and a data system. The data created by the human services industry is colossal and "data-rich". All things considered, it cannot be deciphered physically. Information mining is often viably wont to anticipate ailments from these datasets. During this paper, various information mining methods are dissected on the coronary illness database. Order methods, as an example, Decision trees, Naïve Bayes, and neural systems are applied here. The associative arrangement is another and productive procedure that includes affiliation rule mining and characterization to a model for expectation and accomplishes the best exactness. Taking everything into consideration, this paper examines and appears at how changed arrangement calculations take a trial at a coronary illness database.¹¹ The proposed prototype of heart condition prediction using data processing techniques was done using Naïve Bayes. Naive Bayes may be a

measurable classifier that allocates no reliance between the characteristics. The rear likelihood should be augmented for deciding the category. Here, the Naïve Bayes classifier additionally performs well. In likelihood and constant master framework, Naïve Bayes gives off control of being the simplest model for malady expectation pursued by the neural system and Decision trees.¹² Developed a classifier technique for the guts sickness prediction and likewise, they've confirmed how Naïve Bayes are often used for the classification purpose. No, low, normal, high, and very extensive clinical knowledge was classified. A new sample will be classified according to the class labels if it is detected. 303 observations and 14 parameters are included in this dataset from the Cleveland health institution coronary cardiopathy collection. The system works in two phases i.e. coaching phase and therefore the testing phase. Within the coaching segment, the classification is supervised. The trying out segment involves the prediction of the unknown knowledge or the lacking values. The Naïve Bayes algorithm is employed which is predicated on the Bayesian theorem. The result proves that the accuracy has been obtained by altering the number of occasions within the given dataset.¹³ Recently,¹⁴ researchers proposed an ensemble of neural networks model for the diagnosis of cardiovascular disease and achieved 89.01% accuracy, 80.95% sensitivity, and 95.91% specificity.¹⁵ Developed a unique hybrid system supported ANN and fuzzy analytic hierarchy process

i.e., Fuzzy-AHP technique for the diagnosis of cardiovascular disease. The ANN and Fuzzy-AHP based system achieved a prediction accuracy of 91.10%. Last, it was also shown that the adaptive weighted fuzzy system ensemble technique for cardiopathy detection problems has a classification accuracy of 92.31%.¹⁶

5. Source of Data and Data Collection

The sources of data for this study will be medical records of patients diagnosed with heart disease problems from Specialist Hospital, Yola Adamawa State. The researcher will also use data from the UCI Machine Learning repository to generalize it all.

6. System Design

System design encompasses the processes of designing and specifying the architecture of the system, system modules, user interface and data needed to satisfy the system requirement¹⁷. To design a system, the functional parts need to be evaluated at each phase of development. Therefore, we specify our data and users at every phase of development. We break down the system into application architecture, data flow diagram (DFD), the application interface, database model and the code. The development tools used in this research are presented in table 1.

Table 1. Development Tools

Programming Languages	IDEs	Test Tools	Database
Python, JavaScript, HTML, CSS	Pycharm, Jupyter Lab	POSTMAN, Google Chrome, Microsoft Edge. Opera	MongoDB

7. Proposed Model

Figure 1. Proposed Model for Heart Disease prediction

7.1 Raw Data

Raw Data Raw data typically refers to tables of information where each row contains observation and each column represents a variable that describes some property of each observation. Data during this format is often mentioned as tidy data, flat data, primary data, atomic data, and unit record data. Sometimes information mentions data that has not yet been processed. During this study, our information contains features that are waiting to be extracted for our model.

7.2 Transformed Data

This is the ready data that the researcher achieved after from data. It's the cleaned and transformed data watching for feature extraction.

7.3 Data Preprocessing

Data Preprocessing is that step during which the researcher transformed data in other to bring it to such a state that the machine can easily parse it. In other words, the features of the information can now be easily interpreted by the algorithm. At this phase, the information that may be taken from the dataset are going to be cleaned by generating a structured format and treating missing values.

7.4 Feature Extraction

Feature extraction could be a process in which the researcher identifies important features or attributes of the info. This is often useful in reducing the number of attributes that describe the dataset.

7.5 Training and Test Dataset

The researcher, at this phase, will attempt to create a model to predict the test data. So, we use the training data to suit the model and testing data to check it. The models generated are to predict the result unknown which is called because the test set. As we pointed out; the dataset is split into train and test set so as to test accuracies, precisions by training and testing it.

7.6 Validation

At this phase, the researcher will evaluate the trained data with a testing data set. The testing data set could be a separate portion of the identical data set from which the training set springs. The most purpose of using the testing dataset is to check the generalization ability of a trained model.

7.7 Ensemble Model

The researcher will aggregate the prediction of every base classifier and leads to one final prediction

for the unseen data. The motivation for using ensemble models is to cut back the generalization error of the prediction.

7.8 Sample Data

The dataset to be used during this study will include a dataset from the Kaggle repository, precisely a UCI Machine Learning Repository. The UCI dataset will contain a complete of 14 attributes with 303 instances.

7.9 Method of Data Sampling

After the determination of the sample data, the researcher will use sampling for this study.

7.9.1 Data Dictionary

Table 2 describes the attributes produced from the heart-disease dataset;

Table 2. Data Dictionary

Attributes	Description	Data Type	Character Length	Required?	Accept Null Value?
First Name	Patient first name	String	250	Y	N
Surname	Patient surname	String	250	Y	N
Other Name	Patient other name	String	250	Y	Y
Age	Age in years	Integer	4	Y	N
Gender	Gender (1 = male; 0 = female)	Integer	4	Y	N
Cp	Chest pain type	Integer	4	Y	N
Trestbps	Resting blood pressure (in mm Hg on admission to the hospital)	Integer	4	Y	N
Chol	Serum cholesterol in mg/dl	Integer	4	Y	N
Fbs	Fasting blood sugar > 120 mg/dl (1 = true; 0 = false)	Integer	4	Y	N
Restecg	Resting electrocardiographic results	Integer	4	Y	N
Thalach	Maximum heart rate achieved in beats per minute (bpm)	Integer	4	Y	N
Exang	Exercise induced angina (1 = yes; 0 = no)	Integer	4	Y	N
Oldpeack	ST depression induced by exercise relative to rest	Integer	4	Y	N
Slope	The slope of the peak exercise ST segment	Integer	4	Y	N
Ca	Number of major vessels (0-3) colored by fluoroscopy	Integer	4	Y	N
Thal	Thalassemia inherited blood disorder 3 = normal; 6 = fixed defect; 7 = reversible defect	Integer	4	Y	N

Model Performance

The researcher will evaluate the performance of the model joined of the core stages within the data science process. It indicates how successful the prediction of a dataset has been by a trained model.

Unified Modeling Language

According to Habeeb 2018, the Unified Modeling Language (UML) may be a family of graphical notations, backed by one meta-model that helps in describing the designing software systems,

particularly software systems built using the article oriented style. For the researcher to achieve his aim and have a better understanding system; the researcher will use Use-Case and Sequence Diagram. The Use-Case and Sequence Diagram clearly show the interaction between the users and therefore the system.

Use Case

This is an efficient technique that helps for communicating system behaviour within the user's terms by specifying all externally visible system behaviour as depicted in Figure 2.

Figure 2. Use Case - Ensemble Model for Heart Disease

8.1.1 Description of the System Functions depicted from figure 2

Login: This authenticates the access for the user into the system

Dataset: The Admin collect and store object record that made the dataset

Data Validation: In this case, the admin generalized the ability of the trained model

Parameters: The user inputs the behavioural entities from the learning model to predict the presence of heart disease

Model Performance: The system evaluates the classifiers and returned their performance to the admin such as the accuracy of the model.

Result: The system returned the prediction outcome based on the parameters issued.

8.1.2 Sequence Diagram

The diagram represented in Figure 3 describes the integration between the users of the system;

Figure 3. Sequence Diagram - Ensemble Model for Heart Disease

8.2.1 Description of the System Function (Sequence)

Login: This authenticates the access for the user into the system

Dataset: The Admin collect and store object record that made the dataset

Data Validation: In this case, the admin generalized the ability of the trained model

Parameters: The user inputs the behavioural entities from the learning model to predict the presence of heart disease

Model Performance: The system evaluates the classifiers and returned their performance to the admin such as the accuracy of the model.

Result: The system returned the prediction outcome based on the parameters issued.

9. Implementation of the Diagnostic System

During the implementation of this work, the system interfaces, along with their source codes, is a result of the deployment phases at the realization.

9.1 The Sign-Up Interface

This interface enables system users to register their credentials by creating an account that will be used within the system at the authentication phase (Figure 4).

ENSEMBLE MODEL FOR HEART DISEASE PREDICTION

Sign Up

Username

Medical Lab

Email

Password

Sign up

Already have an account? [Sign In](#)

Figure 4. The Sign-Up Interface

9.2 The Authentication Interface

This interface enables system users to be identified by the identity of the user. It is a mechanism to combine an incoming request with a set of

credentials. The credentials supplied are compared with those of the authorized user data in a database (Figure 5).

ENSEMBLE MODEL FOR HEART DISEASE PREDICTION

Sign in to your account to continue

Email

Password

[Forgot password?](#)

☒ Remember me next time

Sign In

Don't have account? [Sign Up](#)

Figure 5. The Authentication Interface

9.3 Dashboard Interface

A dashboard in this work is used to visually tracks, analyzes and displays key performance indicators (KPI) and key data points to navigate

within the system. The dashboard of this study has four (4) commands button (navigation interfaces) which shows in Figure 6.

Figure 6. The Dashboard Interface

9.4 The Data Capture Interface

This interface allows the user of the system to input disease attributes of patient for the prediction of Heart disease presence (Figure 7).

Form

Surname: _____

First name: _____

Other name: _____

Age: age in years _____

[Select Gender] _____

Cp: chest pain type _____ Value 1: typical angina o Value 2: atypical angina o Value 3: non-anginal pain o Value 4: asymptomatic

Trestbps: resting blood pressure _____ Chot: serum cholesterol in mg/dl _____

Fbs: fasting blood sugar > 120 mg/dl _____ (1 = true; 0 = false)

Restecg: resting electrocardiogram _____ Value 0: normal o Value 1: having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV) o Value 2: showing probable or definite left ventricular hypertrophy by Estes criteria

Thalach: maximum heart rate achieved in beats per minute (bpm) _____

Exang: exercise induced angina _____ (1 = yes; 0 = no)

Oldpeak: ST depression induced by exercise relative to rest _____

Slope: the slope of the peak exercise ST segment _____ (1 = yes; 0 = no)

Ca: number of major vessels _____ (0-3) colored by fluoroscopy

Thal: thallium scan _____ 3 = normal; 6 = fixed defect; 7 = reversible defect

Submit

Figure 7. The Data Capture Interface

9.5 The Diagnoses Interface

This interface is used for diagnosing the disease of a patient by selecting patient data as depicted in Figure 8.

Figure 8. The Diagnoses Interface

9.6 The User Profile Interface

The user profile interface in this study enables the system user to update his/her profile information (Figure 9).

Figure 9. The User Profile Interface

9.7 Comparison Chart for Extended Classifiers

Figure 10. Comparison Chart for Extended Classifiers

Figure 10 above depicts the performance of the extended classifiers utilized and their predictive accuracy, from which the researcher chose bagging as the classifier with the best predicting performance for the study's implementation.

RESULTS AND DISCUSSION

In this research, the researcher adopts Naïve Bayes, Decision Tree and Support Vector Machine as base learning algorithms in machine learning technology which contains a set of outputs and combines them into a strong and enhanced prediction of the model by comparing the two extended classifiers or meta-algorithm.

The implementations of this ensemble model were applied on a dataset from the UCI Machine Learning Repository for the training and testing of our model for the prediction of heart disease. The data collected contains 303 instances of patients diagnosed with heart disease and each clinical instance of patience consists of 14 raw attributes.

Ensemble technique is a well-proven methodology used in research for achieving extremely accurate data classification by integrating several machine learning algorithms to get more dependable and accurate prediction outcomes.

Based on the findings of this study, ensemble learning prediction models were built and created using Bootstrap Aggregating as one of the extended classifiers employed in the ensemble method implementation to diagnose and classify heart disease existence in patients as a diagnostic outcome and it is used in the ensemble model for heart disease prediction.

The study's findings suggest that Bagging is the best ensemble classifier to be adopted in the implementation of the ensemble model for heart disease presence in patience. The study model developed; is dependable, efficient, accurate, and can be used in modern health care facilities for the prediction of heart disease.

CONCLUSION

Prediction of heart disease has been the most promised approach that will help in the suitable reduction in the fertility rate and will assist in the development of the alerts on the large scale.

The proposed model for heart disease prediction using the ensemble method discussed in this research was successfully implemented and simulated using python and MongoDB. The model captures symptoms and risk factors to diagnose a patient with

heart disease and present it in a Graphical User Interface (GUI) form where the user will key in the attribute and the system will diagnose the patient based on the trained dataset used in Bagging.

Conflicts of Interest

All contributing authors declare no conflicts of interest.

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None

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