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An Intelligent Heart Disease Prediction by Machine Learning Using Optimization Algorithm

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Abstract

Heart and circulatory system diseases are often referred to as cardiovascular disease (CVD). The health and efficiency of the heart are crucial to human survival. CVD has become a primary cause of demise in recent years. According to data provided by the World-Health-Organization (WHO), CVD were conscientious for the deaths of 18.6M people in 2017. Biomedical care, healthcare, and disease prediction are just few of the fields making use of cutting-edge skills like machine learning (ML) and deep learning (DL). Utilizing the CVD dataset from the UCI Machine-Repository, this article aims to improve the accuracy of cardiac disease diagnosis. Improved precision and sensitivity in diagnosing heart disease by the use of an optimization algorithm is possible. Optimization is the process of evaluating a number of potential answers to a problem and selecting the best one. Support-Machine-Vector (SVM), K-Nearest-Neighbor (KNN), Naïve-Bayes (NB), Artificial-Neural-Network (ANN), Random-Forest (RF), and Gradient-Descent-Optimization (GDO) are just some of the ML strategies that have been utilized. Predicting Cardiovascular Disease with Intelligence, the best results may be obtained from the set of considered classification techniques, and this is where the GDO approach comes in. It has been evaluated and found to have an accuracy of 99.62 percent. The sensitivity and specificity were likewise measured at 99.65% and 98.54%, respectively. According to the findings, the proposed unique optimized algorithm has the potential to serve as a useful healthcare examination system for the timely prediction of CVD and for the study of such conditions.

Keywords: Optimization Algorithm, Cardiovascular Disease, Prediction, Gradient Descent, Machine Learning, Neural Networks, Deep Learning

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Introduction

A disease is a medical disorder that does not occur naturally in the human body. It has deleterious effects on the human body's ability to function. There are typically very few physical manifestations of the condition. In the previous 15 years, cardiovascular disease, especially heart attacks and strokes, have become the leading cause of death worldwide, with an estimated 17 million deaths annually (Guleria et al., 2022). Stroke and heart disease account for the majority of deaths. Machine learning can help doctors forecast cardiac disease by spotting trends they haven't seen before and giving them insight into patient management that will improve outcomes.

Diseases of the heart can affect the organ itself, the blood arteries that supply it, the heart's muscles and valves, or the underlying electrical pathways in the body that cause the muscles to contract. Heart disease is a major killer worldwide. CVDs account for over 31% (17.9 million) of all fatalities annually, placing a significant clinical health and economic burden on the world. In the United States, cardiovascular disease is responsible for one in every four deaths (Ashok et al., 2023). In many parts of the world, heart disease affects roughly the same number of men and women. Therefore, it is important to think about possible causes of cardiovascular disease. Heart disease is partially predetermined by genes, but environmental and dietary variables also play important roles. Heart-disease (HD) risk factors include age, gender, family history, smoking, some chemotherapy medicines and cancer, hunger, hypertension, high cholesterol levels in the blood, diabetes, obesity, and lack of exercise, stress, and poor hygiene. The patient's vulnerability to cardiovascular disease (CVD) development is increased by these factors (Rustam et al., 2022).

Numerous innovations, including fitness and health bands, have been made in the medical care sector. Electrocardiograms and computed tomography scans are just two examples of the diagnostic tools that aid in the analysis of coronary HD. However, due to reasons such as high cost and impracticality, 19M people mislay their lives each year to coronary HD. According to the 2013 Lancet-Study on the Global-Burden of Disease, chronic diseases pose the greatest threat to human health (Shaker et al., 2022). Undue alcohol usage, high blood-pressure, gender, and advanced age are all factors that enlarge a patient's likelihood of emergent this disease. In high-income nations like the United States, where chronic diseases accounted for 87% of fatalities, these problems are common. However, low and middle-income countries require special attention because of the rise in the incidence of chronic diseases. To to the author: "In the slums of today's megacities, we are seeing non-communicable diseases caused by unhealthy diets and habits, side by side with undernutrition (Tiwari et al., 2022)." Angiography is one of the standard diagnostic tools for coronary heart disease, but it comes with a number of limitations, including a high price tag, a number of potential side effects, and a need for extensive technical knowledge.

Clinical decision-making can be aided by employing predictive models to identify individuals at high risk, as recommended by a number of CVD evaluation and care guidelines. Because of this, most existing models have little predictive ability, and more development is necessary. ML strategies have proven to be very useful anticipations in the field of cardiovascular research (Dhanalakshmi et al., 2022; Ahmed et al., 2024). They do a better job of representing the interdependencies and nonlinear relationships between the variables and the outcomes than do traditional statistical models. The largest cause of death worldwide is cardiovascular disease (10), which includes heart conditions such CAD and atrial-fibrillation. The prevalence of CVD is increasing rapidly as people's livelihood values rise and their anxiety also remain high. Recent projections suggest that CVD will kill over 23 million persons worldwide by 2030. Figure 1 depicts the relationships between risk factors for cardiovascular disease, such as age, gender, BMI, height, and torso length (Wong et al., 2022).

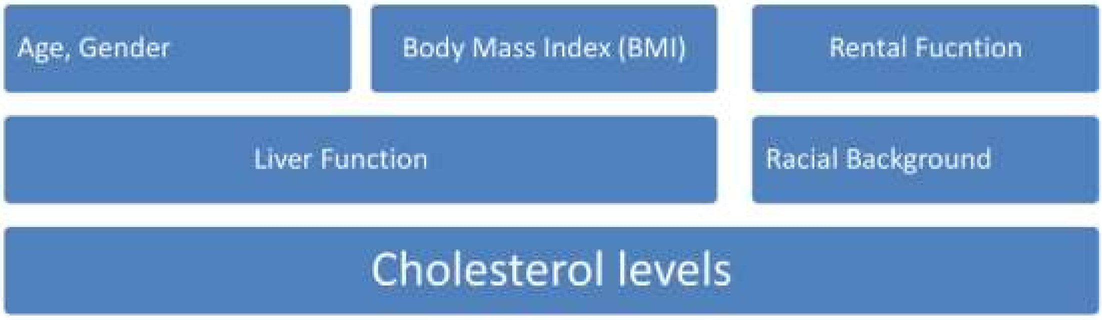

Figure.1.Various factors controlling occurrence in CVD

The complicated interconnections between these elements can play a role in the onset of a wide range of health issues. Because there are so many risk factors, conventional statistical methods cannot capture all of the intricate associations between them. The Internet-of-Things has been proven to be extremely important in today's world of big data (Sabitha et al., 2022). As a result, patients can now use technologies like smart medications and smart bracelets to track their vital signs and provide valuable information during a pandemic. This occurs as IoT data becomes increasingly commonplace in hospital settings. First, we will standardize medical data in an effort to examine unidentified threats (Suneel et al., 2024). These potential risk factors may show associations with illness occurrence, providing potential mechanistic insights. Furthermore, the analysis of massive volumes of data is required for disease incidence prediction models to be accurate (29, 30). Artificial intelligence (AI) and large datasets are increasingly being used in the prediction of CVD models (Nadakinamani et al., 2022).

Women's cardiovascular health has received much less attention than men have since heart disease has traditionally been seen as a disease of men. WHO announced the first set of clinical guidelines for preventing cardiovascular disease in women in 1999. Women's heart disease awareness increased from 30% in 1997 to 54% in 2009. (Reddy et al., 2022). Optimization is the process of evaluating a number of potential answers to a problem and selecting the best one. An optimization algorithm can be used to determine the minimum value of a function. Gradient descent is used to update model parameters in machine learning. In neural networks, parameters are weights (Baashar et al., 2022), but this varies from algorithm to algorithm. It is believed that the current challenges that doctors and patients encounter while trying to diagnose cardiac disease could be mitigated with the creation of a strategy based on GDO. Since the system's primary goal is to improve the accuracy of diagnosis, its primary goal is to reduce mortality from heart disease. Therefore, a timely prevention plan might eradicate the disease at its core and the neural network system would eradicate the fault on the part of the medicinal specialists (Algahtani et al., 2022).

However, this study would need to be organized around a particular dataset that will effectively feature the data of analysis of different people who have previously been diagnosed with probable cardiac disease. This study's major goal is to determine the neural network pattern among diagnosed patients by tracing the many processes of diagnosis (validation, testing, etc.). In this article, a fresh AI-based strategy is proposed for the detection of cardiac disorders. Based on these symptoms, the suggested smart system classifies heart disease as either positive or negative. Since heart failure is a leading cause of death, it is crucial that we find a way to diagnose heart illness early and accurately. Reliable, affordable infrastructure is a major challenge for healthcare organizations (e.g., medical clinics, hospitals). The current models' key issues are their accuracy, utility, and reliability. The objective of this study is to recognize the most promising ML strategy for enlarging the accuracy CVD diagnostics.

The study's primary originality and contribution are as follows:

- Collecting information from novel cardiac characteristics
- We then began by standardizing the data and partitioning the CVD dataset into train &test.
- CVD incidence anticipation and classification utilizing ML strategies
- Finally, we will compare the outcomes of multiple assessments of performance metrics.
- This paper follows the subsequent structure: In Section2, we provide an analysis of the relevant literature. Models with feature selection are implemented in Section3. In Section4, we present the experimental outcomes of various machine learning models. Section 5 provides the summarization of the article.

Methodology

Any classification that pertains to the selection of Features plays an important role. Later on, swarm algorithms are proposed, and their subsequent performance for feature selection proves to be quite beneficial. The research that has been done on how heart disease should be categorized can be found in the published works. One of these is the research (Sucharitha et al., 2022) conducted on hybrid intelligent modeling approaches for the classification of HD. The prediction of HD is based on thirteen different risk factors in this article. This research (L K S et al., 2021), in contrast to other approaches that have been taken, suggests using a novel strategy to accomplish the numerous risk factors. This is comprised of three different regression techniques: multivariate-adaptive-regression (MAR), logistic-regression (LR), and ANN. In the beginning, LR and MAR are utilized in order to decrease the encoded values of risk factors. The remainder of the encoded parameters is subsequently incorporated into the training of the ANN. The results of the simulation reveal that the hybrid method achieves better outcomes than the traditional single-stage NN. The research conducted (Muthappa et al., 2023) on the application of data analytics to the forecasting of HDs included a comparison of the efficiencies of the NB and DT techniques. The findings showed that the DT produced significantly more flourishing results than the NB algorithm, which provided an exactness of 98.2%.

The fields of data science and medical care are both expanding, which means there will soon be a greater demand for automated diagnostic tools. The work of data scientists has resulted in the creation of a number of models that have been of assistance in the field of medical treatment. Neural networks, Naive Bayes classifiers, and associative categorization have all been demonstrated to be effective diagnostic tools for coronary heart disease in earlier research. This is due to the fact that associative-classification offers lofty data exactness in addition to data-flexibility, both of which are lacking in classical classifiers (Kumar et al., 2023). A data mining technique was developed for the purpose of data collection and predictive modeling in order to facilitate the process of developing a classifier for heart disease. The authors mined one thousand patient records from CHD patients and used a SVM, ANN, and a DT to classify the data into binary categories (Abdalrada et al., 2022). The approaches each had an accuracy of 91%, and together they produced an accuracy of 89.6%.

Another author utilized ensemble to improve the reliability of the data as well as the precision of the data. Bagging and boosting were utilized by the author when working with NB and MLPNN. When it came to forecasting coronary heart disease, these ensemble strategies brought the accuracy up by 8.12 percentage points (Chillakuru et al., 2023). The application of SVMs in the field of disease prediction has been shown to be beneficial. When it came to perfecting the features, Majid Feshki relied on techniques such as feed-forward backpropagation neural networks and particle swarm optimization. The accuracy of the approaches was determined to be 91.94% (Bhaskar et al., 2023). The Maximal Frequent Itemset Algorithm (MAFIA) was used to mine the data, and the K-Means was applied in order to extract features from the frequent patterns that were found. In conclusion, Muhammad, Tahir, and their colleagues carried out an exhaustive study of base classifiers with the purpose of making a prediction regarding coronary heart disease (Liu et al., 2022). With an exactness of 92.09% and AUC of 98.21%, the Extra-Tree Classifier (ETC) was shown to be the most successful. After it came the Gradient Boosting method, which had an exactness of 93.16%. The effect of feature selection techniques like Lasso and Relief was also highlighted in the study.

The diagnosis of CHD has also been shown to benefit from the utilization of clustering methodologies. Data scientists evaluated and contrasted a variety of clustering methods, including EM, Cobweb, K-Means, and Farthest First, amongst others. When it came to identifying coronary heart disease, a strategy that focused on density proved to be the most successful. The innovative model achieved an accuracy of 83% in its predictions. The use of ensemble methods has demonstrated remarkable efficacy in the diagnosis of cardiac disease. A team of investigators (Shanmugaraja et al., 2023) examined and contrasted three models: c4.5, j4.8, and the bagging. Based on their findings, they came to the conclusion that the bagging algorithm was the superior, with an exactness of 84.37%. This illustrates the breadth of possibilities for ensemble approaches. Researchers (Shaker Reddy et al., 2023) brought together a number of different models and evaluated the advantages of each one. The effective approach was developed by fusing a fuzzy version of the NB with a genetic one. This was accurate to 97.14% of the time. A number of researchers (Dritsa et al., 2022) contributed to the development of a cost function in order to circumvent the shortcomings of the older ensemble methods, which included limited accuracy and feature selection. According to research conclusions, ensemble frameworks offer a potential solution to the challenge of making accurate predictions from an imbalanced dataset. This was done using the participants in the study who were at the greatest risk for developing the disease. The findings of the trials allowed for the creation of a radio frequency approach that is more appropriate to the eastern region of China.

To make an accurate diagnosis of heart failure from the information provided, professionals in the medical field require a complete diagnostic tool. In the example of the fuzzy expert system that was provided, the most important processes were called Fuzzification, Rule Base, and Defuzzification respectively (Reddy et al., 2021). MATLAB Fuzzy Logic Toolbox was utilized throughout the development of the system, and Mamdani Fuzzy Interface System (MFIS) was put into action. Both accuracy and sensitivity were examined, and the results showed that they were very high (Sampath et al., 2023). Accuracy was 94.50%, while sensitivity was 90.19%. Both the DNN anticipation and the DNN training classification model were combined to create the DNN learning model. These two subsystems are also recognized as the DNN learning approaches constituent parts. During the initial stage, a DNN training class was implemented, and once the final weights had been achieved, the diagnosis was performed using the deep neural network. When compared to a conventional MLPNN, a DNN includes an increased number of hidden layers. For the objective of anticipating CVD, ML strategies have been the subject of substantial research (Reddy et al., 2021). On the dataset obtained from the UCI MLR, data mining methods such as NB, LR, DT, and RF have been applied. Based on these performance methods, it was determined that the RF achieved the top accuracy for predicting HD, which was found to be 90.16 percent (Ahmed et al., 2021).

Experimental Design

Emulating a decision-making that is able to detect CVD utilizing binary-classification is an important part of the design process for an intelligent system. It uses human indications as inputs will attempt to diagnose the illness. Instead of relying on procedural code, the operation of a classic expert system is carried out with the assistance of if-then rules. On the other hand, in the workplace, if-then-else rules have been replaced with machine learning algorithms in order to construct intelligent systems. After passing through a number of critical stages, the intelligent system produces output. After the data has been preprocessed, it is transferred to binary classification algorithms in order to undergo training and validation. The accuracies and sensitivities of the results provided by the GDO, K-NN, NB, ANN, & RF are contrast to one another. Figure 2 presents a diagrammatic representation of the design of the proposed framework. The diagnosis of cardiovascular illness is handled by the intelligent system, which has several stages to choose from.

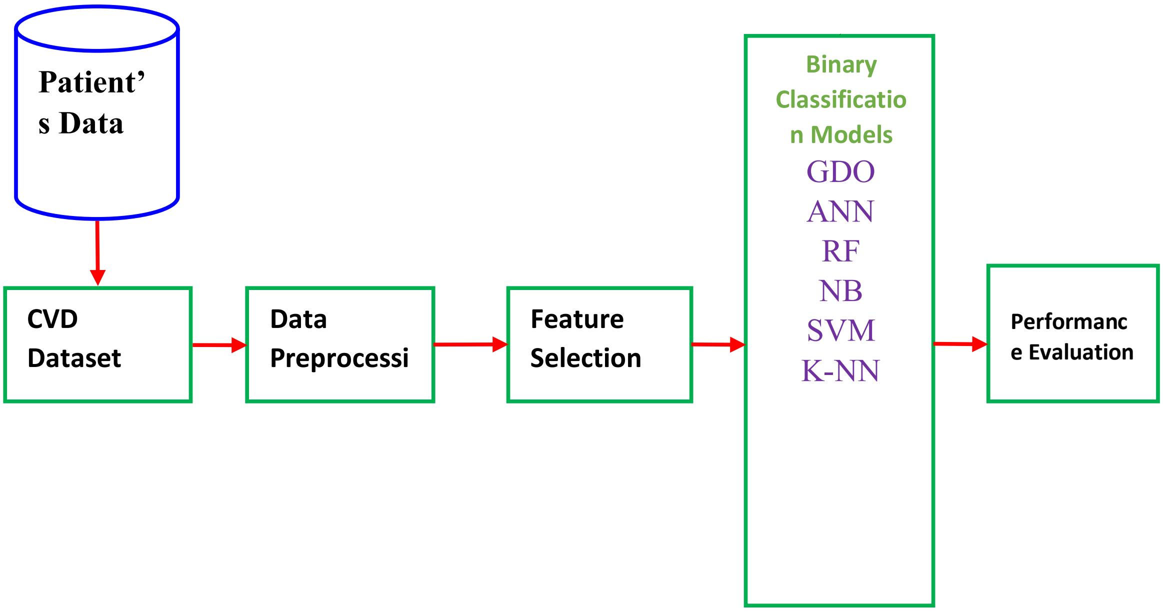

Figure 2. Concept diagram of proposed model.

Dataset Description

The dataset that was utilized in this investigation was retrieved from the repository at UCI. In order to identify instances of heart illness, training &testing, of an algorithm called Intelligent CVD anticipation Empowered with GDO strategy are carried out on the Cleveland dataset. The dataset can be accessed online and used for instructional and instructional purposes. This data set includes 14 features, including human qualities and biological properties. These characteristics were compiled from a variety of sources. There are 1384 patient records included in the dataset. There are a total of 622 healthy samples and 762 sick samples in this study. The collection includes records from 956 male samples and 428 female samples in total.

Model Building

Figure 3 depicts the framework of intelligent CVD anticipation that is equipped with GDO. In order to gather information for the proposed model, datasets that may be found in UCIMLR are used. The approach that is being given can be broken down into dual levels: training &validation phase. During the first level, there are four levels that are respectively referred to as the sensor, object, preprocessing &application layer. The first layer acquires in the inputs from the dataset, such as age, sex, the type of chest discomfort the patient is experiencing, thallium, and so on. These inputs are sent from the sensor to object layer over some sort of wireless link, which may result in the introduction of certain noisy values. The acquired data are sent from the Object layer to the Data Preprocessing layer, where any noise that may be present in the data is dealt with using various methods such as moving average, mean, etc.

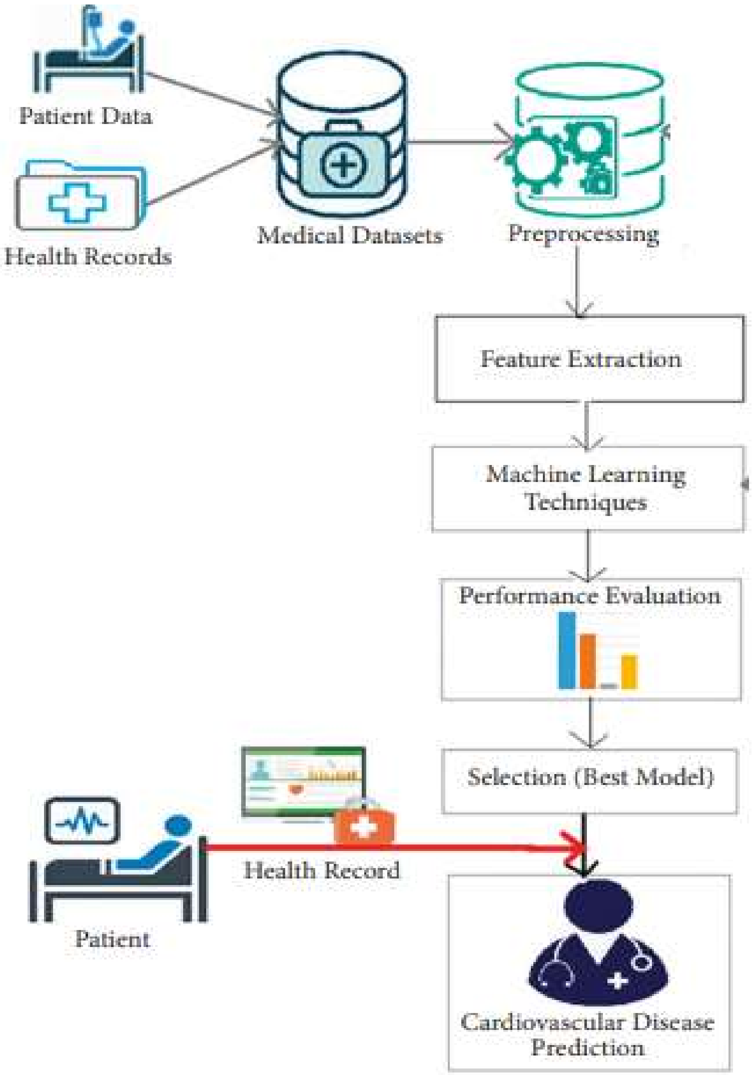

Figure 3. Workflow diagram of the proposed model

Following the completion of any necessary preprocessing, the data will be transferred to application layer, which is composed of an extra two sub-layers: the prediction &performance-evaluation layer. In this stage of development, the training of the suggested model is accomplished through the application of the GDO approach. After the training has been completed, an assessment is made of the system's accuracy, sensitivity, specificity, and precision. The training phase is considered ended and the outcomes are saved on the server in preparation for the next phase if the required training criteria are satisfied. Otherwise, the system is retrained with GDO in order to satisfy the training requirements. The next phase of the intelligent approach is used for the evaluation of CVDs, and the data for the system's input comes from a dataset that is located in the UCIMLR, Irvine. This information is taken into consideration by the trained approach to determine whether or not CVD is present.

Results and Discussion

In order to improve the accurateness of the diagnosis of cardiovascular disease, a new model called "Intelligent Cardiovascular Disease Prediction Empowered with Gradient Descent Optimization" has been presented. This model uses the same dataset to train a variety of ML strategies, including ANN, RF, KNN, SVM, and NB. Investigation results showed that the suggested model predicted CVD with superior accuracy, sensitivity & specificity. The comparison of the outcomes of the performance investigation of ML strategies, with the results of the Proposed GDO framework is included in the results. In addition, performance is evaluated using various measures of classification accuracy. These measurements include the counting of True Positive and False Positive factors, as well as the creation of a comparison graph for the two factors.

Accuracy (Acc) is calculated by using equation 1

$$\text{Acc} = \frac{Tr_{Positive} + Tr_{Negative}}{Tr_{Positive} + Tr_{Negative} + Fa_{Positive} + Fa_{Negative}} \quad (1)$$

Sensitivity (Se) and Specificity (Sp) are computed using equations (2) & (3) respectively.

$$\text{Se} = \frac{Tr_{Positive}}{Tr_{Positive} + Fa_{Negative}} \quad (2)$$

$$\text{Sp} = \frac{Tr_{Negative}}{Tr_{Negative} + Fa_{Negative}} \quad (3)$$

Table 1 presents the outcomes of an analysis of the proposed framework performance utilizing a variety of train-test ratios. Table 2 displays the average accuracy of the gradient descent optimization model after k-fold cross-validation has been applied with the value of k set to 5, 10, 15, and 20.

Table 1. Outcomes achieved by the proposed model with diverse train-test ration

Train/Test Ratio	Acc (%)	Se (%)	Sp (%)
60/40	97.3	99.12	97.12
75/25	99.62	99.65	97.36
80/20	96.31	97.21	98.54
90/10	98.01	98.69	97.01

Table 2. Outcomes achieved by the proposed model with K-fold cross-validation

K-Fold	Acc (%)
5	98.68
10	98.23
15	98.78
20	99.01

Calculations are made to determine the accuracy, sensitivity, and specificity of GDO, NB, SVM, K-NN, RF, and ANN. Table 3 presents a contrast of the performance of the proposed GDO with NB, SVM, K-NN, RF, &ANN. This analysis was carried out using gradient descent optimization.

Table 3. Simulation results proposed model

Model	Acc (%)	Se (%)	Sp(%)
SVM	77	74	76
K-NN	67.84	69	65
NB	84	77	86
ANN	96.28	96.12	96.27
RF	93.54	92.57	94.21
GDO	99.62	99.65	98.54

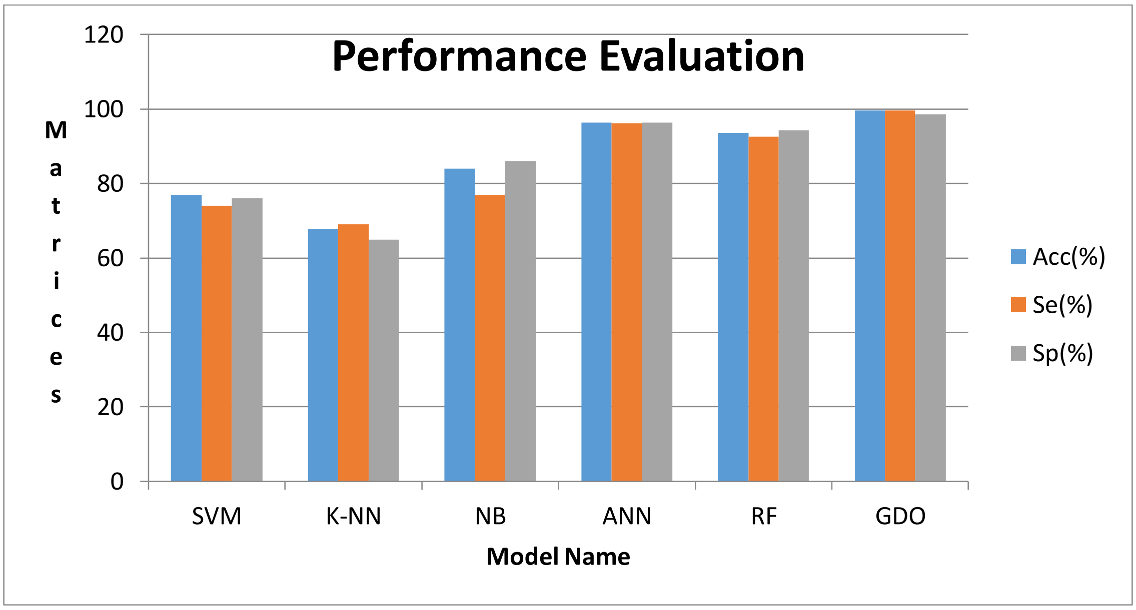

Figure 4. Performance Assessment of proposed models

It was discovered that the Gradient Descent Optimization (GDO)-based model enabled the classification module to function with the highest possible accuracy and precision value. The automatic selection of characteristics for binary classification enabled GDO to achieve its highest level of accuracy, which was 99.62%. With a classification success rate of 96.28 percent, ANN has achieved the second highest possible level of accuracy. The accuracy that Naive Bayes generates is 84%, which is considered to be quite respectable but is not quite up to the mark. On the UCI data set, it has been reported that SVM finds with a good amount of accuracy. When compared to other approachessuch as ANN and K-NN, SVM only achieved an accuracy of 77%. This is an extremely low percentage. The accuracy achieved by Random Forest is 93.54%. Additionally, it has been noticed that the proposed model (GDO) achieved a higher degree of accuracy as a consequence of the automatic selection of features. A graphical comparison of various machine learning strategies is presented in Figure 4.

Comparative Study

In terms of performance, the recently presented model has been contrasted with research models that have only recently been published. It has been demonstrated that the proposed model has given results that are significantly more accurate than those obtained from earlier research models. The comparison results from the various models are included in tables 4 and figure 5 respectively.

Table 4. Comparison of the proposed model with existing works

Model	Acc (%)
SVM	94.18
Deep Neural Network Based System	92.54
Fuzzy Expert System	90.27
Proposed Approach	99.62

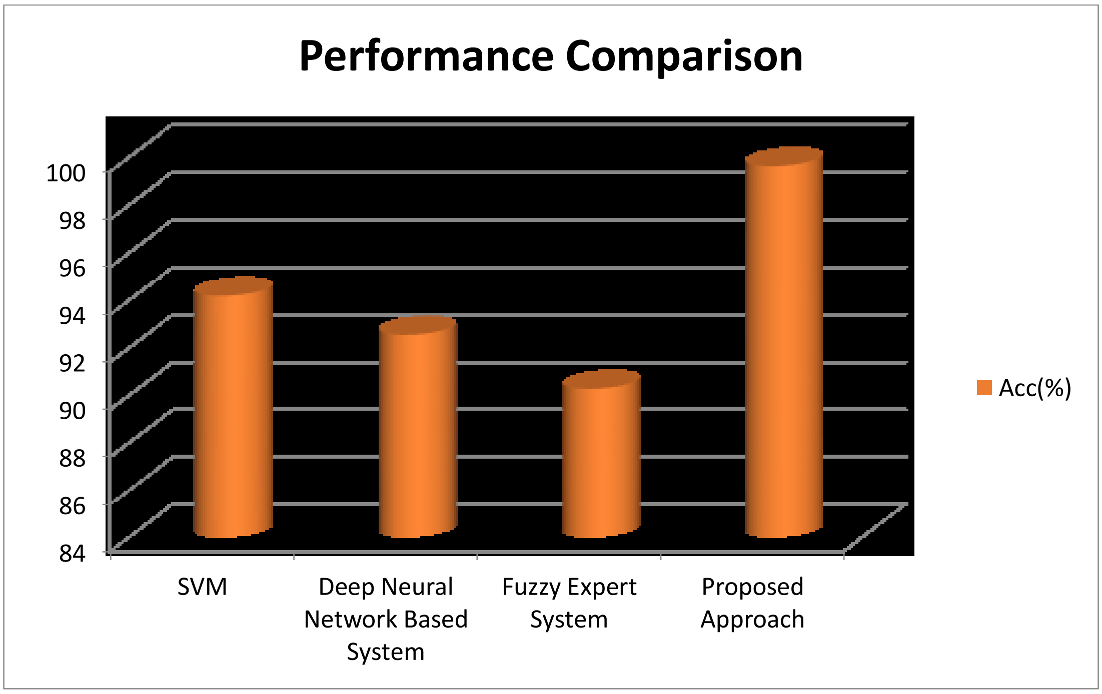

Figure 5. Proposed model Acc comparison with existing works

Conclusion

Because of the prevalence of cardiovascular illness, research into cardiovascular disease is one of the main active areas in the modern era. This is due to the fact that cardiovascular disease is so serious. According to data and statistics that were made public by the WHO in 2017, cardiovascular diseases were directly responsible for the deaths of around 17.9 million persons worldwide. For the study of CVD, various strategies have been utilized; nonetheless, the accuracy of anticipation and recognition has remained the primary priority throughout this endeavor. The performance of cardiovascular disease detection has been demonstrated to improve significantly, as this research demonstrates. This research will have a greater influence as a result of the fact that the proposed system is noticeably superior to the majority of the existing methodologies in terms of its accuracy, precision, sensitivity, and specificity. In this research study, comparative studies were also included as a topic of discussion. It has been determined that the accuracy, sensitivity, and specificity of the test are, respectively, 99.62%, 99.65%, and 98.54%. This research is carried out using a small sample size of approximately 1384 occurrences. Deep extreme machine learning will be able to improve the diagnostic process in the future by making use of larger datasets that contain a larger number of parameters, as well as fused datasets that can be created by joining two separate datasets. These types of datasets will be used.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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References

Abdalrada, A.S., Abawajy, J., Al-Quraishi, T. and Islam, S.M.S., (2022). Machine learning models for prediction of co-occurrence of diabetes and cardiovascular diseases: a retrospective cohort study. *Journal of Diabetes & Metabolic Disorders*, *21*(1), pp.251-261.

Ahmed, S. T., Singh, D. K., Basha, S. M., Abouel Nasr, E., Kamrani, A. K., & Aboudaif, M. K. (2021). Neural network based mental depression identification and sentiments classification technique from speech signals: A COVID-19 Focused Pandemic Study. *Frontiers in public health*, *9*, 781827.

Ahmed, S. T., Vinoth Kumar, V., Mahesh, T. R., Narasimha Prasad, L. V., Velmurugan, A. K., Muthukumaran, V., & Niveditha, V. R. (2024). FedOPT: federated learning-based heterogeneous resource recommendation and optimization for edge computing. *Soft Computing*, 1-12.

Alqahtani, A., Alsubai, S., Sha, M., Vilcekova, L. and Javed, T., (2022). Cardiovascular disease detection using ensemble learning. *Computational Intelligence and Neuroscience*, *2022*.

Ashok, K., Boddu, R., Syed, S.A., Sonawane, V.R., Dabhade, R.G. and Reddy, P.C.S., (2023). GAN Base feedback analysis system for industrial IOT networks. *Automatika*, *64*(2), pp.259-267.

Baashar, Y., Alkawsi, G., Alhussian, H., Capretz, L.F., Alwadain, A., Alkahtani, A.A. and Almomani, M., (2022). Effectiveness of artificial intelligence models for cardiovascular disease prediction: network meta-analysis. *Computational intelligence and neuroscience*, *2022*.

Baskar, S., Nandhini, I., Prasad, M. L., Katale, T., Sharma, N., & Reddy, P. C. S. (2023, November). An Accurate Prediction and Diagnosis of Alzheimer's Disease using Deep Learning. In 2023 IEEE North Karnataka Subsection Flagship International Conference (NKCon) (pp. 1-7). IEEE.

Chillakuru, P., Madiajagan, M., Prashanth, K.V., Ambala, S., Shaker Reddy, P.C. and Pavan, J., (2023). Enhancing wind power monitoring through motion deblurring with modified GoogleNet algorithm. *Soft Computing*, pp.1-11.

Dhanalakshmi, R., Bhavani, N.P.G., Raju, S.S., Shaker Reddy, P.C., Marvaluru, D., Singh, D.P. and Batu, A., (2022). Onboard pointing error detection and estimation of observation satellite data using extended kalman filter. *Computational Intelligence and Neuroscience*, *2022*.

Dritsas, E., Alexiou, S. and Moustakas, K., (2022), April. Cardiovascular Disease Risk Prediction with Supervised Machine Learning Techniques. In *ICT4AWE* (pp. 315-321).

Guleria, P., Naga Srinivasu, P., Ahmed, S., Almusallam, N. and Alarfaj, F.K., (2022). XAI framework for cardiovascular disease prediction using classification techniques. *Electronics*, *11*(24), p.4086.

Kumar, K., Pande, S.V., Kumar, T., Saini, P., Chaturvedi, A., Reddy, P.C.S. and Shah, K.B., 2023. Intelligent controller design and fault prediction using machine learning model. *International Transactions on Electrical Energy Systems*, *2023*.

Liu, J., Dong, X., Zhao, H. and Tian, Y., (2022). Predictive classifier for cardiovascular disease based on stacking model fusion. *Processes*, *10*(4), p.749.

LK, S. S., Ahmed, S. T., Anitha, K., & Pushpa, M. K. (2021, November). COVID-19 outbreak based coronary heart diseases (CHD) prediction using SVM and risk factor validation. In *2021 Innovations in Power and Advanced Computing Technologies (i-PACT)* (pp. 1-5). IEEE.

Muthappa, K.A., Nisha, A.S.A., Shastri, R., Avasthi, V. and Reddy, P.C.S., (2023). Design of high-speed, low-power non-volatile master slave flip flop (NVMSFF) for memory registers designs. *Applied Nanoscience*, pp.1-10.

Nadakinamani, R.G., Reyana, A., Kautish, S., Vibith, A.S., Gupta, Y., Abdelwahab, S.F. and Mohamed, A.W., (2022). Clinical data analysis for prediction of cardiovascular disease using machine learning techniques. *Computational intelligence and neuroscience*, *2022*.

Reddy, P.C., Nachiyappan, S., Ramakrishna, V., Senthil, R. and Sajid Anwer, M.D., (2021). Hybrid model using scrum methodology for softwar development system. *J Nucl Ene Sci Power Generat Techno*, *10*(9), p.2.

Reddy, P.C.S., Pradeepa, M., Venkatakiran, S., Walia, R. and Saravanan, M., (2021). Image and signal processing in the underwater environment. *J Nucl Ene Sci Power Generat Techno*, *10*(9), p.2.

Reddy, P.C.S., Suryanarayana, G. and Yadala, S., (2022), November. Data analytics in farming: rice price prediction in Andhra Pradesh. In *2022 5th International Conference on Multimedia, Signal Processing and Communication Technologies (IMPACT)* (pp. 1-5). IEEE.

Rustam, F., Ishaq, A., Munir, K., Almutairi, M., Aslam, N. and Ashraf, I., (2022). Incorporating CNN Features for Optimizing Performance of Ensemble Classifier for Cardiovascular Disease Prediction. *Diagnostics*, *12*(6), p.1474.

Sabitha, R., Shukla, A.P., Mehbodniya, A., Shakkeera, L. and Reddy, P.C.S., (2022). A Fuzzy Trust Evaluation of Cloud Collaboration Outlier Detection in Wireless Sensor Networks. *Adhoc & Sensor Wireless Networks*, *53*.

Sampath, S., Parameswari, R., Prasad, M.L., Kumar, D.A., Hussain, M.M. and Reddy, P.C.S., 2023, December. Ensemble Nonlinear Machine Learning Model for Chronic Kidney Diseases Prediction. In 2023 IEEE 3rd Mysore Sub Section International Conference (MysuruCon) (pp. 1-6). IEEE.

Shaker Reddy, P.C. and Sucharitha, Y., (2022). IoT-Enabled Energy-efficient Multipath Power Control for Underwater Sensor Networks. *International Journal of Sensors Wireless Communications and Control*, *12*(6), pp.478-494.

Shaker Reddy, P.C. and Sucharitha, Y., (2023). A Design and Challenges in Energy Optimizing CR-Wireless Sensor Networks. *Recent Advances in Computer Science and Communications (Formerly: Recent Patents on Computer Science)*, *16*(5), pp.82-92.

Shanmugaraja, P., Bhardwaj, M., Mehbodniya, A., VALI, S. and Reddy, P.C.S., (2023). An Efficient Clustered M-path Sinkhole Attack Detection (MSAD) Algorithm for Wireless Sensor Networks. *Adhoc & Sensor Wireless Networks*, *55*.

Sucharitha, Y. and Shaker Reddy, P.C., (2022). An autonomous adaptive enhancement method based on learning to optimize heterogeneous network selection. *International Journal of Sensors Wireless Communications and Control*, *12*(7), pp.495-509.

Sucharitha, Y., Reddy, P.C.S. and Suryanarayana, G., (2023). Network Intrusion Detection of Drones Using Recurrent Neural Networks. *Drone Technology: Future Trends and Practical Applications*, pp.375-392.

Suneel, S., Balaram, A., Amina Begum, M., Umapathy, K., Reddy, P. C. S., & Talasila, V. (2024). Quantum mesh neural network model in precise image diagnosing. Optical and Quantum Electronics, 56(4), 559.

Tiwari, A., Chugh, A. and Sharma, A., (2022). Ensemble framework for cardiovascular disease prediction. *Computers in Biology and Medicine*, *146*, p.105624.

Wong, D.Y., Lam, M.C., Ran, A. and Cheung, C.Y., (2022). Artificial intelligence in retinal imaging for cardiovascular disease prediction: current trends and future directions. *Current Opinion in Ophthalmology*, *33*(5), pp.440-446.

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