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RESEARCH ARTICLE

Experimental evaluation of artificial intelligence assisted heart disease prediction using deep learning principle

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Abstract
The system for detecting cardiac illness utilizing artificial intelligence (AI) and deep learning algorithms is the main topic of the study. Researchers demonstrate how artificial intelligence can be used to forecast if someone would get cardiac disease. The goal of this work is to create an artificial intelligence system that can detect cardiac problems using machine learning. Diagnose, risk stratification, and management are essentially some of the essential thinking-intensive elements of healthcare that have been automated due to the creation of AI along with information science, reducing the burden on doctors and lowering the risk of human error. Clinical decision-support platforms frequently employ artificial intelligence approaches for accurate disease prediction and diagnosis. Considering the health history of the individual, we developed a system to determine if a heart disease diagnosis is likely or not for the patient. In order to demonstrate the effectiveness of the suggested strategy, this research established a revolutionary deep learning-based cardiovascular disease diagnosis logic called efficient learning health evaluator (ELHE). It is cross-validated with the traditional deep learning model known as artificial neural network (ANN). Many people with cardiovascular disease have the same blatant warning signs that may be used to make a diagnosis. A scheme of detection built around these risk indicators would benefit healthcare providers as well as patients by alerting them to the potential for heart disease before they enter a hospital or undergo pricey diagnostic tests. Finally, the popular learning-oriented tool Python is used to create the recommended prediction logic known as ELHE, which allows the user to input clinical information and understand the present state of a patient's health. This strategy improves healthcare while lowering the cost of treatment. For the medical professional, this technology will serve as a promising tool for accurate diagnosis.
Keywords: Artificial intelligence, Heart disease, Deep learning, Health evaluator, Prediction logic.

Introduction
Cardiovascular disorders are frequently substituted for heart diseases. Stroke, angina, and heart attacks all originate from clogged or constricted blood arteries, the underlying cause of these disorders (Archana Singh & Rakesh Kumar 2020). Diseases affecting the heart may also cause problems with the heart's beat, controls, or muscles. Heart illness can only be detected with the help of artificial intelligence, unfortunately. It would be considerably easier for clinicians to get essential data for evaluating and diagnosing individuals if these could be predicted in advance. In most cases, the symptoms of cardiovascular disease are misdiagnosed as heart disease. Because of its association with the heart, it is often confused with cardiovascular illness (Govindaraj, *et al*., 2023).

Python is a language for object-orientated programming with a lively, energizing set of construction choices and rapid development cycles. One of the most secure languages, it finds extensive use in the healthcare industry. It is also generally regarded as a popular and recognized programming language, with applications ranging from online application creation to software based on AI. When the robust prediction algorithm is applied to the preexisting system modules, a thorough report is produced. The person receiving treatment and the physician provide the input data for this work. The data provided by doctors is fed into artificial intelligence systems that analyze cardiac problems

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(Pritpal Singh & Ishpreet Singh Virk 2023). The result achieved is then compared to previous models' results in the same area, and is shown to be superior. The current system's primary function is to analyze past patient illness outputs, compare them to those of new patients and estimate an individual's risk of developing coronary artery disease. The above-mentioned model will help us achieve our aim of creating a system that can more precisely predict the likelihood of a heart attack occurring in a new patient. The model is provided for the heart disease forecasting program employing several AI algorithms and approaches, and their performance and accuracy are evaluated using data from patients diagnosed with heart disease obtained from the UCI laboratory. However, even when utilizing all of the available methods, accuracy remains low.

Problem Statement

Recent medical research has uncovered potential risk factors for the emergence of heart disease, but this knowledge needs additional investigation before it can be put to use in lowering the prevalence of heart disorders. Hypertension, diabetes and high levels of cholesterol are major contributors to the development of cardiovascular disease. The risk of cardiovascular disease increases with poor eating habits, a lack of physical activity, cigarette use, excessive drinking, and overall body fat. Prevention efforts may benefit from a decrease in coronary artery disease risks, according to research. The risk of cardiovascular disease is a common topic of study and investigation. Population-based data on risk factors for cardiovascular disease, such as smoking history, lipid profiles, and glucose levels, has improved heart disease forecasting. Researchers have adapted these prediction algorithms into more user-friendly score sheets for individuals to use in assessing their own risk of acquiring cardiovascular illness.

Risk Evaluation

Predicting when a person is at a high risk is crucial. Diagnosing a medical condition accurately and efficiently is crucial. Although artificial intelligence may sometimes produce erroneous assumptions and unanticipated results, automating the same would greatly aid doctors in making more accurate diagnoses. This automation is useful for doctors, but it also alerts people as to whether or not they need to see a doctor. Therefore, illness analysis plays an important role in the healthcare sector. There may be a wealth of untapped data and insights within a hospital's massive database including patient information. A deep learning method may be used to make illness predictions using the accumulated data. Discovering previously undiscovered details inside a dataset, with the goal of gaining novel, transferable knowledge and in order to distill usable information from a massive dataset, deep learning employs a wide variety of methodologies (A. Anbarasi, *et al*., 2022). All three of those uses of knowledge-discovery, application, and prediction are possible with this method. The learned data is used heavily in the prediction process. Artificial neural networks employing the backpropagation method may be used to learn from this dataset. Multilayer perceptrons, used in its construction, are a type of fundamental processing unit that can tackle nonlinear issues when a single perceptron can only handle linear ones. Deep learning's predictive abilities are very important in the healthcare sector.

Objectives of the Proposed Work

The following are some of the goals of the research:

- To evaluate the Python language's diagnostic applications for heart disease.
- Describing the defined issues necessitates doing a thorough analysis of the preceding steps and using an appropriate methodological approach.
- The goal is to use Python to evaluate information interpretation methodologies for disease detection.
- With the aid of privacy-preserving methodologies, critically evaluate the artifact or product by determining its strengths and weaknesses.

Related Study

Among the many significant challenges in contemporary research is the ability to foresee the onset of cardiovascular illness (Sudipta Modak, *et al*., 2022). Predicting cardiovascular illness by the analysis of risk factors such as blood sugar levels, cholesterol level and arterial pressure. Predictions may now be made more quickly by using a variety of machine-learning techniques that learn from historical data. Predictions, however, continue to be unreliable. This is because fewer records are available in the searchable databases. Using a modified form of an infinite selection of features and a multilayer perceptron, we propose a new method for predicting cardiovascular illness. In order to objectively assess the dataset as a whole, we have combined all the datasets and divided them into training and assessment tests, giving 20% of the entire set for evaluation.

Heart disease has surpassed all other leading causes of mortality worldwide at this time. Heart disease has also been called cardiovascular disease in previous eras. Each year, cardiovascular disease and stroke account for one out of every four deaths in India. The healthcare industry generates massive amounts of data, making the application of computerized learning to the task of making decisions and predictions from that data extremely beneficial. This is due to the fact that machine learning can more accurately anticipate outcomes by analyzing patterns in the data. In India, heart disease accounts for 24% of mortality from NCDs (Nirmala, S *et al*., 2022), according to data supplied by the World Health Organization. The leading cause of mortality in this group is cardiovascular disease (CVD). Moreover, in industrialized nations like the USA and other affluent countries, coronary artery disease is the leading cause of mortality. Mortality from cardiovascular disease is the largest cause of death worldwide, affecting over 17 million people annually; it is most common in Asia. The main objective was to collect data for the sake of analysis. The prediction model makes use of various well-established categorization methods and a wide variety of feature integrations in its implementation.

Heart disease is becoming increasingly common in modern society (C.N. Vanitha, *et al*., 2022). Only using behavioral data makes diagnosing a cardiac issue a difficult medical procedure. Cardiovascular disease detection, heart function assessment, and knowledge of the patient's fitness history all play a role in making a diagnosis. There are major currents in the direction of developing the prediction to construct intelligent machine-managed structures that help doctors treat patients at an early stage and ultimately cure them. Predictive cardiology has been refined to provide better support for patients. Its findings are superior to those obtained using more conventional methods such as multiple stratum perceptrons, CNN and so on. The evaluation and planning for efficiently diagnosing the system and verifying the severity of the cardiac condition's risk are included in the forecast. The outcomes demonstrate the adaptability of the enhanced deep CNN with additional variables and their subsequent calibration.

Heart disease, or cardiovascular disease (Kapil Joshi, *et al*., 2023), has risen to prominence over the past several decades as the leading global killer and the most hazardous disease in India and elsewhere. The healthcare business is a treasure trove of information. With this mountain of data, it's possible to foresee the illness, identify it, and maybe treat it. Infections pose a major threat to humankind by causing conditions like cardiovascular disease, cancer, tumor growth, and so on. In this piece, we provide special attention to the prediction of cardiac sickness by using artificial intelligence techniques. Information such as blood pressure, diabetes, and a person's history of smoking cigarettes is combined with other factors to create a prediction. random forest, KNN and a decision tree are some of the algorithms employed. In this study, we provide a comprehensive prognostic assessment of cardiac issues. The accuracy of the prototype may be tested with a series of calculations. The approach for foreseeing the spread of bravery allows for more precise action at that time. Researchers are accelerating the development of heart disease detection and prognostic software by employing machine learning techniques. The primary goal of this effort is to use machine learning methods to predict a patient's cardiac status.

Heart disease and other circulatory disorders are the major killers worldwide. One of the many cardiovascular disease symptoms that is getting greater attention from physicians is heart failure, however, the standard of care in this area still isn't very good. Clinical practitioners' understanding of the results is enhanced by the fact that machine learning is useful not only for feature evaluation but also for clinical prediction. In order to solve the problem of unanswered questions around machine learning models in healthcare, AI has been conceptualized as a means of equipping doctors with decision-making tools that have been trained using patient data to improve treatment and diagnosis. In this work, researchers use a machine learning and tree-based algorithm to create a survival prediction model for patients with cardiac issues (Shilpi Mishra, *et al*., 2023). One of the tree-based algorithms shown to provide the most accurate results (83% accuracy with unknown data) is called extreme gradient boosting (XGBoost). To ensure that only relevant features are used in the model, an attribute screening process is performed.

Methodology

There are a number of factors contributing to the rising rate of heart disease. Treating cardiac disease effectively requires prompt diagnosis. This condition is met by the approach discussed in this paper, which employs a number of deep learning methods to ensure that everyone can gain early insight about their own risk. The primary objective of this research is to rapidly develop a model capable of automatically and correctly predicting cardiovascular disease. This research presented a unique method; the efficient learning based health evaluator (ELHE), which used a multi-stage procedure to analyze cardiac data. The study technique utilized to reach this objective is broken down into the following sections: data collection, preliminary processing, extraction of features and decision-making, several deep learning algorithms, and their performance analysis. The first step is to obtain the patient's information. The data has been preprocessed to complete any blanks, remove any ambiguities or duplicates, and ensure a consistent format throughout. The most important characteristics have been extracted and combined to form a new collection of features using selecting features and extraction techniques. For the proposed system, we have acquired two types of datasets: one with all characteristics and another with only some of the attributes. Both datasets have been subjected to various artificial intelligence methods in an effort to determine which is more useful for predicting cardiac events. Different ML methods have been compared to one another in order to find the best method for creating a cardiovascular disease forecasting system that can accurately diagnose heart disease based on various performance criteria for both datasets. If you want to confidently use various AI methods to the task of heart disease identification, it's important to keep an eye on the essential processes depicted in Figure 1. The diagram in Figure 2 provides a clear overview of the structure of the proposed ELHE model (Ruqya Abdelrahim Alhammadi, *et al*., 2023).

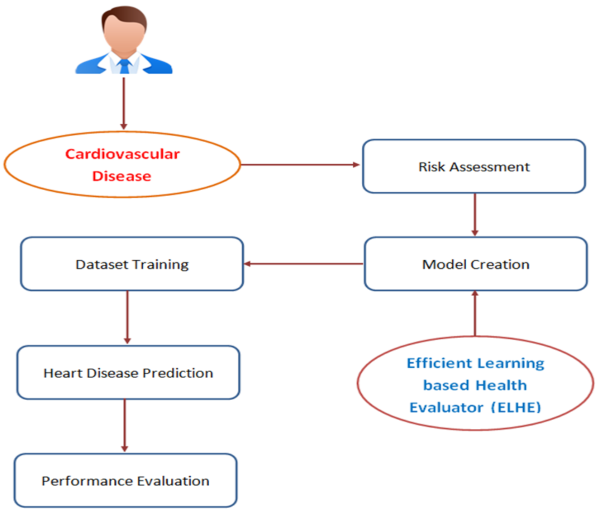

Figure 1: Process flow diagram of the proposed work

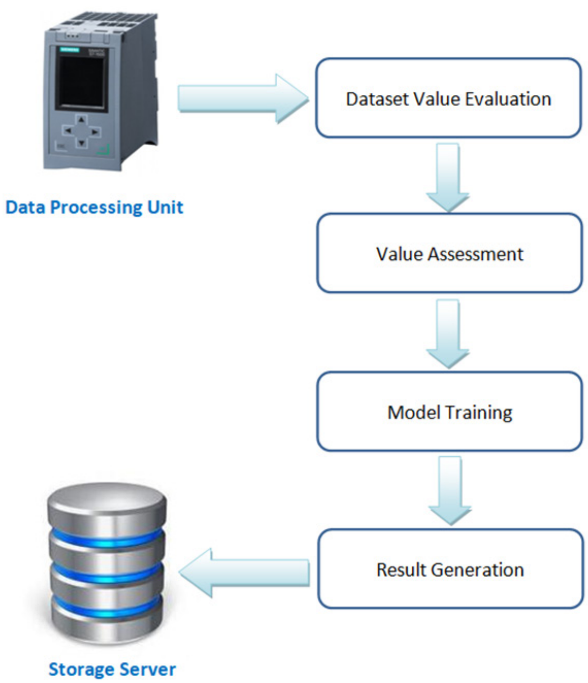

Figure 2: ELHE architectural diagram

Feature Selection Process

This evaluation formula is combined with an appropriate connection measurement and a heuristic search strategy in the similarity-based knowledge subset selection algorithm. As the external variable's correlation with each component grows, so does that between the composite and the external variable. When there is less coherence among the parts, the composite's correlation with the outside variable holds up better. When there are more outside factors influencing the composite, the association between them increases.

Dataset Evaluation

Table 1 shows how the dataset is often split into testing and training information. In order to generalize to new data, the model is trained using data with a known outcome. 72% of the data is used for training in this study. Consequently, 28 instances from the total of 72 are selected as the experimental collection. In data training, it is common for the training accuracy to be high, suggesting that the model does well on the set used for training but badly when compared to the test set.

Table 1: Dataset proportions

S.No.	*Dataset values*	*Proportion*
1.	Training data	72
2.	Testing data	28

Therefore, a method called ten-fold cross-validation is used to ensure accurate results. The test set is a subset of the data used to evaluate the model and is often the dependent variable in the data. The dataset is tested using 20 occurrences, or 35% of the entire data, in this investigation. Cross-validated data may fare better or worse in tests, depending on the model employed. Therefore, a technique called as parameter tweaking is used to guarantee optimal performance in every model.

Results and Discussions

The problem with the risk factors that are associated with heart disease is that there are many risk factors involved, such as age, usage of cigarettes, blood cholesterol, person's fitness, blood pressure, stress, and so on, and it is a difficult task to understand and categorize each one according to its value. The factors that are associated with heart disease include age, usage of cigarettes, blood cholesterol, a person's fitness, blood pressure, and stress. In addition, it is normal for a patient to be diagnosed at an advanced stage of their heart illness before the issue is identified. This is because heart disease tends to progress slowly. As a direct consequence of this, the risk factors were looked at utilizing a wide variety of resources. The dataset contained twelve important risk factors, including cigarette smoking, alcohol consumption, lack of physical exercise, diabetes, high blood pressure, an unhealthy diet, and obesity. These aspects were broken down into their respective categories: sex, age, the history of one's family, blood pressure, smoking habits, and bad nutrition. The method of diagnosis was used to establish whether or not the patient was at an increased risk of getting heart disease. Surveys conducted by a variety of Heart Associations provided the data for one hundred individuals, and these surveys were used to compile the information. It was shown that the vast majority of people suffering from cardiovascular disease had multiple risk factors in common.

This system came up with an innovative method for predicting cardiac illnesses called the ELHE for short. In this system, the initial step is to collect input from the doctor on information pertaining to the patient's heart, such as whether or not they smoke, their cholesterol levels, their blood pressure, or whether or not they have diabetes,

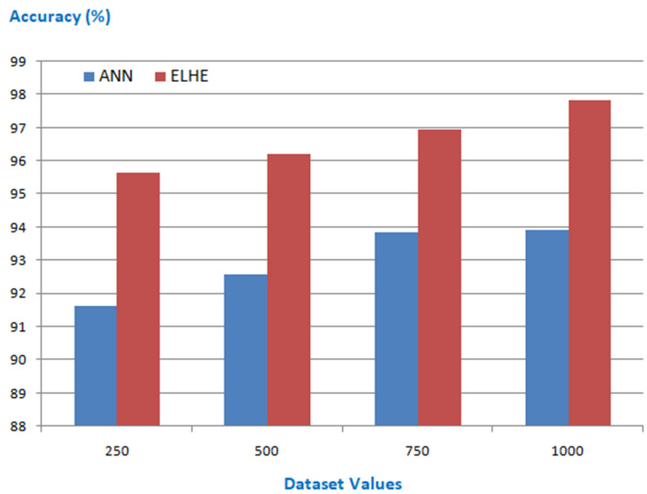

Figure 3: Training efficiency

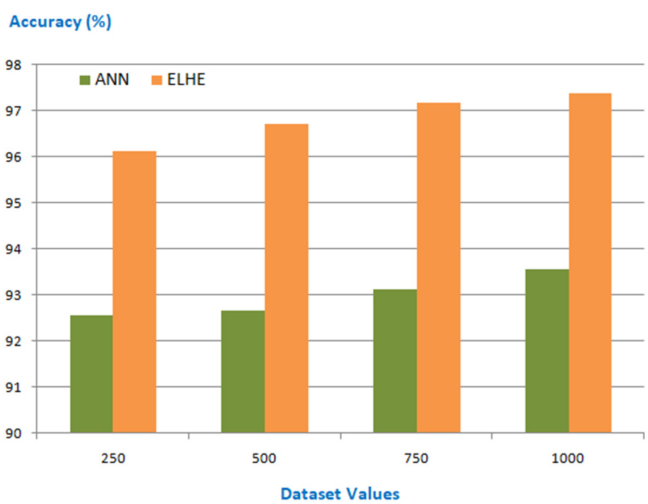

Figure 4: Testing efficiency

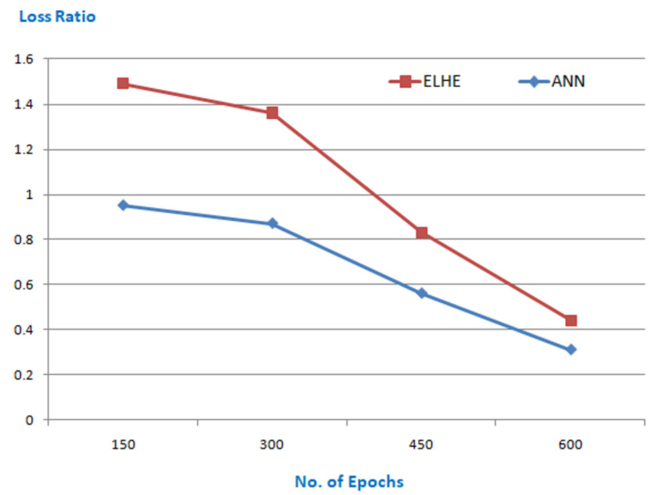

Figure 5: Training loss

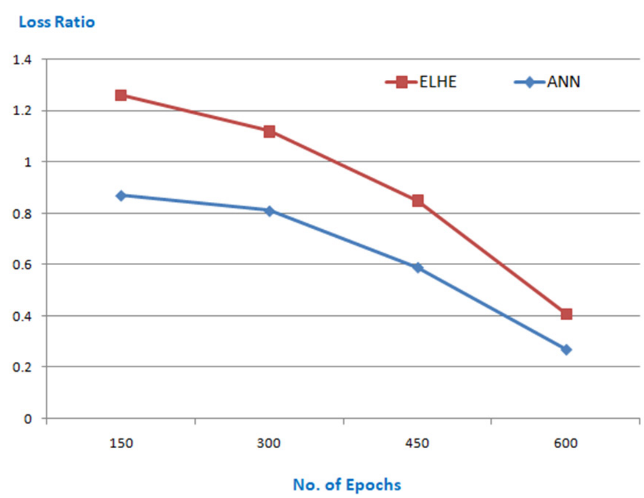

Figure 6: Validation loss

etc. Our system will provide a complete report on the heart illness based on its prediction, which will be derived from the specified algorithms and will be based on the aforementioned parameters. Because of this, we are in a position to ascertain which algorithm is the most reliable in terms of its ability to forecast instances of heart disease. As part of the process of transforming the data into a form that is usable, analysis of the data has been carried out. As part of this process, the values have been encoded with the majority of them falling inside the range [0, 1].

Following the completion of the data analysis, all of the inconsistencies and irregularities that were present in the data were removed. This was a must. It was necessary for us to perform an analysis on the data before we could accurately preprocess the data. Eliminating inputs that are either nonexistent or incorrect will assist the neural network in becoming more generalized. Python was used in the creation of the application that will be offered, and it will be able to detect whether or not a patient suffers from heart disease. Python was used in the development of the application that will be offered. Having a history of heart disease in your family, smoking cigarettes, having high cholesterol and blood pressure levels, being overweight, and not getting enough physical exercise can all boost the risk of developing heart disease. Other risk factors include not getting enough physical activity and not having a history of heart disease in your family. In our day and age, heart disease has developed into a significant problem for the general public's health. Consequently, it is an unavoidable necessity to work toward the creation of a system that will utilize artificial intelligence to provide heart illness prognoses.

Figure 3 illustrates the training efficiency of the proposed model, in which the resulting summary is cross-validated with the conventional deep learning model called ANN to prove the training efficiency of the proposed approach clearly.

Figure 4 illustrates the testing efficiency of the proposed model, in which the resulting summary is cross-validated with the conventional deep learning model called ANN to prove the testing efficiency of the proposed approach clearly.

Figure 5 illustrates the training loss of the proposed model, in which the resulting summary is cross-validated with the conventional deep learning model called ANN. Figure 6 illustrates the validation loss of the proposed model, in which the resulting summary is cross-validated with the conventional deep learning model called ANN.

Conclusion

In this system, we introduced a novel approach called ELHE, in which the application that is suggested includes reference to risk conditions which must be acknowledged by medical Professionals before the application may be used. If other risk factors are included, a different result may occur. The application may provide deceptive outcomes if certain risk factors are incorrect or missing. In the future, the program may use various artificial intelligence techniques to analyze its interactions and refine its responses accordingly. The efficiency of the program relies on how well the categorization algorithms work. In the event of poor precision, there is a larger possibility that the output is inaccurate. It's feasible that if we increase the size of the dataset, we'll get more reliable results. By using risk variables, we may build a smart system that can forecast the disease, which will reduce the need for expensive and time-consuming medical testing and screenings. The patient will be able to track their own health, which is important for early illness detection and the development of prevention strategies.

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