# ARTIFICIAL NEURAL NETWORK TECHNIQUES FOR HEALTHCARE SYSTEMS: FOCUSING ON HEART ATTACK BY INCORPORATING 'INFECTED WITH CORONAVIRUS' AND 'CORONAVIRUS VACCINE' AS ADDITIONAL CRITERIA

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**Abstract**

**Artificial neural networks have revolutionized data-driven applications in the medical area. Machine learning is a type of artificial intelligence that is used to solve a variety of data science challenges. The prediction of a result based on existing data is a typical use of machine learning. Diagnosing heart disease is a difficult process that takes a great deal of expertise and knowledge. Traditional methods of forecasting heart illness include hospital examination or a variety of medicinal checks. The health-care business has a massive amount of health-care data, much of which are buried. This concealed knowledge can help you make better decisions. For the best outcomes, computer-based data are combined with modern data mining techniques. The neural network is a widely utilized tool for predicting the diagnosis of heart disease. There is no evidence that the COVID-19 vaccination increases the risk of heart attack. However, it is being used as "proof" that the vaccine kills in social media posts. As a result, we investigated this issue by incorporating 'infected with coronavirus' and 'coronavirus vaccine' as additional criteria for improved accuracy. This study describes a proposed artificial neural network model to predict a heart attack. The technology makes predictions based on eight medical characteristics. The current study's findings demonstrated that the model developed using the artificial neural network efficiently predicts a patient's heart attack. In order to evaluate the accuracy of the suggested model, the RandomForest technique was tested.**

***Keywords*: Medical diagnosis; Feed-forward back propagation network; Decision support systems.**

## 1. Introduction

Heart problems are currently the leading cause of death throughout the world. The World Health Organization (WHO) estimates that 12 million people worldwide die each year from heart disease. Heart disease claimed the lives of 17.3 million people in 2008 and it is responsible for almost 80% of all fatalities worldwide. According to the WHO, heart disease will have claimed the lives of roughly 23.6 million people by 2030.

ANNs are a valuable tool that may help physicians in a number of medical contexts analyze, model, and make connections between different clinical data. The vast majority of ANN applications in medicine are classifying tasks, in which the goal is to assign a patient to one of a small number of classes based on measurable data [1]. In [2], the authors suggested a multilayer, probabilistic, learning vector optimization, and generalized regression technique for comparative chest ailment diagnosis. Using SAS enterprise miner 5.2., [3] developed a neural network ensemble-based approach for detecting heart disease. Three separate neural network models were used to create the ensemble model.

The artificial neural network is a mathematical feature of the human neural system that shows the importance of learning and adaptation. Nonlinear functions, which contain a complicated or unknown link or association between input features, are used in the bulk of ANN techniques. An ANN consists of a series of nodes, also known as neurons, arranged in layers. In a common mathematical approach of an ANN, each neuron is directly connected to the neurons of the other layers using some parameters that describe the strength or power of the link among cells [4, 5].

The task of predicting heart disease is the most complex and challenging in the field of medicine. The human heart is considered to be the most essential organ in the body [6]. There is a critical requirement to accurately forecast the severity and level of cardiac disease in order to deliver accurate treatment to patients. Heart disease refers to a variety of disorders that cause improper heart function and may involve blood vessels, arteries, and other organs. A correct diagnosis of cardiac disease leads to the proper treatment of the patient. This necessitates a thorough examination of the patient's cardiovascular system and inquiring about symptoms such as chest discomfort, tightness of the chest, chest stress, breathing difficulty, and immobility [7]. Certain decisions must be made based on a person's health history and clinical test results in order to make a cardiovascular diagnosis. Medical practitioners face a difficult challenge in making decisions, which must be done precisely and efficiently because even a minor error could put a patient's life at risk.

For proper and accurate diagnosis, an intelligent automation process that supports health professionals in making judgements depending on a patient's current symptoms and medical history is required [8, 9]. In order to make decisions, this study developed an intelligent automated system that combined data mining and machine learning approaches. Automated methods are assisting medical practitioners in providing effective treatment [10-14] and automation technologies are used in data mining methodologies. Data mining approaches help with symptom analysis, while machine learning methods help with disease prediction drawn from the analysis [15, 16]. ANN has been found to be more useful, efficient, and effective in a range of areas of medicine, including interpretation, treatment, and predicting, and can assist both specialists and laypeople [17-19]. The main goal of this paper is to propose a neural network model that can be used to effectively forecast heart disease. The study goal is to provide efficient and reliable prediction with less features and tests. Only eight key attributes are considered in this study. In addition, we consider the patients who have been infected with coronavirus infection and those who have taken the coronavirus vaccine.

## 2. Background and Motivation

Heart problems affect 20-30% of COVID-19 patients who are admitted to the hospital. These people have more severe symptoms and a less favorable prognosis. Their heart problems could be caused by viral damage, which causes inflammation in the heart, or by the indirect effect of inflammatory proteins produced in the bloodstream. Heart failure or an erratic heartbeat (arrhythmia) are common symptoms of myocarditis (inflammation of the heart muscle). These heart defects can cause COVID-19 patients to die suddenly from arrhythmia.

COVID-19 is also linked to vascular lining inflammation and an increased risk of blood clots developing in big and small blood arteries, notably in the heart and lungs. Inflammation and blood clots can cause these vital organs to have low oxygen levels. COVID-19 patients have a greater risk of heart attack and stroke. The right side of the heart has to work harder to pump blood to inflamed lungs packed with fluid and arteries loaded with blood clots when COVID-19 is present. This additional effort will place greater strain on the heart, resulting in right heart enlargement. Leg swelling, as well as liver and renal failure, are symptoms of this condition.

The coronavirus that started the global pandemic, COVID-19, is primarily a respiratory or lung disease, but it can also harm the heart. According to preliminary studies from China and Italy, two countries where COVID-19 spread early in the pandemic, up to 1 in 5 COVID-19 patients experienced heart damage. Heart failure has been the cause of mortality among COVID-19 participants who did not have significant breathing issues like acute respiratory distress syndrome, or ARDS.

The European Medicines Agency (EMA) stated on July 9, 2021, that myocarditis and pericarditis could occur in extremely rare cases after vaccination with the COVID-19 vaccines. The incidents happened most frequently within 14 days following immunization, more frequently after the second dose, and in younger adult men, according to the EMA Committee. Many other committees believe there is no causal association between heart disease and the COVID-19 vaccinations at this time. As a result, we looked for probable correlations between heart attack and the coronavirus vaccine and infection with coronavirus, by including them as attributes in the proposed model or by excluding them. The role of coronavirus and vaccination in heart attacks has received a lot of attention around the world. The stakes are quite high for all of humanity. Due to regulatory and security concerns, these data are frequently not made public. I believe that the various departments within the AI community would be better at identifying trends that could aid doctors in prioritizing therapy. Nonetheless, significant concerns remain unsolved, such as "does coronavirus induce heart attacks?" and "does coronavirus vaccine cause heart attacks?" The goal of this study is to add to our current knowledge of the impact of coronavirus and coronavirus vaccine on heart attack prediction.

The remainder of this paper is structured as follows: The prior related study of heart attack prediction is presented in Section 3. Section 4 discusses the proposed technique and how it will be implemented. Section 5 introduces the results and evaluation, followed by a conclusion of the study and recommendations for further research are given in Section 6.

## 3. Related Work

In [20-21], the authors created a prediction system using data mining algorithms such as DT, NBayes, and NN. The suggested system can answer difficult "what if" queries, based on input variables, and it can determine the probability of persons having heart disease. It is a data management system that is internet, user-friendly, scalable, dependable, and adaptable.

Neural networks were used by [22] to predict newborn illness diagnosis. The proposed method involves using a BP learning algorithm to train a Multi-Layer Perceptron to diagnose a configuration for the diagnosis and prediction of newborn illnesses. The ANN design was trained using the backpropagation algorithm, and it was then tested for several types of newborn illness. In this model, 94 examples of various sign and symptom parameters were examined. This research shows that ANN-created prediction of newborn illness improves diagnosis accuracy by 75% while maintaining stability.

The suggested research by [23] examines the cardiovascular disease dataset using data mining classification approaches such as the RIPPER classifier, DT, ANNs, and SVM. To compare the effectiveness of various procedures, sensibility, specific, accuracy, error rate, true positive rate, and false positive rate were all employed. To determine the unbiased estimate of these prediction models, a 10-fold cross validation procedure was applied. RIPPER, Decision Tree, ANN, and SVM had error rates of 2.756, 0.2755, 0.2248, and 0.1588, respectively, according to our findings. The researchers suggested a recommendation system for congenital classification and prediction [24]. With the construction of a backpropagation neural network, the proposed system was conceived and developed utilizing a GUI feature. The multi-layered Feed Forward Neural Network employed in this study is trained using a supervised delta learning rule. The signs, symptoms, and results of a patient's medical examination served as the dataset for this investigation. The proposed approach was able to obtain a 90% accuracy rate.

## 4. Proposed Methodology and Implementation

### 4.1. *Data Collection and Representation*

These data should accurately depict the clinical status of the patient during the database creation procedure for neural network training. It is not recommended to use data that contain unneeded or incorrect information concerning the patient's diagnosis. The goal of the doctor is to select appropriate characteristic data. Typically, these data include basic information on the patient's health, biochemical test results, symptoms, and other information that aids in determining the accurate diagnosis. All of the data from one patient that were collected and analyzed represent one neural network input pattern. The capacity to generalize the discovered correlation between symptoms and diagnosis is highly dependent on the input patterns employed throughout the training phase. As a result, the database should have a sufficient number of credible patterns that characterize the diagnosis.

Unfortunately, this study, as well as the new features offered as additional criteria for improved accuracy, such as coronavirus infection and coronavirus vaccine, were unable to collect more than 318 instances in the heart attack dataset.

The collected data have 8 attributes for predicting patients' heart attack. 'Infected with coronavirus' and 'coronavirus vaccine' are incorporated as additional criteria for improved accuracy. The goal is to predict whether a person will have a heart attack or not based on the specified diagnostic key features included in the dataset.

The proposed framework depicted in the following figure shows how ANN algorithms anticipate, validate, and systematically test the network for the intended objective of increasing self-confidence and significant certainty. During ANN training, operations and parameters are yielded, and the expected output is given. For ANN optimization, the obtained values are compared. Figure 1 depicts the whole sequence of events.

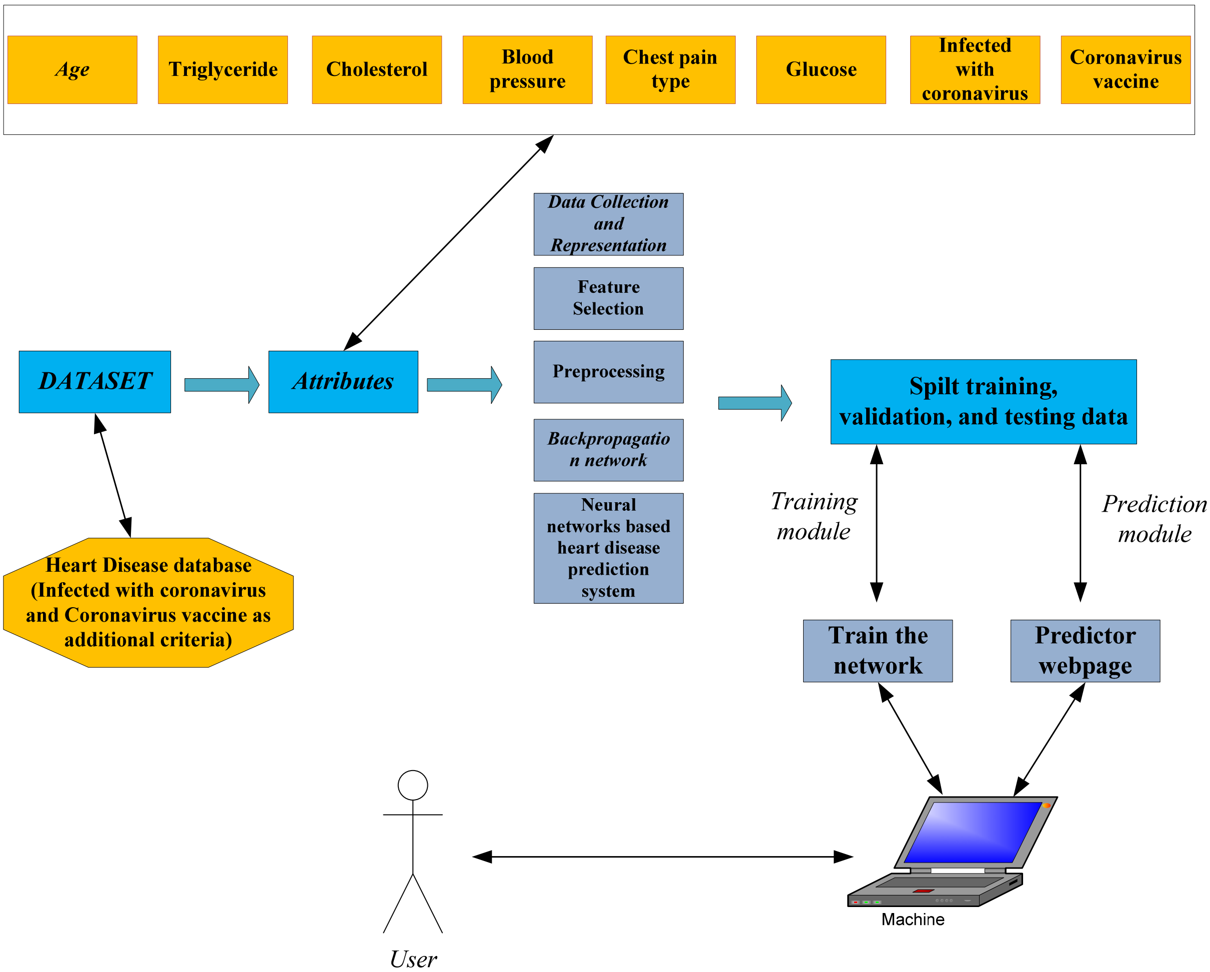


Fig. 1. Proposed framework of heart attack prediction using neural network

### 4.2. *Feature Selection*

The most important features for correctly identifying a heart attack are usually independent of one another. These features, known as structures in ANN, as well as heart attack signals and other essential data that can assist predict a heart attack, can be detected. Medical experts carefully consider the features and determine whether each is necessary for determining the correct diagnosis. On the basis of the PID dataset, Choubey et al. [25] employed GA to choose attributes (features) and NBs for classification. It identifies heart attack patients because feature selection is a method of determining the most significant features taken from the entire set [25]. Given [26], these variables must be robust and noise-free; as a result, a rigorous selection of these features is made over the entire dataset. In the selected dataset, there are eight explanatory input variables and one output responder variable. Each component has a significant impact on the diagnosis of diabetes. The network can be efficiently trained and perform heart attack prediction by accumulating their values. The details of both types of variables are presented in Table 1.

| Attributes | Values |
|---|---|
| (Age) | 0=<25, 1=25-55, 2= >55 |
| triglyceride | 0= <150<br>1= 150-199<br>2= 200-499<br>3= > 500 |
| cholesterol | 0= <200<br>1= 200-240<br>2= > 240 |
| Blood pressure | 0= normal<br>1= prehypertension<br>2= hypertension |
| Chest_pain_type | 0= typical_type_1 1=typical_type_angina<br>2= non-angina_pain<br>3= asymptomatic |

| | |
|---|---|
| Glucose | 0= low<br>1= normal<br>2= diabetes |
| Infected with coronavirus | 0=Don't know 1=Yes<br>2=No |
| Coronavirus vaccine | 0=Yes<br>1=No |
| Target (output)<br>Heart attack | 0=Yes<br>1=No |

Table 1. The input and output variables for the proposed system framework.

### 4.3. *Preprocessing*

Preprocessing the data in the dataset before model evaluation is possible using a variety of methods [27, 28]. The preprocessed result requirement indicates the expected result. The learning rate, momentum, and time were all measured as a result of the preprocessing procedure. The data must be changed in order to meet the approval criteria. The given values for triglycerides, cholesterol, type of chest pain, and blood pressure must map to the result value. The heart attack dataset has 318 cases with 8 input variables, which is sufficient to predict the diagnosis of a heart attack using the suggested model. Before getting the dataset from the relevant authority, any noisy data were previously removed [29].

### 4.4. *Backpropagation Network*

An artificial neural network (ANN) is a computer framework for understanding the concurrent aspects of the human brain. A parallel processing network of densely coupled processing components (neurons) is referred to as an ANN [30-37]. These features were inspired by the biological nervous system. The connections between elements govern the network's function, just as they do in nature.

A layer in the network is a subdivision of processing elements. The input layer is the first, while the output layer is the final. Additional layers of units, referred to as hidden layers, may exist between the input and output layers(s). The standard neural network is seen in Figure 2. By adjusting the values of the connections (weights) between elements, it can train a neural network to perform a specific function.

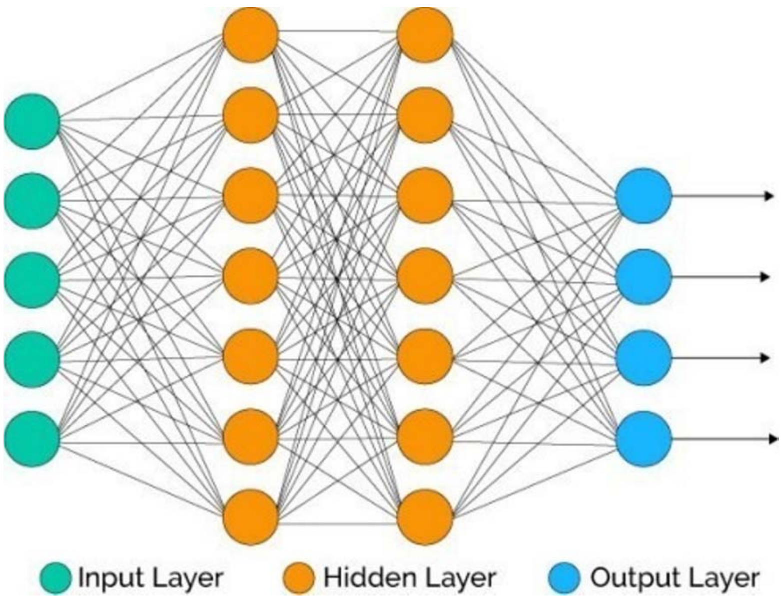


Fig. 2. A typical neural network

In artificial neural networks, a node layer consists of an input layer, one or more hidden layers, and an output layer. Every node, or artificial neuron, is linked to the others and has its own weight and threshold. When a node's output reaches a specific level, it is activated, and data are transferred to the network's next layer. Then, all data are transferred to the next tier of the network.

Data are used to train neural networks, which allows them to learn and improve their efficiency over time. Once fine-tuned for accuracy, these learning algorithms become formidable instruments in computer science and artificial intelligence, allowing for successful data classification and collection.

For multilayer and feed forward networks, backpropagation is the most often used training algorithm. The difference between actual and anticipated values is calculated and propagated backwards from the output node to the node in the previous layer, hence the name "backpropagation." This is done to make the processing weights more efficient. The steps that make up the backpropagation algorithm are as follows:

1. Provide the network with training data;
2. Make a comparison between the actual and desired results;
3. Determine each neuron's error;
4. Determine what each neuron's output should be as well as how much lower or higher production is required to achieve the desired result;
5. Adjust the weights after that.

### 4.5. *Neural Network-Based Heart Disease Prediction System*

A decision support system was built for forecasting a patient's cardiac condition. The forecast is based on a database of previous heart disease cases. Medical terms such as age, chest pain type, and cholesterol are employed as 8 input attributes by the system. Two further features, ‘infected with coronavirus’ and ‘coronavirus vaccination’, are employed to produce more relevant findings, as these are regarded as important attributes for heart disease. Despite the fact that there is no conclusive evidence of a link between heart attack and the coronavirus vaccine and becoming infected with coronavirus, the decision is not final. The Multilayer Perceptron Neural Network (MLPNN) with Backpropagation algorithm was utilized to construct the system (BP).

### 4.6. *Implementation*

The input node, hidden node, learning rate, momentum, epoch, and number of targets are all displayed on the main menu screen. This allows one to import the original data that are also presented. The training, testing, validation, feedforward, backpropagation, and prediction tabs are all important, as shown in Figure 3.

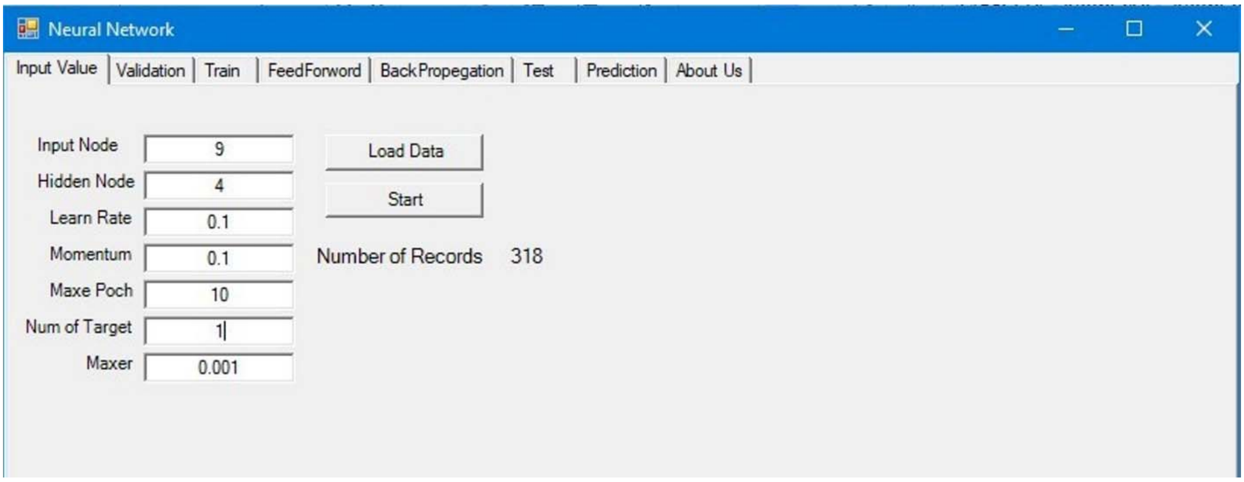


Fig. 3. Main menu

Figure 4 and Figure 5 show the validation page and training result page respectively. Figure 6 shows the test result page. Finally, Figure 7a and 7b show the feed forward and backpropagation.

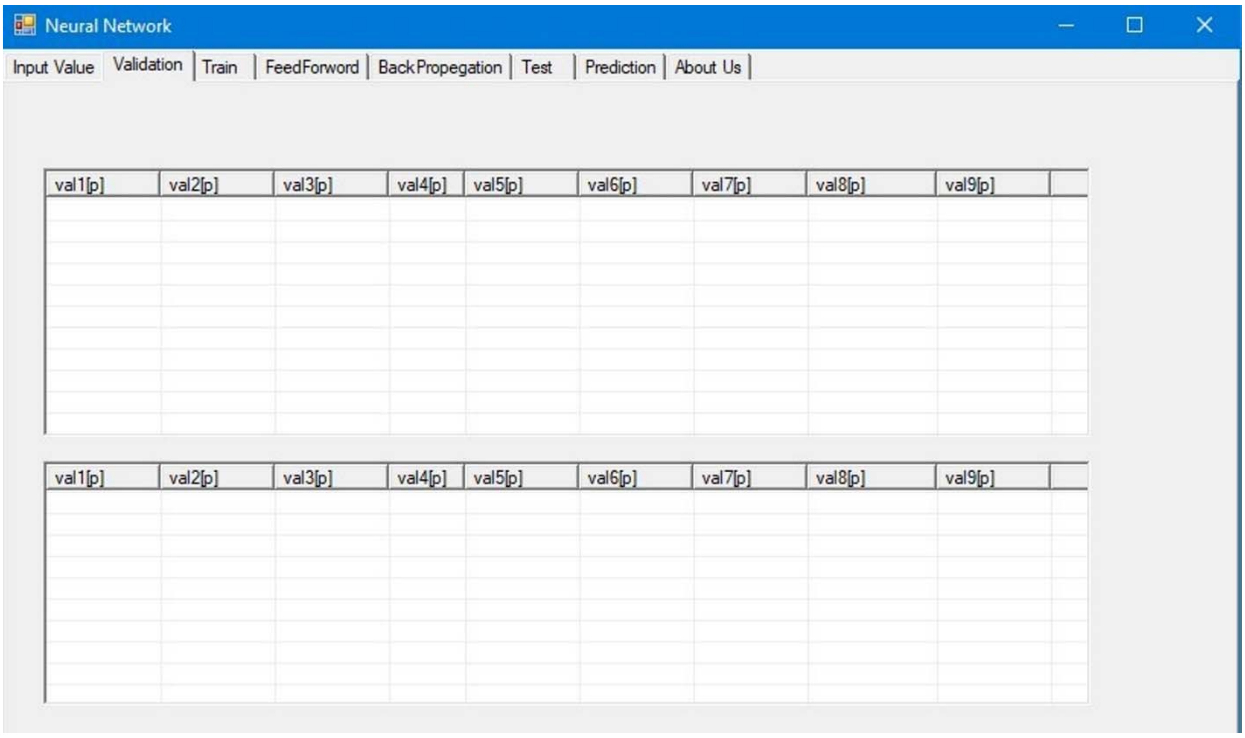


Fig. 4. Validation page

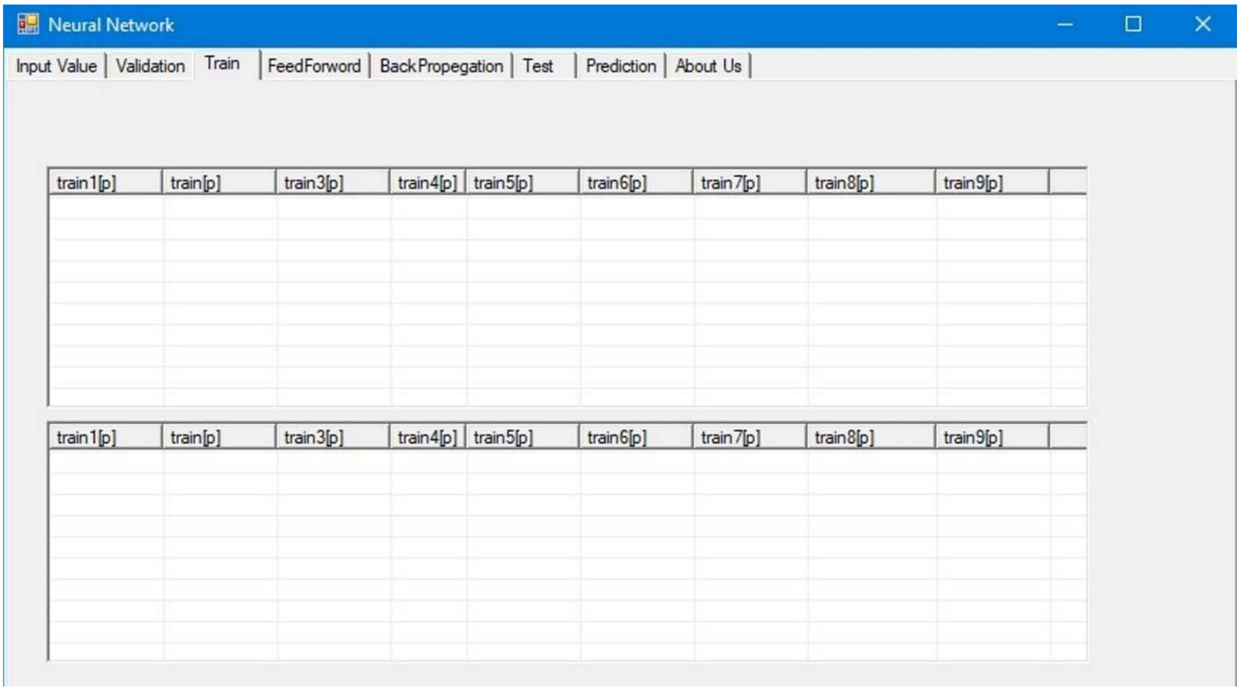


Fig. 5. Training result page

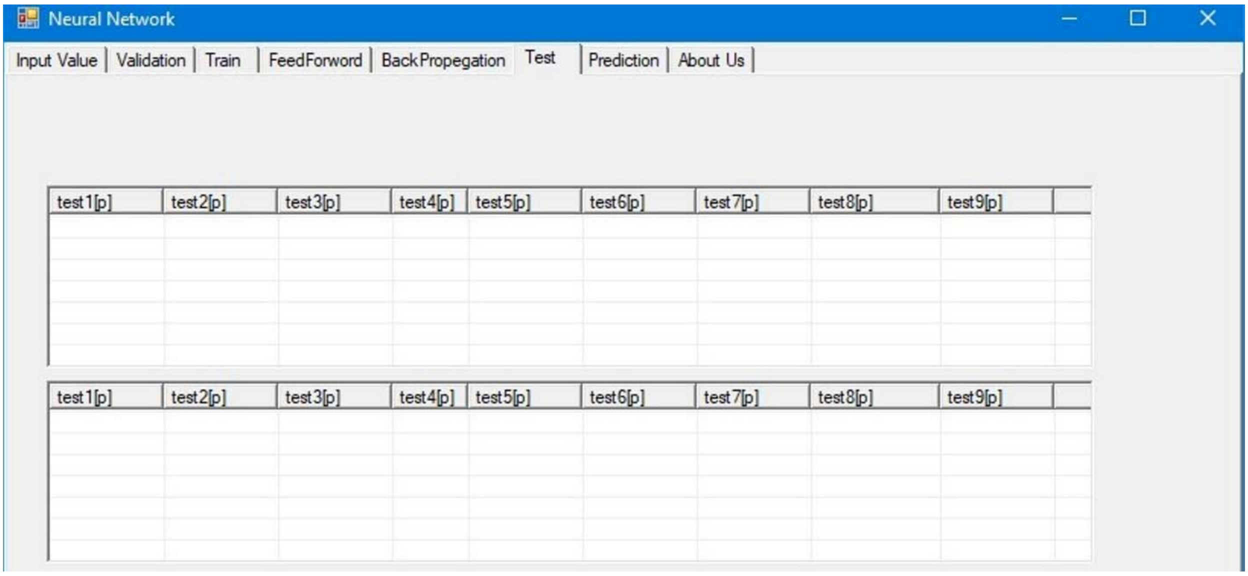


Fig. 6. Test result page

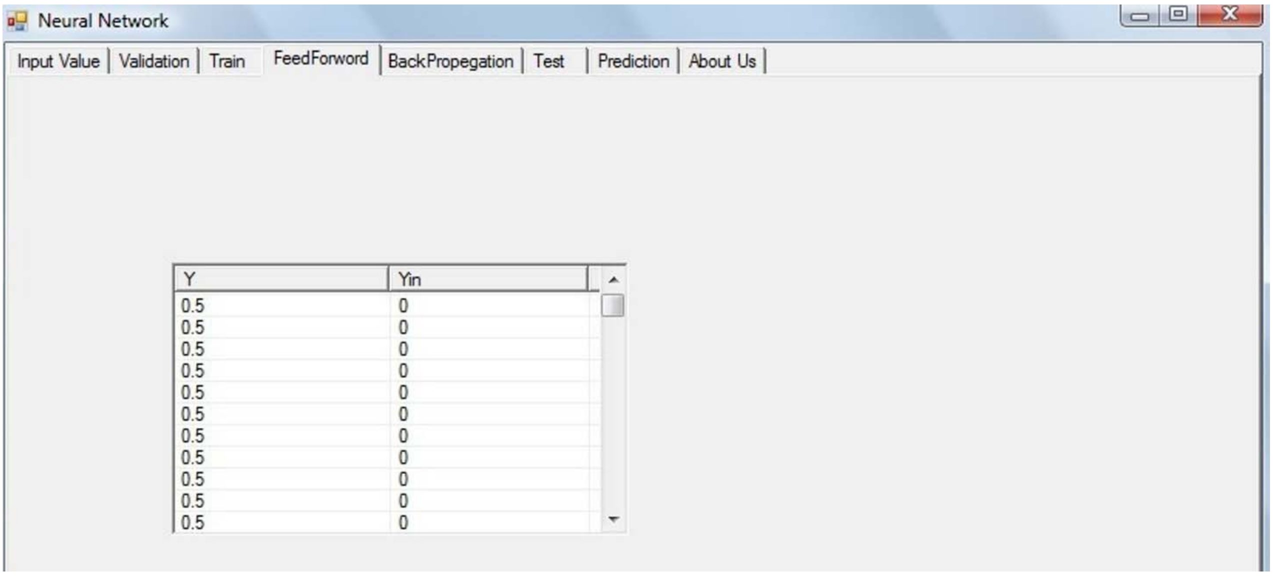


Fig. 7A. Feed forward and back propagation

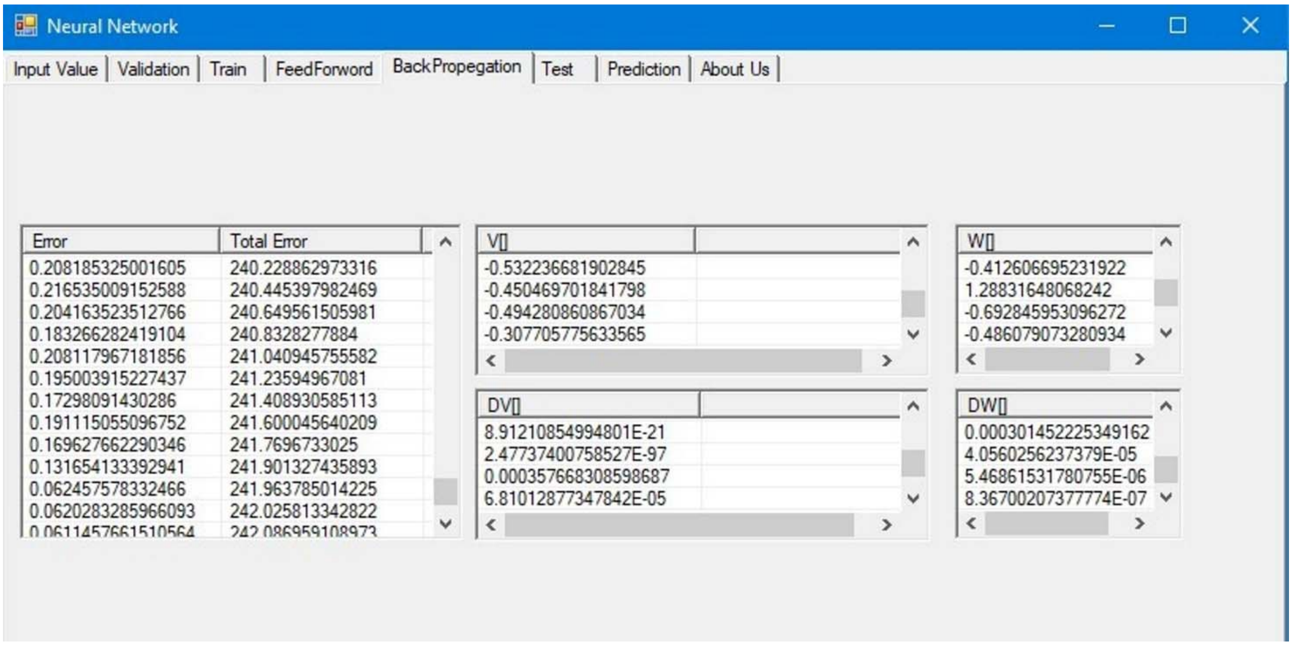


Fig. 7B. Feed forward and back propagation

## 5. Results and Evaluation

Patients, hospital resources, disease diagnostics, electronic patient records, and medical gadgets, among other things, generate vast volumes of intricate data in today's healthcare industry. The enormous amount of data available is a significant resource that must be managed and assessed in order to extract knowledge and encourage cost-cutting and decision-making. For proper diagnosis, only human intelligence is insufficient. Several difficulties will develop during diagnosis, including less accurate outcomes, a lack of competence, time-dependent performance, and challenging knowledge upgradation.

Predicting performance is crucial for assisting healthcare workers and ensuring their retention, as well as for increasing the hospital's ranking and managing the recovery process and resources. Predicting a patient's heart attack based on input data is obviously critical for assisting patients and healthcare workers since it generates answers to the problems they face and assists patients in overcoming them. We proposed a neural network model for the prediction of heart attacks in this paper. The suggested model takes as inputs eight variables (age, triglyceride, cholesterol, blood pressure, chest pain kind, glucose, coronavirus infection, and coronavirus vaccine), each of which is treated and handled separately. The ability to efficiently exploit information in mixed data is a great benefit of the chosen medical profession, as various types of data are typically treated separately. Furthermore, in terms of flexibility and ability to adapt for cheap computing cost, it outperforms the typical fully connected neural network architecture.

Intelligent data processing based on addressing optimization tasks using ANNs is one of the modern techniques to tackling classification difficulties. The findings show that ANNs could be utilized to develop a highly accurate and effective model for predicting heart attacks.

According to the findings of the clinical instrumental investigation, triglyceride-induced heart attack was diagnosed in 318 (57.4%) patients. A total of 124 individuals had normal blood pressure and no indication of a link between heart attack and coronavirus infection or the coronavirus vaccine. We were able to pick eight factors related to the condition after conducting a correlation study between the stated variable factors. ANNs were used to examine these variables.

We investigated the impact of various qualities, instructional methods, and neural network topologies on the accuracy of heart attack diagnosis in this study. We discovered that a MLP is the best topology for resolving this classification problem. The ideal input combines eight of the most important factors.

We employed Neural Networks to build an efficient and reliable heart attack model in order to increase diagnosis accuracy and reduce diagnosis time. A multilayer perceptron neural network frames the suggested technique for heart disease prediction with proper diagnosis. A backpropagation technique was used to train the data and compare the parameters iteratively for effective prediction. The propagation method was used again and again until the error rate was as low as it could be. The findings show that based on the eight criteria, the suggested method accurately predicts heart disease.

We experimented with different hidden layers, learning rates, and attribute changes in a neural network to improve accuracy. When we increased the number of hidden layers, the accuracy improved, but the computation time increased, which was not ideal for prediction; however, when we reduced the number of hidden layers, we got better results with a much shorter calculation time, which was more trustworthy. This research can be expanded to forecast and analyze the severity of the ailment by taking into account more features. Figure 8 shows a classifier that uses backpropagation to learn a multi-layer perceptron to classify instances. Finally, detailed accuracy by class and summary of RandomForest are shown in Tables 2 and 3, respectively.

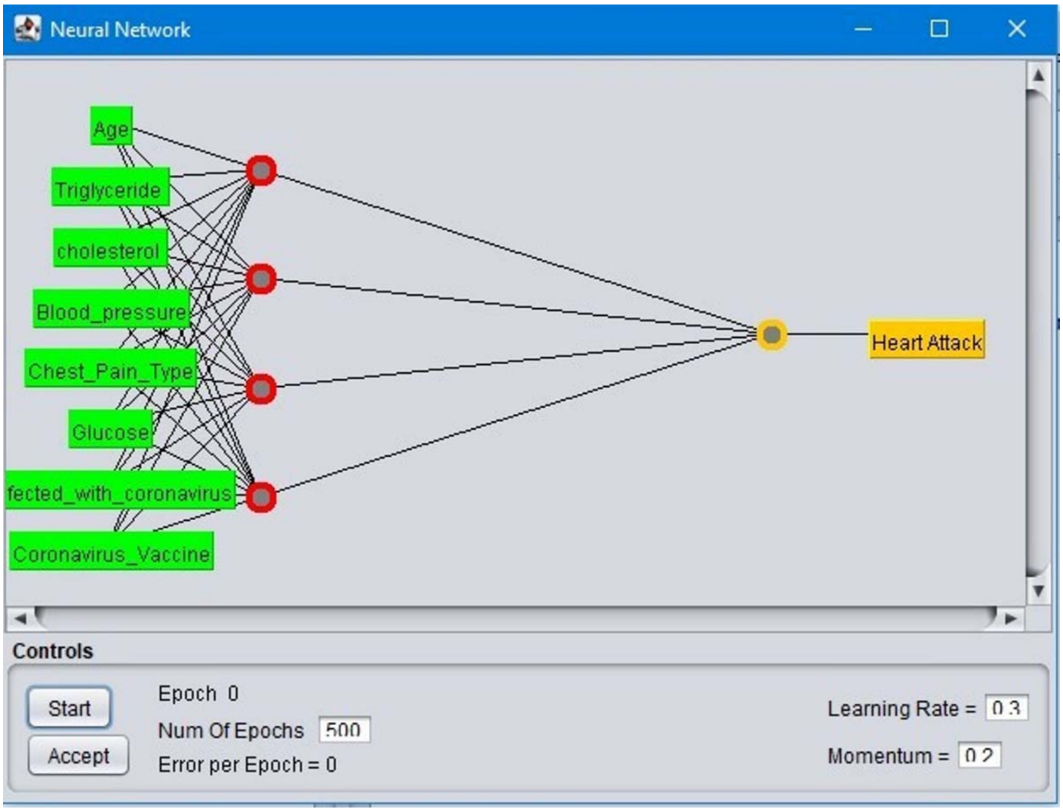


Fig. 8. Backpropagation to learn a multi-layer perceptron to classify instances

| | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC | ROC Area | PRC Area | Class |
|---|---|---|---|---|---|---|---|---|---|
| | 0.954 | 0.697 | 0.750 | 0.954 | 0.840 | 0.358 | 0.662 | 0.758 | Yes |
| | 0.303 | 0.046 | 0.750 | 0.303 | 0.432 | 0.358 | 0.671 | 0.487 | No |
| **Weighted Avg.** | 0.750 | 0.493 | 0.750 | 0.750 | 0.712 | 0.358 | 0.665 | 0.673 | |

Table 2. Detailed accuracy by class.

| | | |
|---|---|---|
| **Correctly Classified Instances** | 267 | 84.4937 % |
| **Incorrectly Classified Instances** | 49 | 15.5063 % |
| **Kappa statistic** | 0.6263 | |
| **Mean absolute error** | 0.2489 | |
| **Root mean squared error** | 0.3296 | |
| **Relative absolute error** | 57.777 % | |
| **Root relative squared error** | 71.0513 % | |
| **Total Number of Instances** | 316 | |
| **Ignored Class Unknown Instances** | 2 | |

Table 3. Summary of Random Forest.

The model accurately categorized 207 data points belonging to the positive class and 30 data points belonging to the negative class. The model wrongly identified 10 data points from the negative class as belonging to the positive class. Finally, the model mistakenly identified 69 positive class data points as belonging to the negative class. The correlation matrix for all variables is shown in table 4.

| | Column 1 | Column 2 | Column 3 | Column 4 | Column 5 | Column 6 | Column 7 | Column 8 | Column 9 |
|---|---|---|---|---|---|---|---|---|---|
| **Column 1** | 1 | | | | | | | | |
| **Column 2** | 0.028073 | 1 | | | | | | | |
| **Column 3** | -0.0795 | -0.03775 | 1 | | | | | | |
| **Column 4** | 0.149336 | -0.03984 | -0.01715 | 1 | | | | | |
| **Column 5** | 0.030197 | 0.138105 | -0.027 | -0.12193 | 1 | | | | |
| **Column 6** | 0.083474 | -0.12525 | 0.044696 | 0.229786 | -0.17938 | 1 | | | |
| **Column 7** | -0.09894 | -0.06244 | 0.087026 | -0.09421 | -0.04298 | 0.018138 | 1 | | |
| **Column 8** | 0.037141 | 0.166067 | -0.17061 | -0.01942 | 0.133901 | -0.05701 | 0.026958 | 1 | |
| **Column 9** | -0.13501 | -0.06615 | 0.182548 | -0.14137 | -0.09805 | -0.0981 | 0.018641 | -0.23177 | 1 |

Table 4. Correlation Matrix for all variables.

In the medical industry, an adaptive artificial neural network is a non-parametric method for classifying people into sick or healthy based on input variables. Artificial neural networks are used in the classification and prediction of a patient's condition depending on risk factors [38]. Artificial neural networks are based on the complex structure of the human brain. A biological neural network in the human brain is dedicated to human tasks such as reading, comprehending, speaking, breathing, movement, voice recognition, and face detection, as well as resolving obstacles and data storage, due to billions of nerve cells (neurons) communicating with each other. Artificial neural networks do indeed simulate some brain functions [38.39]. The fact that only 318 samples were used in this study is a limitation. According to preliminary experimental results, the proposed method looks capable of producing a reliable and accurate model. However, we aim to expand our database with data from more sample sites and years in order to complete a comprehensive performance evaluation of the compared models on various datasets.

## 6. Conclusion and Future Work

To lower the risk of heart disease, prediction is essential. The symptoms, indicators, and physical assessment of a patient are frequently used to make a diagnosis. Practically all clinicians use learning and experience to predict cardiac illness. Determining the etiology of an ailment is a challenging and time-consuming mission in medicine. Predicting heart attack based on a range of indicators or symptoms is a complex task that can lead to erroneous assumptions and unexpected results. The goal of this study was to use MLP ANNs to construct a heart attack diagnostic model with adequate analytical properties. The model that incorporated both individuals infected with coronavirus and Coronavirus vaccination variables linked with the disease had the best accuracy. The models with a high level of accuracy could be used to construct software tools for heart attack diagnosis and prediction. This study presents a heart attack prediction model based on neural network strategies. A multilayer perceptron neural network and a backpropagation algorithm derived from the ANN were used to construct the system. The MLPNN model works quite well even when not retrained since it generates superior results and supports domain experts and others in the area in planning for a better diagnosis and offering early diagnosis results to patients. The experiment's findings show that by utilizing neural networks, the system can accurately predict heart disease. One of the advantages of this new technique is the model's ability to assess the community's health system memory for future policy creation, as such policies may reduce heart attacks in the endeavor to control heart diseases. Using the proposed approach, the present hazard level of suffering a heart attack, and the probabilities of contracting COVID-19 and receiving the coronavirus vaccine, the probability that these affect heart attack rates may be estimated and interpreted. This study also addresses the problem of obtaining clinical data on heart attacks. In addition, the attributes and characteristics are linked to the coronavirus pandemic and coronavirus vaccination. Furthermore, creating health databases is necessary for the neural network training process.

Future work will also focus on strengthening the model for determining all probable complications, as well as an orderly sequence in terms of the percentage of possible issues. By including various other deep learning algorithms and approaches, the work can be extended and enhanced for automated heart attack analysis.

The model can handle a large amount of data. Because training too many parameters in the hyper parameter tuning approach can easily lead to overfitting, the algorithm can simply change the last output layer. If the data are too different from the original, the model can fine-tune half of the layer after the top layer's output is fine-tuned.

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**Ethical approval**

In this study, a dataset was constructed consisting of 318 sample. The data were collected through questionnaire. Informed consent was obtained from all of the respondents in this study. Ethical approval for the use of these data. It is used for model training and testing.

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