Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

The Application of Support Vector Machines and Artificial Neural Networks to the Prediction of Heart Disease

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Heart-related ailments, which are also commonly referred to as cardiovascular diseases, have been the leading cause of death throughout the world for the past few decades. They are now acknowledged as the most significant sickness in India as well as the rest of the world. It is possible to prevent the severity of the disease by receiving the appropriate care at the appropriate stage. This illness asserts that early and accurate prognosis is necessary in order to prevent causalities. Because there is a lack of effective medical care, illnesses are not being recognized at the appropriate time, and treatment cannot be initiated. It has been demonstrated that machine learning algorithms have the potential to accurately estimate the risk of heart disease based on patient data. A model for the prediction of heart disease that is based on machine learning has been provided that was developed for this study. Building a model that is based on machine learning with the purpose of providing an accurate and timely prediction of cardiac disease is the goal of this endeavor. An accuracy of 81.6% and 86.6%, respectively, has been achieved by the suggested model through the utilization of support vector machine and artificial intelligence algorithms. The results of the study indicate that the model is capable of accurately predicting the risk of acquiring heart disease with high levels of sensitivity and specificity. This provides medical practitioners with a valuable instrument that may help them identify individuals who may be more likely to acquire heart disease.
Keywords: ANN, SVM, ML, AI & Heart Disease.

1. Introduction

Among the most common reasons people die is from cardiovascular illness. Headaches, angina, swollen legs, extreme tiredness, and many other symptoms can be used to detect heart disease.

A person's way of life, including their eating choices, level of physical activity, and the existence of other health conditions like high blood pressure, all significantly contribute to the development of heart disease. An extremely concerning problem in the healthcare industry is the shortage of qualified medical professionals throughout the world. The area of illness prediction is one where machine learning has shown to be an invaluable asset to the healthcare system. One may train machine learning models to properly forecast the likelihood of various diseases in people by utilizing massive volumes of patient data and advanced algorithms. By paving the way for earlier diagnosis and more tailored treatment of illnesses, this may radically alter the healthcare system.

This problem has been solved by the suggested model for heat illness identification using AI and ML.

The suggested model was created using AI and support vector machines (SVM). The data set was retrieved via the Kaggle platform. High-dimensional data space and memory efficiency are two areas where support vector machines (SVMs) have shown to excel.

One of the many benefits of artificial neural networks (ANN) is its supposed fault tolerance and ability to function with partial knowledge sets.

One important outcome of this study is an AI model that can anticipate the onset of cardiovascular illness at an early stage, which will allow for faster treatment and ultimately benefit society. Applying ANN yielded an accuracy of 86.6%, whereas SVM yielded an accuracy of 81.6%; this is the most important finding. Supervised by artificial intelligence, the SVM is no longer used. This work's originality lies in its use of SVM as a classifier in conjunction with artificial intelligence and feature selection based on correlation coefficients to forecast the onset of cardiac illness in its early stages.

Section 2 details the results of the background research. Section 4 analyses the results, whereas Section 3 presents the recommended model.

2. Literature Review

Many studies utilizing various data mining and machine learning methods have been conducted by medical facilities in an effort to develop illness prediction systems. The proposed model for predicting the occurrence of cardiovascular disease using multiple linear regressions is appropriate for this purpose (Polaraju& Durga Prasad, 2017). A model for chronic illness prediction using ANNs, decision trees, SVMs, and naïve bayes (NB) was proposed by Seema and Deepika (2016). This model will mine data from previous health records. In this experiment, SVM has the best accuracy rate. Classification trees, NB, logistic regression, SVM, ANN, and k-nearest neighbor (KNN) were among the methods suggested in Dwivedi (2016). The logistic regression method outperforms its competitors in terms of accuracy. In order to detect cardiac issues, Shetty and Naik (2016) proposed a method that analyzes medical records from patients. We created the algorithm with 13 input attribute risk factors in mind. Data integration and cleaning were carried out once the dataset's data was analyzed. In order to forecast the occurrence of cardiovascular disease, Banerjee Majumder et al. (2021) suggested an ensemble ML model. Modeling techniques like as bagging, logistic regression, NB, and KNN were employed by the base learners. Using NB, multilayer perceptron (MLP), support vector machine (SVM), and random forest (RF), Boukhatem et al. (2022) presented a model for the prediction of cardiac illness. Jindal et al. (2020) presented a model for the prediction of cardiac disease using KNN and logistic regression. Using RF, SVM, NB, and decision tree, a model was suggested in which RF attained the maximum accuracy (Sharma et al., 2020). Using RF, Decision Tree, logistic regression, and NB, Rajdhan et al. (2020) presented a model for the prediction of heart disease. A maximum accuracy of 90.16% was attained with RF. A new model for the prediction of cardiac illness using weighted associative rule mining was proposed by Yazdani et al. (2021). The model put out by Bharti et al. (2021) relies on deep learning. Using Isolated Forest, the model was able to pick features with an accuracy of 94.2%. Kritthanawong et al. (2020) presented a model that included support vector machines (SVM), convolutional neural networks (CNNs), and booting approach; SVM was shown to be the most effective of the three. The model for predicting heart illness that was put up by Karthick et al. (2022) makes use of SVM, XGBoost, RF, and Gaussian naïve bayes lite GBM. A model predicting the risk of cardiovascular illness using an ensemble process was suggested by Latha and Jeeva (2019). Sarra et al. (2022) suggested a support vector machine (SVM) model that used X2 to pick features. Raut et al. (2020) reported their efforts to develop a computationally efficient model for the prediction of cardiovascular disease using the UCI dataset. To forecast the spread of COVID-19, Pathak et al. (2022) put forward a model based on deep transfer learning. Using a convolutional neural network (CNN) and an integrated space transfer network, Soni et al. (2022) developed a model for predicting lung diseases. Using an ensemble mechanism, Tuli et al. (2020) suggested a healthcare support system for the prediction of cardiac disease. A model for cardiovascular disease prediction was presented by Ahmed et al. (2022) that makes use of many machine learning techniques, including KNN, NB, RF, and LGBM. By far, LGBM has the best accuracy. Using a bioinformatics framework that takes into account several aspects including lifestyle and eating habits, Gupta and Banerjee (2015) suggested a degree of risk for cardiovascular disease. A model for the prediction of cardiac disease using an SVM and MLP neural network was proposed by Gudadhe et al. (2010). A model for the prediction of cardiovascular sickness was sought to be developed by Shah et al. (2020) with the use of machine learning. With 303 cases and 17 characteristics, the Cleveland heart disease dataset provided the data utilized for this study. Its location was at the UCI. database for machine learning. The writers make use of a wide variety of supervised classification methods, including NB, decision trees, RFs, and KNN. According to the results, the KKN model outperformed the others with a precision of 90.8%. As its title suggests, Hasan and Bao's (2020) primary objective was to identify the most efficient feature selection technique for cardiovascular disease prediction. The results demonstrated that the highest accurate prediction results for cardiovascular illness were obtained by combining the XGBoost classifier with the wrapper method. With 73.74% accuracy, XGBoost, SVC, and ANN all met expectations.

3. Proposed Model

Based on the data obtained from Kaggle, this model attempts to forecast the occurrence of heart disease. With the help of SVM and ANN, the suggested model was constructed. Figure 1 displays the model block diagram.

3.1. Heart failure dataset

Datasets obtained from Kaggle form the basis of the study. In all, thirteen columns are present. Out of those, twelve will be used as independent characteristics for prediction. Individuals in this dataset range in age from forty to ninety-five. A gender value of 1 indicates a male patient while a gender value of 0 indicates a female patient. In Figure 2 we can see the compiled dataset.

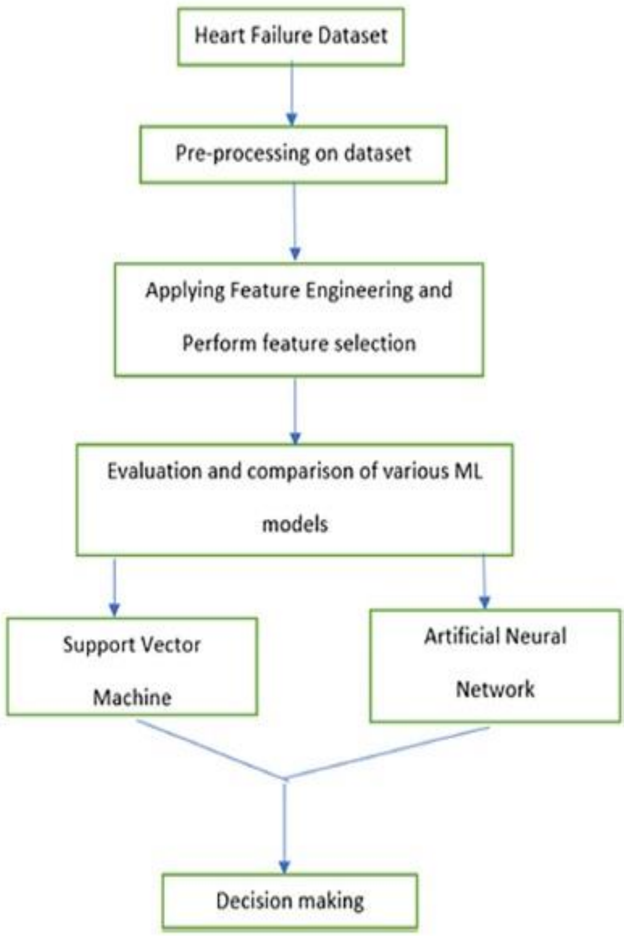

Figure 1: Proposed Model for Heart Disease Prediction

Proper dataset compression is required prior to model training. As can be seen in Figure 3, the dataset does not include any null values. Additionally, at this stage, any outliers in the dataset have been eliminated.

	age	anaemia	creatinine_phosphokinase	diabetes	ejection_fraction	high_blood_pressure
0	75.0	0	582	0	20	1
1	55.0	0	7861	0	38	0
2	65.0	0	146	0	20	0
3	50.0	1	111	0	20	0
4	65.0	1	160	1	20	0

Figure 2: Dataset Description

```
In [7]: dataset.isnull().sum()

Out[7]: age                         0
        anaemia                     0
        creatinine_phosphokinase    0
        diabetes                    0
        ejection_fraction           0
        high_blood_pressure         0
        platelets                   0
        serum_creatinine            0
        serum_sodium                0
        sex                         0
        smoking                     0
        time                        0
        DEATH_EVENT                 0
        dtype: int64
```

Figure 3: Null Value checking

3.2. Applying feature engineering and perform feature selection

The decision-making process is negatively impacted by characteristics that are not equally essential in every dataset. Features must be carefully chosen before a decision-making system may proceed.

In this proposed model, important characteristics have been selected using a heat map. Heat map of correlations (3.2.1), with the use of colors, a heat map may show two-dimensional data and reveal the association between various parameters. If you want your dataset to perform better, you should delete characteristics that are highly associated. Figure 4 displays the heat map that was generated from the dataset. We used a heat map to verify the association. When there is a strong relationship between two variables, we eliminate one of them. In this case, we see which characteristics have a correlation greater than 0.1. The remaining functionalities are deactivated. Figure 5 displays the code snippet that demonstrates feature selection.

3.3. Model development

Applying SVM and ANN has been done in this suggested study.

3.3.1. Support vector machine

The support vector machine (SVM) is a popular supervised learning technique. Classification and regression problems are both addressed by this application in machine learning. In order to make future data point classifications easier, the SVM algorithm seeks to determine the optimal decision boundary for dividing n-dimensional space into categories. The term "hyperplane" describes this perfect decision-making boundary. Selective vector machine (SVM) is used to choose the extreme vectors or points that contribute to the hyperplane. Support vectors characterize these severe cases. This is the inspiration for the SVM algorithm's name. Our model's accuracy increased to 81.6% after using SVM. In Figure 6, we can see the final model that was created using SVM.

3.3.2. Artificial neural network

The term "ANNs" describes a subfield of AI that draws inspiration from biological models of the brain. In most cases, the biological neural network that built the human brain serves as the basis for artificial neural networks (ANNs). Similar to how neurons in the human brain are connected at different layers of the network, ANNs likewise have their neurons linked to one another.

Nodes describe these neurons. Figure 7 displays the created ANN model. The input layer of the suggested ANN model makes use of the rectified linear activation (ReLu) function, whereas the hidden layer makes use of the sigmoid activation function. The uniform initializer makes use of the initialize. Adam was employed as the optimizer, while binary_crossentropy was used as the loss function. Figure 8 displays the results of the model fitting. Figure 9 shows that after implementing ANN into our model, we attained an accuracy of 86.6%. Specificity, sensitivity, and precision are additional metrics that are taken into account with accuracy. The model's accuracy is 93.54%, sensitivity is 87.87%, and specificity is 83.33%.

4. Result Analysis

The proposed model has been implemented applying SVM and ANN. ANN has achieved better accuracy over SVM.

4.1. Support vector machine

The training set is used to fit the SVM classifier. To create the SVM classifier, we utilized the sklearn.svm application. Because support vector machines (SVMs) are best separated linearly, Kernel='Linear' was used.

An accuracy measure has been computed based on the model's performance evaluation using the generated confusion matrix. The sklearn confusion matrix function is imported in order to generate the confusion matrix. Figure 10 shows the confusion matrix formed by using SVM for classification.

For this project, we have an accuracy rate of 81.6%. Scores of 97.14% for accuracy, 77.27% for sensitivity, and 93.75% for specificity were attained. There is a 0.25 R2 score.

4.2. Artificial neural network:

Layers of a model are constructed using ANN using a sequential model type. The weights in each layer are directly related to the layer that permits it. The ReLu and sigmoid activation functions are used to create layers. The units are specified according to the requirements. Finally, the model is built using the optimizer "adam" and the loss function "binary_crossentopy." The train set has epochs= 100 and batch size= 8. This is used to train the model. The suggested ANN model's performance has been validated using a confusion matrix, and its accuracy value has been demonstrated. In Figure 11, we can see the ANN-generated confusion matrix.

As seen in Figure 12, our project's computed accuracy is 86.66%. Achieved accuracy, sensitivity, and 93.54%, 87.87%, and 83.33% are the specificity scores. Also taken into account is the R2 score of 0.27.

This suggested model takes into account the benefits of both SVM and ANN for predicting the occurrence of heart disease. After comparing and contrasting the two classifiers' performance in the results section, it became clear that ANN was the superior choice.

Figure 13 shows the precision, sensitivity, accuracy, and specificity scores of the two classifiers that were utilized in the suggested model. As you can see from Table 1, we compared our planned work to several previous efforts.

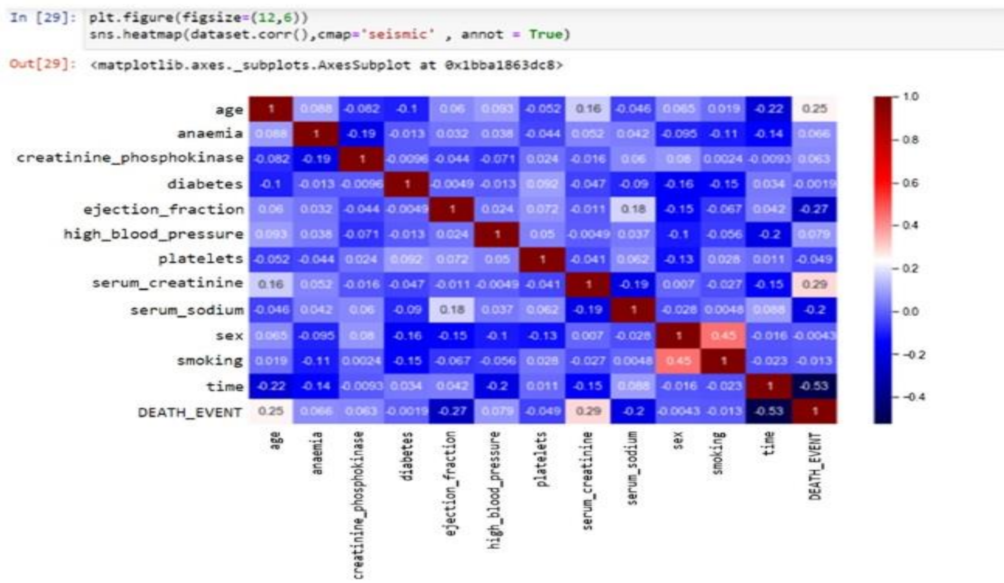

Figure 4 . Heat map

```
In [30]: datacor = dataset.corr()
         data_target = abs(datacor["DEATH_EVENT"])
         relevant_features = data_target[data_target>0.1]
         relevant_features

Out[30]: age                  0.253729
         ejection_fraction    0.268603
         serum_creatinine     0.294278
         serum_sodium         0.195204
         time                 0.526964
         DEATH_EVENT          1.000000
         Name: DEATH_EVENT, dtype: float64

In [31]: dataset.drop('anaemia',axis=1,inplace=True)
         dataset.drop('diabetes',axis=1,inplace=True)
         dataset.drop('high_blood_pressure',axis=1,inplace=True)
         dataset.drop('sex',axis=1,inplace=True)
         dataset.drop('creatinine_phosphokinase',axis=1,inplace=True)
         dataset.drop('platelets',axis=1,inplace=True)
         dataset.drop('smoking',axis=1,inplace=True)
```

Figure 5 : Feature Selection

SUPPORT VECTOR MACHINE

```
In [35]: from sklearn.svm import SVC
         from sklearn.metrics import confusion_matrix
         from sklearn.metrics import plot_confusion_matrix

         # Building a Support Vector Machine on train data
         svc_model = SVC(C= .1, kernel='linear', gamma= 1)
         svc_model.fit(X_train, Y_train)

         prediction = svc_model .predict(X_test)
         confusion_matrix =  confusion_matrix(Y_test,prediction)

         confusion_matrix

Out[35]: array([[34,  1],
                [10, 15]], dtype=int64)

In [36]: # check the accuracy on the training set
         print(svc_model.score(X_train, Y_train))
         print(svc_model.score(X_test, Y_test))

         0.8661087866108786
         0.8166666666666667
```

Figure 6 : Model of SVM

ANN implementation

```
from sklearn.preprocessing import StandardScaler
sc=StandardScaler()
x_train=sc.fit_transform(x_train)
x_test=sc.transform(x_test)
```

```
classifier=Sequential()
classifier.add(Dense(activation="relu",input_dim=12,units=8,kernel_initializer="uniform"))
classifier.add(Dense(activation="relu",units=14,kernel_initializer="uniform"))
classifier.add(Dense(activation="sigmoid",units=1,kernel_initializer="uniform"))
classifier.compile(optimizer='adam',loss='binary_crossentropy',metrics=['accuracy'])
```

Figure 7 : Implementation of ANN

```
In [64]: classifier.fit(x_train,y_train,batch_size=8,epochs=100)

Epoch 1/100
209/209 [==============================] - 1s 3ms/step - loss: 0.6911 - accuracy: 0.6699
Epoch 2/100
209/209 [==============================] - 0s 1ms/step - loss: 0.6861 - accuracy: 0.6746
Epoch 3/100
209/209 [==============================] - 0s 1ms/step - loss: 0.6752 - accuracy: 0.6746
Epoch 4/100
209/209 [==============================] - 0s 2ms/step - loss: 0.6492 - accuracy: 0.6746
Epoch 5/100
209/209 [==============================] - 0s 1ms/step - loss: 0.6071 - accuracy: 0.6842
Epoch 6/100
209/209 [==============================] - 0s 1ms/step - loss: 0.5525 - accuracy: 0.7799
Epoch 7/100
209/209 [==============================] - 0s 1ms/step - loss: 0.4989 - accuracy: 0.8038: 0s - loss: 0.5228 - accuracy: 0.
Epoch 8/100
209/209 [==============================] - 0s 1ms/step - loss: 0.4547 - accuracy: 0.8373
Epoch 9/100
209/209 [==============================] - 0s 1ms/step - loss: 0.4236 - accuracy: 0.8373
Epoch 10/100
209/209 [==============================] - 0s 1ms/step - loss: 0.3988 - accuracy: 0.8230
```

Figure 8 : Model of Fitting

```
y_pred=classifier.predict(x_test)
y_pred=(y_pred>0.5)

cm=confusion_matrix(y_test,y_pred)

cm

array([[58,  4],
       [ 8, 20]], dtype=int64)

acc=(cm[0][0]+cm[1][1])/(cm[0][1]+cm[1][0]+cm[0][0]+cm[1][1])
print(acc*100)

86.66666666666667
```

Figure 9 : ANN

SUPPORT VECTOR MACHINE

```
In [35]: from sklearn.svm import SVC
         from sklearn.metrics import confusion_matrix
         from sklearn.metrics import plot_confusion_matrix

         # Building a Support Vector Machine on train data
         svc_model = SVC(C= .1, kernel='linear', gamma= 1)
         svc_model.fit(X_train, Y_train)

         prediction = svc_model .predict(X_test)
         confusion_matrix =  confusion_matrix(Y_test,prediction)

         confusion_matrix

Out[35]: array([[34,  1],
                [10, 15]], dtype=int64)
```

Figure 10 : SVM Confusion Matrix

```
y_pred=classifier.predict(x_test)
y_pred=(y_pred>0.5)

cm=confusion_matrix(y_test,y_pred)

cm

array([[58,  4],
       [ 8, 20]], dtype=int64)
```

Figure 11 : ANN confusion Matrix

Accuracy of artificial neural network

```
acc=(cm[0][0]+cm[1][1])/(cm[0][1]+cm[1][0]+cm[0][0]+cm[1][1])
print(acc*100)

86.66666666666667
```

Figure 12 : ANN Accuracy

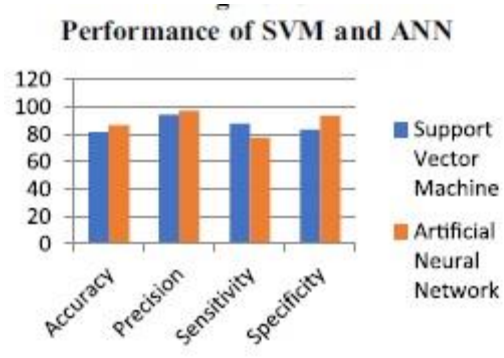

Figure 13: Performance of ANN and SVM

5. Proposed methods Observations

- In 2017, Polaraju and Durga Prasad Make use of multiple linear regression
- Deepika and Seema (2016) Applied artificial neural networks, naïve bayes, decision trees, and support vector machines (SVMs).
- Naik and Shetty (2016) Implemented a hybrid approach utilizing artificial neural networks
- A hybrid model attained 89% accuracy, while an artificial neural network attained 84%.
- Majumder Banerjee et al. (2021) implemented a bagging strategy utilizing logistic regression, naive bayes, and K next neighbor
- Oukhatem and colleagues (2022) Applied naïve bayes (NB), multilayer perceptron (MLP), support vector machine (SVM), and random forest (RF). Got 82.8% for logistic regression, 82.5% for naïve bayes, and 83.2% for K nearest, respectively. Across the street According to Jindal et al. (2020)} Implemented logistic regression and KNN Accuracy achieved was 88.5%
- Decision trees, logistic regression, random forests, naive bayes, and Rajdhan et al. (2020) At its peak, accuracy reached 90.16 percent.
- Researchers Yazdani et al. (2021) Utilized weighted associative rule mining hit 98% threshold
- Krittanawong and colleagues (2020). Booting technique, convolutional neural network, and support vector machine were utilized. Hit a remarkable 94.2% accuracy rate.
- The following methods were utilized by Karthick et al. (2022): SVM, XGBoost, random forest, and Gaussian naïve bayes lite GBM. Got an average accuracy rate of 78.77%.
- The authors of the study are Pathak and colleagues (2022). Implemented deep transfer learning strategy; averaged 92% accuracy.

- Ahmed and colleagues (2022) Opted for KNN, naïve bayes, random forest, and LGBM and Best accuracy was attained with LGBM.
- According to Shah et al. (2020) Implemented K-nearest neighbor, naïve bayes, decision trees, and random forests The maximum accuracy attained by KNN was 90.08%.
- Bao and Hasan (2020) Applying XGBoost, SVC, and ANN, we got 73.74 percent, 73.18%, and 73.20% accuracy, respectively.
- We have developed a model Employed SVM (support vector machine) and ANN (artificial neural network) yielded 81.6% and 86.6% accuracy, respectively.

6. Conclusion

During the course of this study, we trained the machine by utilizing SVM and ANN.SVM was used, and the accuracy that was reached was 81.6%. The artificial neural network (ANN) model is made up of hidden layers, and the result of each layer is carried over to the subsequent input, which guarantees that the model is more accurate. An accuracy of 86.66% is being demonstrated by the ANN model. Through the utilization of this model as a classifier, it is possible to make an early and reliable prediction of heart disease. Additionally, in the future, we want to make use of a variety of ensemble mechanisms and deep learning approaches.

References

1. Ahmed, S., Shaikh, S., Ikram, F., Fayaz, M., Alwageed, H. S., Khan, F., & Jaskani, F. H. (2022). Prediction of cardio vascular disease on self-augmented datasets of heart patients using multiple machine learning models. Journal of Sensors, 2022, 1–21. https://doi.org/10.1155/2022/3730303
2. Bharti, R., Khamparia, A., Shabaz, M., Dhiman, G., Pande, S., & Singh, P. (2021). Prediction of heart disease using a combination of machine learning and deep learning. Computational Intelligence and Neuroscience, 2021, 1–11. https://doi.org/10.1155/2021/8387680
3. Banerjee Majumder, A., Gupta, S.,& Singh, D. (2021). An ensemble heart disease prediction model bagged with logistic regression, Naïve Bayes and K Nearest neighbor. Journal of Physics: Conference Series, 2286(1), 012017. http://doi.org/10.1088/ 1742-6596/2286/1/012017
4. Boukhatem, C., Youssef, H. Y., & Nassif, A. B. (2022). Heart disease prediction using machine learning. Advances in Science and Engineering Technology International Conferences, 1–6, http://doi.org/10.1109/ASET53988.2022.9734880.
5. Dwivedi, A. K. (2016). Performance evaluation of different machine learning techniques for prediction of heart disease. Neural Computing and Applications, 29, 685–693. https://doi.org/ 10.1007/s00521-016-2604-1
6. Gudadhe, M., Wankhade, K., & Dongre, S. (2010). Decision support system for heart disease based on support vector machine and artificial neural network. In 2010 International Conference on Computer and Communication Technology.741–745. https://doi.org/10.1109/ICCCT.2010.5640377.
7. Gupta, S., & Banerjee Majumder, A. (2015). Proposed intelligent system to identify the level of risk of cardio vascular diseases under the framework of bioinformatics.
8. In Gupta,S., Bag, S., Ganguly, K., Sarkar, I., Biswas, P. (Eds.),Advancements of Medical Electronics. Lecture Notes in Bio engineering, (pp. 3–12), Springer.

https://doi.org/10.1007/978-81-322-2256-9_1.
9. Hasan, N., & Bao, Y. (2020) Comparing different feature selection algorithms for cardiovascular disease prediction. Health Technology, 11, 49–62.
https://doi.org/10.1007/s12553-020-00499-2
10. Jindal, H., Agrawal, S., Khera, R., Jain, R., & Nagrath, P. (2020).Heart disease prediction using machine learning algorithms.In IOP Conference Series: Materials Science and Engineering, 1022(1), 012072. http://doi.org/10.1088/1757- 899X/1022/1/012072
11. Karthick, K., Aruna, S. K., Samikannu, R., Kuppusamy, R.,Teekaraman, Y., & Ramesh Thelkar, A. (2022).Implementation of a heart disease risk prediction model using machine learning. Computational and Mathematical Methods in Medicine, 2022, 1–14. https://doi.org/10.1155/2022/6517716.
12. Krittanawong, C.,Virk, H. U. H.,Bangalore, S., Wang,Z., Johnson,K.W.,Pinotti,R.,& Tang,W.W. (2020).Machine learning prediction in cardiovascular diseases: a meta-analysis. Scientific Reports, 10(1),16057. https://doi.org/10.1038/s41598-020-72685-1.
13. Latha, C. B. C., & Jeeva, S. C. (2019) Improving the accuracy of prediction of heart disease risk based on ensemble classification techniques. Informatics in Medicine Unlocked, 16, 100203.https://doi.org/10.1016/j.imu.2019.100203
14. Magar, R., Mamane, R., Raut, S.,& Rupnar,V. S. (2020).Heart disease prediction using machine learning. International Journal of Emerging Technologies and Innovative Research, 7(6),2081–2085. http://www.jetir.org/papers/JETIR2006301.pdf.
15. Pathak, Y., Shukla, P. K., Tiwari, A., Stalin, S., Singh, S., & Shukla,P. K. (2022). Deep transfer learning based classification model for COVID-19 disease. Innovation and Research inBioMedical Engineering, 43(2), 87–92. https://doi.org/10.1016/j.irbm.2020.05.003
16. Polaraju, K., & Prasad, D. D. (2017). Prediction of heart disease using multiple linear regression model. International Journal of Engineering Development and Research Development,5(4), 1419–1425.
17. Rajdhan, A., Agarwal, A., Sai, M., Ravi, D.,& Ghuli, P. (2020). Heart disease prediction using machine learning. International Journal of Engineering Research & Technology, 9(4), 659–662. http:// doi.org/10.17577/IJERTV9IS040614
18. Sarra, R. R.,Dinar, A.M., Mohammed,M.A.,& Abdulkareem,K.H., (2022). Enhanced heart disease prediction based on machine learning and $\chi 2$ statistical optimal feature selection model. Designs, 6(5), 87. https://doi.org/10.3390/designs6050087.
19. Seema, S.,&Deepika, K. (2016). Predictive analytics to prevent and control chronic disease. In 2nd International Conference on Applied and Theoretical Computing and Communication Technology, 381–386. http://doi.org/10.1109/ICATCCT.201607912028.
20. Shetty, A., & Naik, C. (2016). Different data mining approaches for predicting heart disease. International Journal of Innovative in Science Engineering and Technology, 5, 277–281.
21. Shah, D., Patel, S. B., & Bharti, S. K. (2020). Heart disease prediction using machine learning techniques. SN Computer Science, 1, 345. https://doi.org/10.1007/s42979-020-00365-y.
22. Sharma, V., Yadav, S., & Gupta, M. (2020). Heart disease prediction using machine learning techniques. In 2nd International Conference on Advances in Computing, Communication Control and Networking, 177–181. http:// doi.org/10.1109/ICACCCN51052.2020.9362842.
23. Soni, M., Gomathi, S., Kumar, P., Churi, P. P., Mohammed, M. A., & Salman, A. O. (2022). Hybridizing convolutional neural network for classification of lung diseases. International Journal of Swarm Intelligence Research, 13(2), 1–15. http://doi.org/10.4018/IJSIR.287544.
24. Tuli, S., Basumatary, N., Gill, S. S., Kahani, M., Arya, R. C., Wander, G. S., & Buyya, R. (2020) HealthFog: an ensemble deep learning based Smart Healthcare System for Automatic diagnosis of heart diseases in integrated IoT and fog computing environments. Future Generation Computer Systems, 104, 187–200.
25. Yazdani, A., Varathan, K. D., Chiam, Y. K., Malik, A. W., & Wan Ahmad, W. A. (2021). A novel

approach for heart disease prediction using strength scores with significant predictors. BMC Medical Informatics and Decision Making, 21(1), 194. https://doi.org/10.1186/s12911-021-01527-5.

26. K,Gurusharan,T,Namrata,Application of Dijkstra's Algorithm in Wireless Communication System, International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429 Volume 8 Issue IX Sep. 2020 Available at www.ijraset.com.
27. K,Gurusharan,T,Namrata and Verma,M.,Applications of Graph Theory in Science and Computer Science, International Journal of Advances in Engineering and Management (IJAEM),Volume 2, Issue 6, pp: 736-739 www.ijaem.net ISSN: 2395-5252.