NDOL: An Enhanced Heart Disease Prediction System Using Artificial Intelligence (AI) Assisted Neural Decision Optimization Logic

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Keywords: Deep Learning, Heart Disease, Artificial Intelligence, Disease Prediction, AI, Neural Decision Optimization, NDOL, Support Vector Machine, SVM.

Abstract: Since cardiovascular diseases (CVD) remain one of the global leading causes of mortality, the urgent need for new diagnostics and preventative therapies is evident. These are classified as a significant physical condition leading to a high probability of death. Heart disease must then be diagnosed effectively and quickly to avoid further harm to individuals. This study thus investigates whether a learning technique derived from Artificial Intelligence (AI)- Neural Decision Optimization Logic (NDOL) - can be used to predict cardiac illnesses to enable timely treatments and personalized healthcare plans. The suggested model is cross-validated with a common learning model, Support Vector Machine (SVM) to investigate how well the proposed model performs. ML tech, applied to vast volumes of data to identify complex patterns and possibilities of danger from certain combinations that the naked eye cannot see, is what enables these ML models. Some of the important technologies used to predict the probability of heart disease are neural networks, decision trees, and ensemble learning. Also, this study further demonstrates the implementation of artificial intelligence technologies in the clinical workflow to give timely risk assessment and improve patient care and resource distribution. The goal of proactive and precision medicine may be within our reach through AI-enabled heart disease prediction which will combine technical ingenuity with medical expertise to revolutionize cardiovascular health care.

1 INTRODUCTION

The advent of artificial intelligence has revolutionized healthcare sector especially in diagnosis, treatment planning and prevention 1(Archana Singh, et al., 2020). Predicting cardiovascular disease is one of the most promising applications for artificial intelligence. We cannot stress enough the need for early identification and appropriate management, as heart disease remains the leading cause of death worldwide. Clinical exams, imaging and blood testing are the hallmarks of traditional heart disease diagnosis; however, those tools don't always catch threats early enough to prevent a fatal event. This is where AI-powered systems come into their own. AI-Powered Heart Disease Forewarning: By applying machine learning (ML) algorithms, this technology analyses extensive and diverse datasets, such as clinical data, past medical history, test results, genetic markers, and lifestyle patterns, to identify trends that may indicate a greater risk of cardiovascular conditions. AI data-driven heart condition prediction enables early risk detection of heart diseases so that care providers initiate preventative therapeutic treatments or recommend lifestyle modifications for these patients 4.

Artificial intelligence methods used to predict cardiac complications are brain networks, ensemble learning, decision trees, neural networks.] These models can manage and analyse complex data which often uncover latent associations, unlike more traditional techniques. Correlations between predictors such as age, prior smoking, blood pressure, cholesterol, and diabetes create a fuller picture of the individual's risk profile. After training, these artificial intelligence (AI) models demonstrate remarkable precision in predicting the risk of the cardiovascular disease. AI systems continuously learn and improve over time as they are exposed to new data, ensuring that. In addition, these models analyse huge amounts

Venkatasalam, K., Desikan, M., Selvan, S. K., Saranraj, B. and Basha, A. S.
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DOI: 10.5220/0013871100004919

In *Proceedings of the 1st International Conference on Research and Development in Information, Communication, and Computing Technologies (ICRDICCT'25 2025) - Volume 1*, pages 672-679
ISBN: 978-989-758-777-1

of data at once, allowing doctors to act promptly for critical patients (Hosam El-Sofany, et al., 2024). AI-powered heart disease prediction systems have the potential to greatly enhance outcomes by enabling early intervention, reducing healthcare costs, and providing a more personalized approach to cardiovascular health. The incorporation of the AI in clinical practices would allow pre-emptive screening and diagnosis of cardiac ailments, making it possible for practitioners to make informed clinical decisions in the future 7.

The identification of these issues early on provides a means of preventing long-term health problems, including heart disease, the leading cause of death in the world. Traditional methods of spotting heart disease are not always speedy or dependable because they can overlook early symptoms or understated signs. For improvements, AI-based cardiac disease prediction tools are essential for faster and accurate assessments. These algorithms might breezily scour mountains of data a patient's medical records, their lifestyle choices, their test results to reveal hidden threats. This enables cardiac disease to be diagnosed in its earliest stages before encountering the symptoms when the doctors can take steps to intervene. AI also helps tailor therapy, as it can factor in individual risk factors and provide personalized advice. And by automating routine but necessary processes like risk assessments, AI systems might help free clinicians' time for patients with more acute conditions. Not just that, some of these AI-powered devices might work in real-time, monitoring a patient's vitals and altering their risk profile as appropriate. Saving lives, making healthcare much more efficient and better managing cardiac disease across the Globe is also what this kind of technology, 9.

Artificial intelligence-based heart disease prediction primarily aims to create a reliable technique to predict a person' risk of developing cardiovascular disease. One of the goals is to create an AI model capable of predicting the onset of cardiovascular disease on the basis of data acquired from multiple sources such as medical history, lifestyle habits, and test findings. The point of this approach is to detect any cardiac issues before symptoms appear, so that treatment can start sooner rather than later. The system will generate risk assessments that, based on individual patient medical history, can be used to determine customized treatment plans. Once incorporated into processes, healthcare providers will have much ease in employing it during routine health checks. The system automates the risk evaluation process, enabling medical personnel to spend more time and effort on the highest risk profile patients. The end goal is improved forecasts, lighter workloads for healthcare workers and better, more efficient treatment.

2 RELATED WORKS

At this time, cardiovascular disease ranks as the leading death globally. It is difficult to predict cardiac illness since it requires expertise and specific information (Padmakumari Pitchal, et al., 2024). Medical facilities have just recently started collecting sensor data using Internet of Things (IoT) technologies to improve cardiac disease diagnosis and prognosis. The results may not be trustworthy, despite the extensive research on heart disease diagnosis. The three primary steps of the automated model for predicting cardiac problems—preprocessing, feature extraction and prediction—are laid forth in this article. The input data is preprocessed by using an upgraded Z-score normalization. In order to train the prediction model, feature extraction is used to get the important features from the preprocessed data. Statistical features, information gain characteristics, and enhanced entropy are among the features that were retrieved. The Improved Quantum Convolutional Neural Network (IQCNN) uses the retrieved characteristics to make predictions. We compare the IQCNN's performance against that of previous systems using a number of parameters. The proposed IQCNN model achieves a learning rate of 70% and an accuracy of 0.91 when compared to more conventional methods for predicting cardiac problems.

Each year, millions of people die from heart disease, making it one of the most recognized and fatal diseases in the world (Ahmad Ayid Ahmad, et al., 2023). The only avenue to save people's lives is through early detection of this disease. Machine Learning (ML) is an artificial intelligence technique that can diagnose diseases quickly, easily, and inexpensively. Our objective is to create a machine learning model that can accurately forecast the onset of heart disease by analyzing the Cleveland heart disease dataset. Model performance is very sensitive to the properties of the training dataset and the ML technique chosen. The Jellyfish optimization approach was used to reduce the Cleveland dataset to a lower dimensional subspace in order to avoid overfitting. Overfitting is caused by the curse of dimensionality and happens when a dataset has too many characteristics. Finding the optimal

features is made easy with the Jellyfish algorithm's fast convergence speed and flexibility.

According to the World Health Organization, cardiac-related diseases have increased. Therefore, each year 17.9 million people die (Vijeta Sharma, et al, 2020). Detecting and treating these patients earlier is getting more difficult with the growing population. On the other hand, many studies have shown that the recent growth in technology has caused machine learning techniques to accelerate the health-care field. Hence, the purpose of this work is to build a machine learning model for the prediction of heart disease utilizing these significant characteristics. The heart disease prediction dataset at UCI served as a standard for this research; it contains fourteen separate characteristics related to cardiovascular disease. While building the model, many machine learning approaches were employed, including Decision Tree, Naive Bayes, Support Vector Machine (SVM), and Random Forest. As part of our study, we utilized traditional Machine Learning methods to identify correlations between the dataset's many properties, with the goal of applying these findings to the prediction of heart disease risk. As compared to other ML approaches, Random Forest provides more accurate predictions in less time, according to the results. As a decision-support system, this model can be useful for doctors in the clinic.

In the last several decades, cardiovascular illness (heart disease) has become the leading cause of mortality worldwide (Devansh Shah, et al., 2020). It includes a broad variety of cardiac conditions. There are a lot of things that may go wrong with a heart attack, and it's critical that we find ways to diagnose the condition quickly so that we can start treating it effectively. Healthcare organizations often use data mining as a method for coping with large data sets. In order to aid medical professionals in the prediction of heart illness, researchers examine large medical data sets using various data mining and machine learning methods. This research study's model exhibits several characteristics linked to heart illness; it is constructed using supervised learning techniques such Naïve Bayes, decision trees, K-nearest neighbors, and random forest. It draws on the Cleveland database at UCI, which already has information on people with cardiac disease. With 303 cases and 76 characteristics, the data is rather extensive. We can actually evaluate fourteen of those seventy-six attributes the ones that matter most for comparing algorithm performance. This study aims to assess the potential occurrence of cardiovascular disease in individuals. The results demonstrate that K-nearest neighbor offers the highest level of accuracy.

Important medical duties include cardiovascular disease diagnosis and prognosis to guarantee accurate categorization, which aids cardiologists in treating patients appropriately (Chintan M. Bhatt, et al., 2023). The ability of machine learning to identify patterns in data has led to an upsurge in its use in the medical field. To help diagnosticians decrease misdiagnosis, machine learning may be used to categorize the occurrence of cardiovascular illness. In an effort to lower the death toll from cardiovascular disorders, this study builds a model that can accurately forecast these conditions. In order to enhance classification accuracy, this research suggests a k-modes clustering algorithm that starts with Huang. We employ models like XGBoost, multilayer perceptron, decision tree classifier and random forest. In order to get the best possible outcome, the parameters of the applied model were hyper-tuned using GridSearchCV. We test the suggested model on a Kaggle dataset with 70,000 real-world examples. Here is how the models were trained using an 80:20 split of data and how they attained accuracy: In the decision tree model, 86.37% of the trials used cross-validation, while 86.53% did not. In the XGBoost model, 87.12% of the trials used cross-validation, while 87.05% used random forest. In the multilayer perceptron model, 87.28% used cross-validation, while 86.44% used non-validation. The models that have been suggested have AUC (area under the curve) values: XGBoost: 0.95, decision tree: 0.94, random forest: 0.95, multilayer perceptron: 0.95. Based on these foundational studies, we know that multilayer perceptron with cross-validation is the most accurate method currently available. With an accuracy of 87.28%, it was the most accurate.

3 METHODOLOGY

The significance of AI-based heart disease prediction is Early prediction of heart disease even before people develop any serious symptoms. When it is diagnosed early, patients may have a better treatment experience and better outcomes than if diagnosed late. AI can assist doctors in more accurately assessing a person's risk for heart disease by analysing a patient's history and other lifestyle factors. This technology will also improve the effect of health care, as it can accelerate the initial assessment of risk, and enable providers to focus on patients determined to have the greatest need. This technology is integrated seamlessly within healthcare systems, would provide efficiencies for hospitals and doctors. With AI system powered heart disease prediction services, more loved ones can be reached at varying environmental conditions

including under-resourced settings. Artificial intelligence and machine learning have been applied to the health sector to improve diagnosis, treatment, and patient care in various forms. These algorithms can whittle down huge databases in search of patterns and trends, offering the potential for better healthcare decision making.

Deep learning and AI have many possible applications in healthcare from disease prediction to therapy personalization and automating tedious tasks. Deep learning algorithms, for example, can often identify abnormalities such as tumours in X-rays and MRIs significantly faster than human doctors. AI can analyse factors such as blood pressure, cholesterol and lifestyle to predict diabetes, heart disease and other chronic diseases. Deep learning and artificial intelligence (AI), when used in the context of the health-care industry, could significantly reduce processing times for high-volume patient datasets. This will be extremely useful in risk assessment and suggesting preventive measures. These technologies also aid in personalized medicine by enabling therapies targeted to the needs of the patient through the analysis of their hereditary make-up and medical journey. Despite the promise of AI-assisted diagnostics, there are significant barriers to adoption, including the need for reliable datasets and the need to address patient privacy, as well as the issue of black-box AI models. However, AI and ML could transform healthcare to a more organized, accurate, and individualized experience, leading to better outcomes at lower costs.

Over the years, heart disease risk prediction has improved with the development of new risk assessments tools. Traditional risk factors, such as age, blood pressure, cholesterol, and smoking habits, are handled by models like the Framingham Risk Score. Statistical methods like logistic regression work, but can miss complex patterns in the data. Deep learning and deep learning methods combine big data to detect relationships that no one has observed before, yielding better predictions. Real-time health data (now available through smartwatches and other wearables) makes it much easier to monitor your health and catch any potential problems early. These advanced methods of modelling significantly enhance cardiac disease prevention and treatment when compared to previous models. Predicting cardiovascular disease is important, but not without hurdles. Data quality is a major concern simply due to the prevalence of erroneous or missing records in the medical record. These include heredity, lifestyle, and environment, all significant contributors to heart disease but are difficult to accurately represent in models. One complex model that performs well, but is rarely employed in the clinic, is deep learning, because it is simply too difficult for doctors to understand. The second part of the problem of data bias is that models trained on specific, rather than diverse, populations can have results that will be incorrect. And smaller clinics may not be able to afford the pricey, cutting-edge models, and there are concerns over the privacy and security of patient data. Finally, a majority of models are trained on outdated data, even though a user's health can change as time goes on. There are many problems that still need to be addressed for predictive models for heart diseases to become available and reliable.

AI-based heart disease prediction systems still have numerous unresolved matters. Firstly, the lack of diversity in training datasets results in many models' performing poorly when they are deployed in populations in the real world. The integration of these tools into pre-existing hospital workflows is also not easy. To make it worse, doctors may be reluctant to trust AI predictions if they're based on models that are hard to understand.

It is common for existing systems to depend on static data, which fails to consider how a patient's health evolves over time. Concerns around patient data privacy and ethics have not been addressed either. Having said that, a lot of room for growth exists and improving the accuracy of models for various groups of individuals may be achieved through the use of distinct datasets. Through the utilization of AI, wearable gadgets may offer the convenience of real-time health monitoring. Increasing confidence among healthcare practitioners can be achieved by making AI forecasts more understandable. Personalized treatment regimens for patients can also be assisted by AI. One last thing that can be done to enhance healthcare outcomes is to create systems that collaborate with doctors. The following figure 1 shows the system flow design and the following figure 2 shows the architectural diagram.

Filling such gaps and pursuing such opportunities can improve and make artificial intelligence systems more widely accepted. There are several steps involved in using AI to predict the incidence of cardiovascular disease. Data cleaning means combing through databases and medical records for errors and missing information. First the research team needs to decide which of the variables age, cholesterol, blood pressure, etc. deserve most of the researchers' attention. This data can be useful in training deep learning models such as neural networks and decision trees. Numerous performance metrics such as

precision and accuracy are used to valid and tune the model to ensure that it is as accurate as possible.

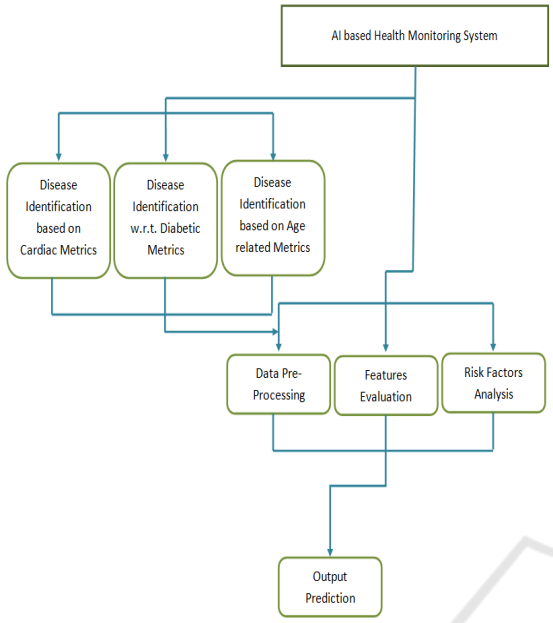

Figure 1: System Flow Design.

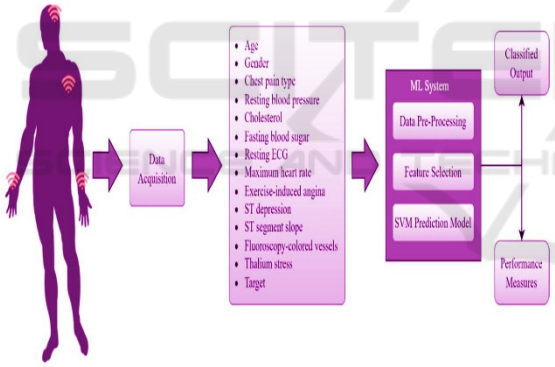

Figure 2: Architectural Diagram.

Finally, the model is built into a system that doctors can use to evaluate possible risks to their patients. This method provides assurance of the system's reliability and usefulness in predicting heart disease. The proposed methods NDOL achieves better prognostication with respect to CVDs over present SVM and enhance issues due to imbalanced data. The proposed system, NDOL, is an AI-driven early prediction system for cardiovascular disease that would help doctors to more accurately assess the risk for their patients. To assess vital signs such as age, cholesterol and blood pressure, the system first collects data from the patients' medical records and wearables, cleans it up to eliminate errors, before deploying it. The system has a very user-friendly user interface which helps Doctors as well as patients to easily view results and insights. In addition, it can streamline processes by integrating with other healthcare systems. This method can help improve patient outcomes in the form of early diagnosis, tailored treatment plans, and the management of cardiac disease.

- **Data Collection and Preprocessing:** To construct a system for the prediction of heart disease, data collection is the initial stage. Information is collected from a wide range of resources, including health records, questionnaires, publicly accessible databases, and wearable technology. Some examples of the types of information included in this data set are gender, age, BP, cholesterol, heart rate, and lifestyle choices. For reliable forecasts, you need data that is both varied and of high quality.
- **Data Preprocessing:** Before data can be analyzed, it must first be cleaned and structured. Cleaning and structuring comprise the following steps: Statistical methods are applied to impute missing data or otherwise remove incomplete records from the dataset, when missing data has been identified; Searching for and removing inconsistent data records; Normalizing values, when possible, to make numerical values more comparable with deep learning algorithms; and Encoding categorical (non-numerical) data, such as gender or lifestyle choice, into numerical representations that the model can understand. Pre-processing improves the prediction model's accuracy and reliability because it ensures the dataset is clean, consistent, and ready to train on.
- **Feature selection and Data Transformation:** An essential part of developing a system to anticipate cardiac problems is feature selection. The first step is to sort the dataset by the variables that affect the likelihood of heart disease. Type 2 diabetes, smoking, exercise, cholesterol, blood pressure, heart rate, and gender are all common characteristics. The accuracy of the model and the reduction of complexity caused by the elimination of extraneous data are both enhanced by selecting useful characteristics. Now that we are looking at the selected, previously discovered features, it is very important that the data is transformed into shapes that are suitable for deep learning

algorithms. This also includes Building scalable and Normalization, which is basically the process of outscoring the numerical variables (cholesterol values and blood pressure etc) so as to enhance the efficacy of the model. Encoding of categorical variables refers to converting categorical non-numerical variables, such as gender or lifestyle features, to numerical values, by techniques such as one-hot-encoding. Extract or combine features to improve the representation of a set of data. An example of this is using age and body mass index (BMI) to predict potential health problems and determining a more effective and accurate risk prediction in heart disease by selection and transformation of relevant features.

- **Developing the Model:** The model building process consists of several simple steps. The first of which is aggregating data from multiple touchpoints such as health devices and hospital data. The data is than cleansed for any errors present and it is also formatted in order to make it prepared for analyzing. Older age and cholesterol values are identified as features to be included in the model. Deep learning algorithms take this data as an input to train the model. After training the model, fine tuning is done to make predictions more accurate. Finally, the model is validated on new data to be sure it is accurate and how good the performance and reliability are. Such a method can be employed to build a model which accurately predicts whether or not a person is likely to develop heart disease.
- **Performance Measures:** Evaluation measures are used to evaluate the usefulness of the model for predicting cardiac events. Accuracy shows the total number of correct predictions. By observing the precision we can know how accurate the positive predictions (heart disease patients) are. Recall measures how well the model is capturing true positives.

4 RESULTS AND DISCUSSION

The use of NDOL and support vector machines (SVMs) to analyze complicated medical data for the purpose of heart disease prediction has greatly advanced the field of AI, which in turn has improved patient outcomes and early detection. One example is a research that suggested a new deep learning architecture for determining if a person has heart disease or not by utilizing optimization logics. Compared to more conventional classification algorithms, such as SVM, our model outperformed them with a total prediction accuracy of more than 98.39%. Research has demonstrated that deep learning models' prediction capabilities may be significantly improved by utilizing feature augmentation approaches. When combined with deep learning methods, these approaches allowed researchers to achieve a level of accuracy that was noticeably higher than that of earlier approaches. This paper's literature review sections emphasize the significance of model selection and the integration of diverse data sources to improve predictive accuracy, and they also highlight the effectiveness of different deep learning-based models in heart disease prediction. Developing models with high accuracy and reliability in heart disease prediction has been made possible by integrating AI and deep learning. In the long run, these innovations should lead to better cardiovascular health outcomes for patients by facilitating earlier diagnosis and treatment. Figures 3 and 4 show the proposed scheme's home page and about us page designs, respectively.

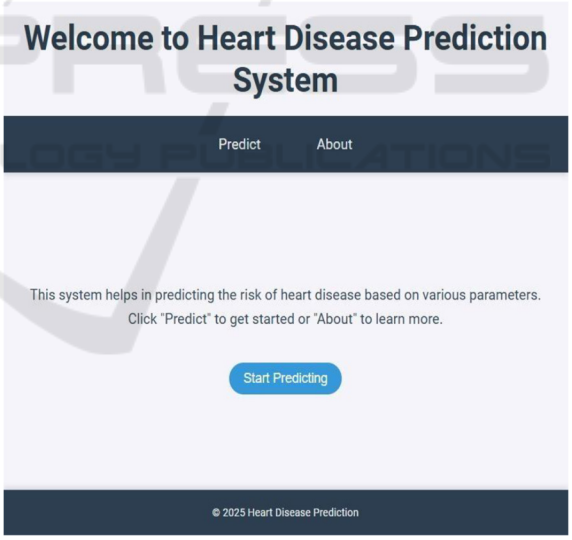

Figure 3: Home Page.

The proposed scheme's health data gathering portal and output prediction page architecture are shown in Figures 5 and 6, respectively.

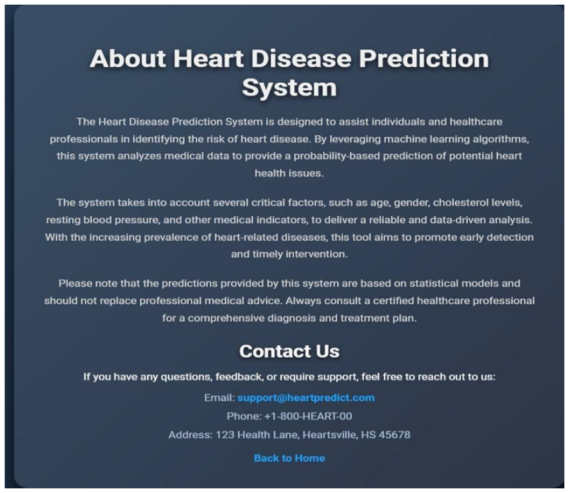

Figure 4: About Us Page.

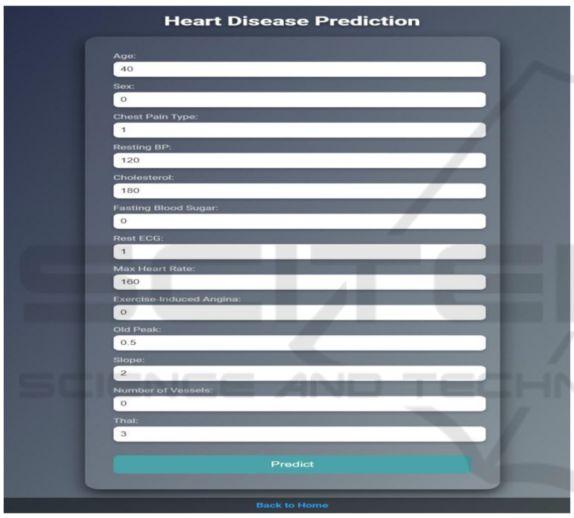

Figure 5: Health Data Collection Portal.

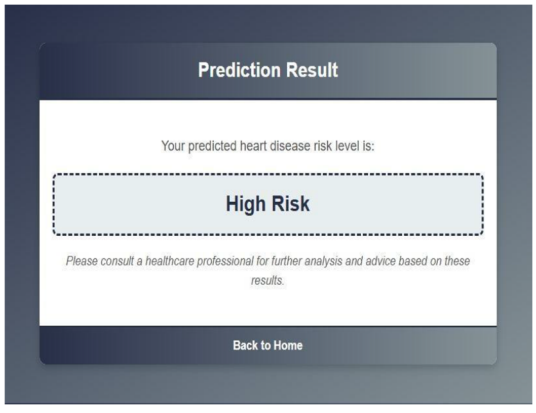

Figure 6: Output Prediction.

As shown in Figure 7, the proposed approach, NDOL, is cross-validated with the traditional learning model, Support Vector Machine (SVM), to see how accurate it is in making predictions. Table 1 provides a descriptive representation of the same.

Table 1: Comparison of Prediction Accuracy Between Svm and Ndol.

No. of Days Tested	SVM (%)	NDOL (%)
5	77.12	98.09
7	78.54	97.71
10	77.64	96.63
14	79.52	97.42
15	79.89	98.39
18	76.17	97.48
27	74.45	96.57
29	75.25	96.26
33	76.44	97.19
36	76.12	98.14

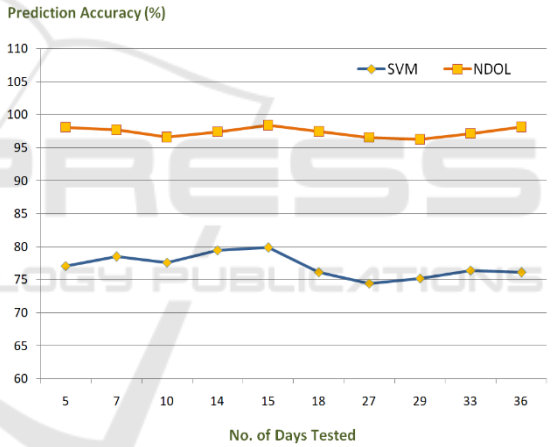

Figure 7: Prediction Accuracy.

5 CONCLUSION AND FUTURE SCOPE

Artificial intelligence (AI) offers enormous promise to revolutionize healthcare with its application to the prediction of cardiac disease. Artificial intelligence models can aid in the early identification and individualized therapy of cardiac disease by providing predictions that are accurate, fast, and consistent using sophisticated algorithms. Optimizing resource allocation and overall care delivery are two additional benefits of these systems that aid healthcare practitioners in identifying high-risk patients. AI's capacity to quickly and accurately

analyse huge amounts of data makes better clinical decisions, with less room for human error and overall better quality of care, possible. Additionally, its scalability allows it to be employed in various healthcare settings, from top hospitals to underserved areas, thus broadening the reach of healthcare globally. However, persistent oversight, collaboration between medical professionals and data scientists, and a focus on data security and privacy are all essential for the successful integration of AI into the healthcare system. AI heart disease prediction: A promising need in heart disease prediction leads to early diagnosis, improved patient outcomes, and a revolutionized healthcare system. Last but not least, AI-based prediction models of cardiovascular disease have the potential to disrupt the health-care system by providing more accessible, faster, and accurate tools for prevention and management of heart disease. Proper practice and further development of AI have the ability to change the approach to the treatment of cardiovascular diseases. The model has paid off, in terms of correctly and quickly predicting heart disease risk. It helps healthcare practitioners to identify high risk individuals at an early stage, through early detection. The methodology enables better risk stratification to categorize patients risk level clearly. It is faster and yields more accurate predictions than more traditional methods. Plus, it's scalable, so it can accommodate large datasets, which is a benefit for all types of healthcare organizations. The model is an important tool in fighting and treating cardiovascular disease because its findings are reliable and it can process data quickly.

Moving forward, AI will enable continuous monitoring of patients through wearables, helping to assess heart disease risk in real time, and accelerating the process to intervene if needed. These models will also deliver more precise risk assessments, which will assist doctors, aiming at high-risk patients and allowing them to make educated decisions in regards to their treatment options. Healthcare providers must keep abreast of these latest advancements to harness the full promise of AI to drive better diagnosis and treatment of heart disease.

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