Journal of Information Technology and Computing
https://jitc.sabapub.com
ISSN: 2709-5916

2023 Volume 4, Issue 1 : 37 – 45
DOI : 10.48185/jitc.v4i1.584

Diagnosing Chronic Kidney disease using Artificial Neural Network (ANN)

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Received: 25.03.2023 • Accepted: 01.05.2023 • Published: 27.06.2023 • Final Version: 27.06.2023

Abstract: The prevalence of chronic kidney disease (CKD), brought on by environmental pollution and a lack of safeguards for people's health, is rising globally. A slow and steady decrease in kidney function over many years is chronic kidney disease (CKD). A person may eventually get renal failure. Using artificial neural networks in concert with machine learning techniques (ANN), Keras, and Google Colab Notebook for serial model construction, this study intends to propose a potent method for identifying chronic kidney disease. This study looked into ANN's accuracy, sensitivity, and specificity in the diagnosis of CKD. Based on the dataset's purpose, categorization of technology's effectiveness. To decrease the feature dimension and increase classification system accuracy, an algorithm model including ANN has been developed. Results indicate that ANN architecture, which was used, achieved the best accuracy (98.56%), whereas other methods, such as SVM, Random-forest, and K-Nearest Neighbor (KNN), delivered accuracy levels that were lower than those of ANN.

Keywords: Machine learning, Artificial Neural Network (ANN), Chronic kidney disease(CKD), Google Colab Notebook

1. Introduction

Kidney disease, already referred to as kidney failure, is a condition marked by a steady decline in kidney function. [1]. Our blood is filtered by the kidneys to remove waste and fluids, which are then expelled through urine. The kidney balances the calcium, phosphorus, sodium, and potassium marine salt that flow in the blood. Additionally, they produce hormones that assist maintain strong bones, creating red blood cells, and regulating blood pressure.

Dangerous concentrations of fluid, electrolytes, and waste products can accumulate in our systems when chronic kidney disease reaches an extreme stage. It is challenging to diagnose chronic kidney disease in its early stages because there aren't many telltale signs or symptoms. Only when there is a considerable impairment in renal function may the symptoms become apparent [2].

renal failure in its last stages, which is fatal without a mechanical kidney transplant or dialysis for filtering, can develop into chronic renal disease if it is not managed. Artificial intelligence (AI)-based methods may accurately predict a wide range of outcomes, especially in the medical industry, and they have capabilities that give them an edge over more established statistical techniques like multivariate regression [3].

About 117,000 patients in the US had the end-stage renal disease (ESRD), necessitating dialysis, and more than 663,000 patients with prevalent conditions were receiving dialysis in 2013.

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Approximately $28 billion, or 5.6% of the overall medical expenditure, was spent on ERDS in 2012. In India, there are 800 people with CKD for every million people and 150 to 200 people with ESRD [4].

Our goal is to develop a sensitive and precise model that can assist in the early detection of CKD. Artificial neural networks (ANN) can anticipate complicated and nonlinear processes with considerable accuracy, and their simplicity and adaptability in implementation help to improve prediction accuracy. [5]. Machine learning approaches frequently employ artificial neural networks (ANN). A mathematical model called ANN imitates the behavior of human neurons. The two main characteristics of ANN are their capacity to generalize and generate an acceptable solution to unknown data and their capacity to learn how to fulfill their functions once properly trained [6].

One dataset from the Kaggle website's dataset repository is used in this study. As shown by the results, machine learning approaches can accurately (98.56%) diagnose chronic renal disease.

2. Related work

The field of medical diagnosis is always being studied and researched. Neural networks have been used widely in research on diseases like cancer, diabetes, heart disease, etc.

Berina Alic. [7] The classification of diabetes and cardiovascular diseases (CVD) using artificial neural networks (ANNs) and Bayesian networks are covered in this paper as an overview of machine learning techniques (BNs). It was found that ANN enabled better accuracy.

Suresh Kumar. [8] Decision Tree (DT) and Naive Bayesian (NB) techniques for machine learning were examined. When compared to the naïve Bayes method, the decision tree method performed 98.25% more accurately.

Elhousaany Rady and Ayman Anwar et al. [9] contrasted the outcomes of using Radial Basis Function (RBF), Probabilistic Neural Networks (PNN), Multilayer Perceptron (MLP), Support Vector Machine (SVM), and (RBF). The study demonstrated that whereas PNN required more time to execute and had an overall classification accuracy of 96.7%, MLP just required 3s.

Vital TP. [10] has described the use of neural networks to classify renal illness using data gathered from Visakhapatnam, Andhra Pradesh, India. They utilized a backpropagation algorithm to classify the data using 50 attributes, including age, height, blood pressure, calcium consumption, eating habits, blood sugar, and more.

Njoud Abdullah Almansour. [11] The accuracy and performance of ANN and SVM algorithms are evaluated using a CKD dataset in this paper. The experiment using the dataset was modified with assistance from WEKA. According to the experimental findings, ANN performed better than SVM in almost every model of this dataset. SVM had a performance accuracy of 96.75%, whereas ANN displayed superior performance with an accuracy of 98.5% when employing the optimized features. Although the ANN classifier ran slower than the SVM classifier, there was little difference in accuracy between the two.

3. Data and methods

3.1. Dataset Description:

We have used of one dataset named is (kidney_disease_test.csv) which was downloaded from the Kaggle website dataset repository. Records for 400 individual patients have been included in the data collection under 25 different attributes. Features are (Ages, “BP” Blood Pressure, “SG” Specific

Gravity, Sugar, “BGR” Blood Glucose Random, Blood Urea, Serum Creatinine, Sodium, Hemoglobin, White Blood Cells, etc.). Thirteen of the fourteen attributes are used as model inputs, while the fourteenth property determines the output's classification.

Table 1. 'Attributes used for classification'

Id	Attribute	Data Type
1	Red blood cells	Normal, Abnormal
2	Pus cells	Normal, Abnormal
3	Pus cell clumps	Present, Not Present
4	Bacteria	Present, Not Present
5	Red blood cell count	Numeric values
6	Hypertension	Yes, NO
7	Packed cell volume	Numeric values
8	White blood cell count	Numeric values
9	Anemia	Yes, NO
10	Pedal edema	Yes, NO
11	Appetite	Good, Poor
12	Coronary artery disease	Yes, NO
13	Diabetes mellitus	Yes, NO
14	Classification	Yes, NO

3.2. Artificial Neural Network (ANN)

A machine learning method is called an artificial neural network (ANN). That uses multiple synthetic neurons to depict the human brain. A computational model is ANN. These computer models consist of a complicated network of fundamental elements or a collection of neurons-named nodes. There are connections between the nodes. Each link between the nodes has a particular weight attached to it. Any neural network's basic architecture consists of 3 layers. The Input-layer is the First-layer, the Hidden-layer is the Second-layer, and the Output-layer is the third and Final-layer. All three of these layers, with one or more nodes, are present in every neural network. One hidden layer will be present in a simple and fundamental neural network. However, a complex neural network may contain numerously Hidden- layers. The initial input layers are where the inputs to the network are fed. The calculations are carried out in the hidden layers, and the corresponding output is revealed through the output layers. There are numerous varieties of neural networks out there [12].

Multiple hidden layers in neural networks are common today and are essential for many significant computational tasks. The Multilayer Perceptron is a wonderful illustration of a neural

network with numerous hidden layers (MLP). A simple neural network is unable to solve a complex problem, but an MLP can. There are numerous perceptions in the multi-layer perceptron. Non-linear functions can be calculated by MLPs. As a result, regression and classification are their main applications in supervised learning [13]. In figure 1. Shows (Artificial neural networks (MLP, or multilayer perceptron).

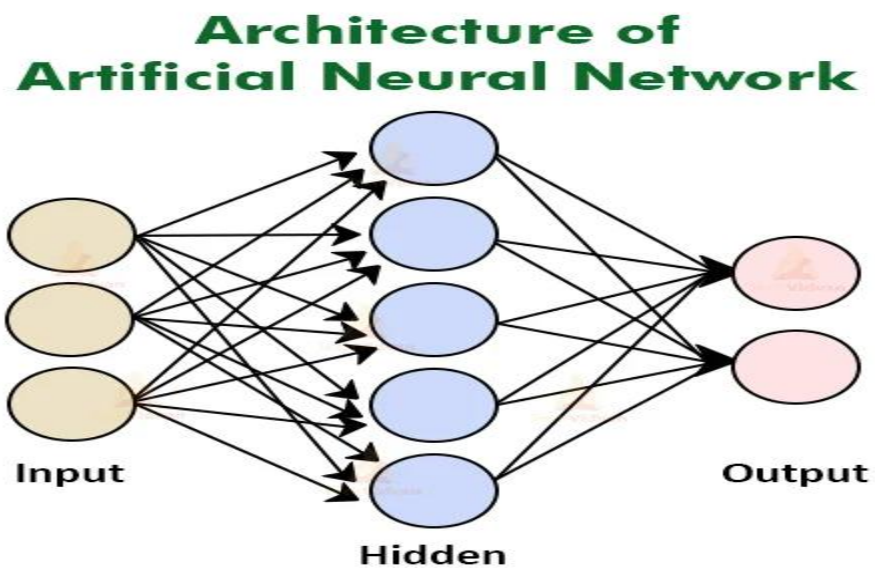

Figure 1. " Artificial neural networks (MLP, or multilayer perceptron)."

In the network layout shown above, data is delivered into the network through three input nodes, and computation takes place over two subsequent hidden layers. If the patient has the disease, the output is finally produced at the output layer as a binary value of yes or no.

3.3. Working of Artificial Neural Network methods

The operating principle of the human brain serves as inspiration for the artificial neural network's operating principle [14]. Numerous billions of neurons in the human brain communicate with one another. Artificial neural networks function similarly to the biological systems that served as their inspiration. The connections between the neurons can be viewed as weighted directed graphs, with the neurons serving as the nodes and the connections between the neurons serving as the edges. The processing portion of a neuron receives a variety of messages (both from other neurons and as input signals from the external world). Sometimes, signals are altered at the receiving synapses, and the processing element adds the weighted inputs. If the threshold is crossed, the signal is input to other neurons (or output to the outside world), and the cycle is repeated.

Over time, ANN will prepare itself for every conceivable card flow scenario. ANN will be able to remember every call since we are not dealing cards with a dealer. As a result, it is a machine learning method with a huge memory. However, it does not perform well when the scoring population differs greatly from the training sample. As an illustration, suppose I want to use an ANN to target clients based on their prior responses. I'm probably employing the incorrect methodology because the association between the response and other variables may have been overly suited by it. For the same reason, it performs exceptionally well in both voice and image recognition scenarios.

3.4. Preprocessing

Through the use of artificial neural networks In the first stage, load the dataset and determine how many rows and columns there are in the data set before classifying patients as having chronic kidney disease or not. A patient is represented by each row, and each patient's data is represented by each column. The data set is divided into two independent data sets, X, the feature data set, and Y, the dependent data set, or the target data set, by removing all the records or rows with null values. The dataset's categorical values are all changed to binary values 0 or 1. divide the data sets into 80% training data and 20% testing data.

Building the architecture models requires two layers, the first of which has 256 neurons and a Rectified Linear Unit (ReLU) activation function with a normal distribution initializer. Given that it is the first layer and we must also specify the number of features/columns in the data set, the second layer, which also happens to be the last layer, will contain one neuron and utilize the 'hard sigmoid' activation function.

Create the model and supply it with the binary classification loss function known as "binary cross-entropy", which evaluates how well the model performed during training before attempting to improve it with the optimizer.

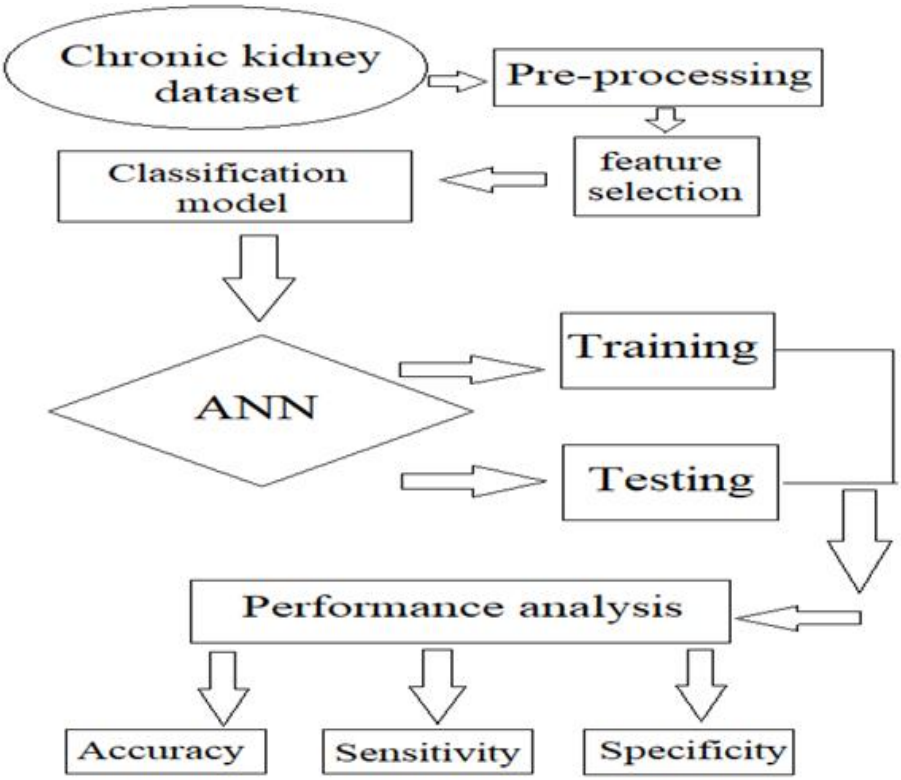

Figure 2. "Architecture System"

3.5. Measurement and Evaluation:

In this stage, a csv_ dataset is categorized as normal or anomalous data [15]. The ANN commonly referred to as "neural networks," is a mathematical representation of biological neural networks that has been used as a classification job for the precise diagnosis of CKD based on different performance

evaluation parameters. The three characteristics that are most usually used to define a diagnostic test are accuracy, specificity, and sensitivity.

Accuracy: It is the proportion of real findings in a population, whether they be positive, negative, or neither. Based on a condition, it calculates the degree of precision of a test.

TP:(true positive), TN:(true negative), FP:(false positive), and FN:(a false negative).

$$\text{Accuracy}=\frac{TP+TN}{TP+FP+TN+FN}$$

Sensitivity: The true positive rate is another name for it. It estimates the proportion of correctly identified positives. The chance of a positive test indicates the patient's illness.

$$\text{Sensitivity}=\frac{TP}{TP+FN}$$

Specificity: It's sometimes referred to as the real negative. It gives an estimate of the proportion of accurately identified negatives. The likelihood of a negative test demonstrates the patient's health.

$$\text{Specificity}=\frac{TN}{TN+FP}$$

4. EXPERIMENT RESULTS AND DISCUSSION:

With examples from every class, a neural network model is selected and trained. The system can identify unknown cases and offer predictions after a successful training phase. The Adam optimizer is the one used for the neural network model. Since the prediction involves a binary classification of yes/no decisions, the loss function binary cross-entropy is applied. The neural network model is tested with 58 data instances after being trained on 229 instances or data pieces. One hidden layer is utilized, which is adequate. There will be 500 epochs in total.

Table 2. 'MLP Variables'

Variables	Values
Number of Training data	229
Number of Testing data	58
Number of Hidden Layers	1
Accuracy	98

The accuracy is initially about lower than the loss when the model first begins to run, but as the model iterates over several hundred epochs, we can observe a sharp increase in accuracy up to 99% and a sharp decline in loss to as little as insignificant. That shows in Figures 3 and 4.

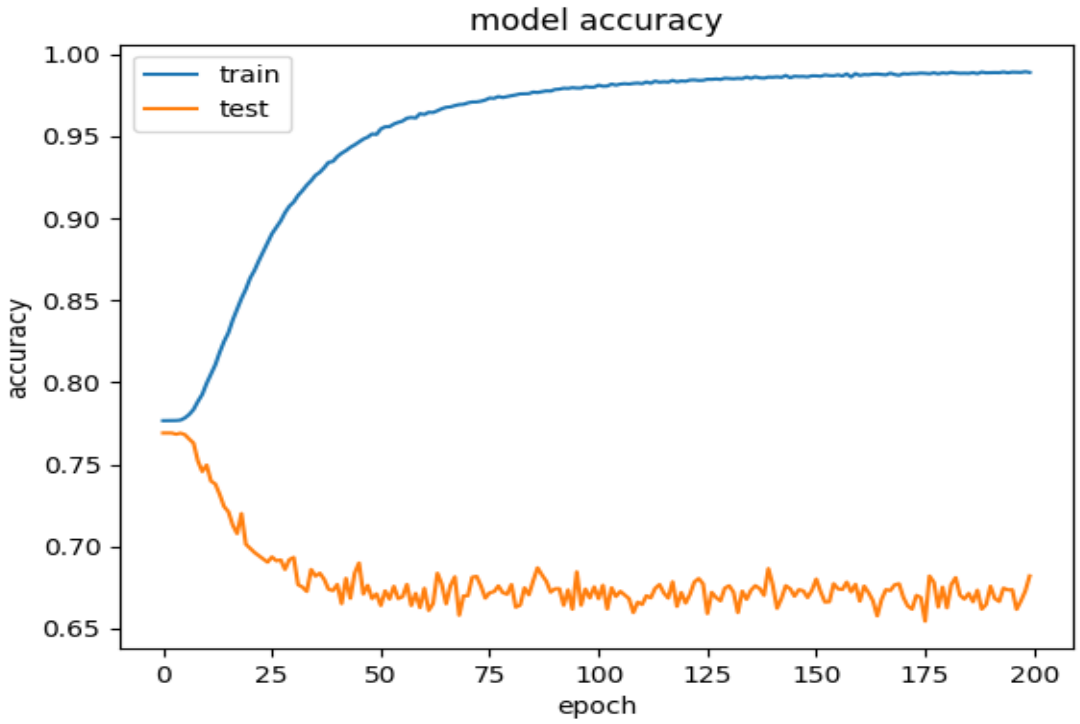

Figure 3. " Accuracy Model"

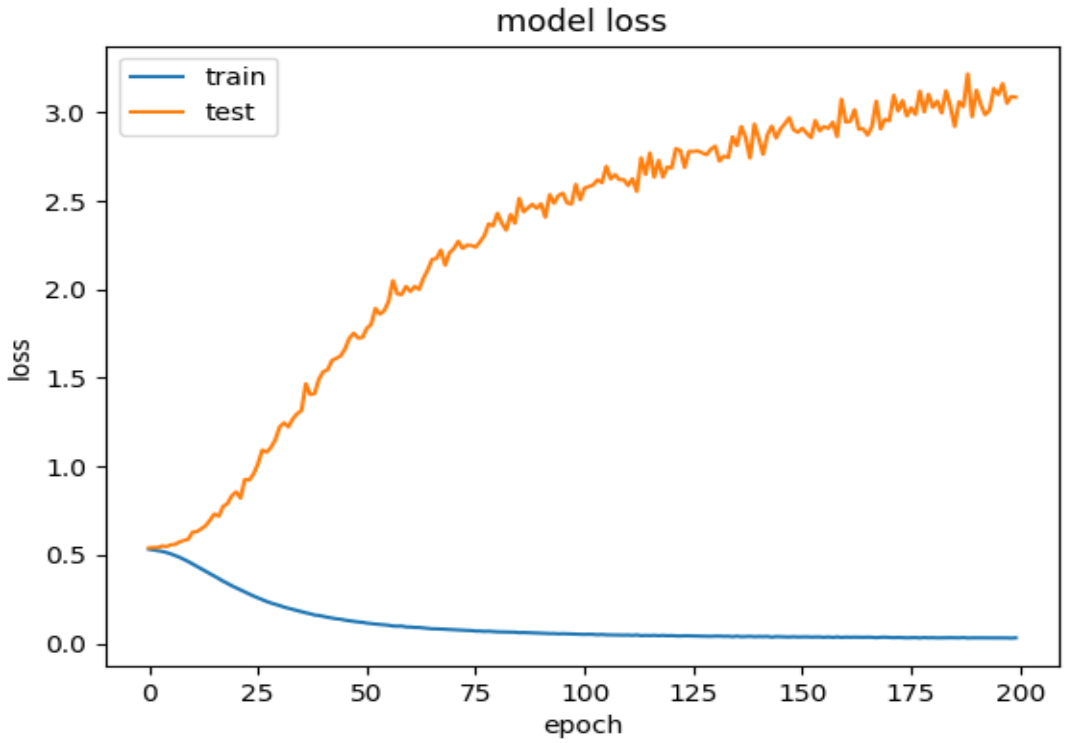

Figure 4. "Loss Model"

Thus, we may conclude that the neural network model employed to categorize the condition is quite effective and precise. We may analyze and assess the classification value (Accuracy, Sensitivity, Specificity, Precision, etc.) for the testing data after receiving the primary result. The accuracy numbers for this purpose are 98%, whereas the accuracy using the training data is 99.56%. As can be seen, the training accuracy is higher than the testing accuracy. That shows in figure 4.

Table 3: 'Analysis table'

Accuracy	98
Sensitivity	1
Specificity	97
Recall _ score	1
f1_score	98
Precision	96

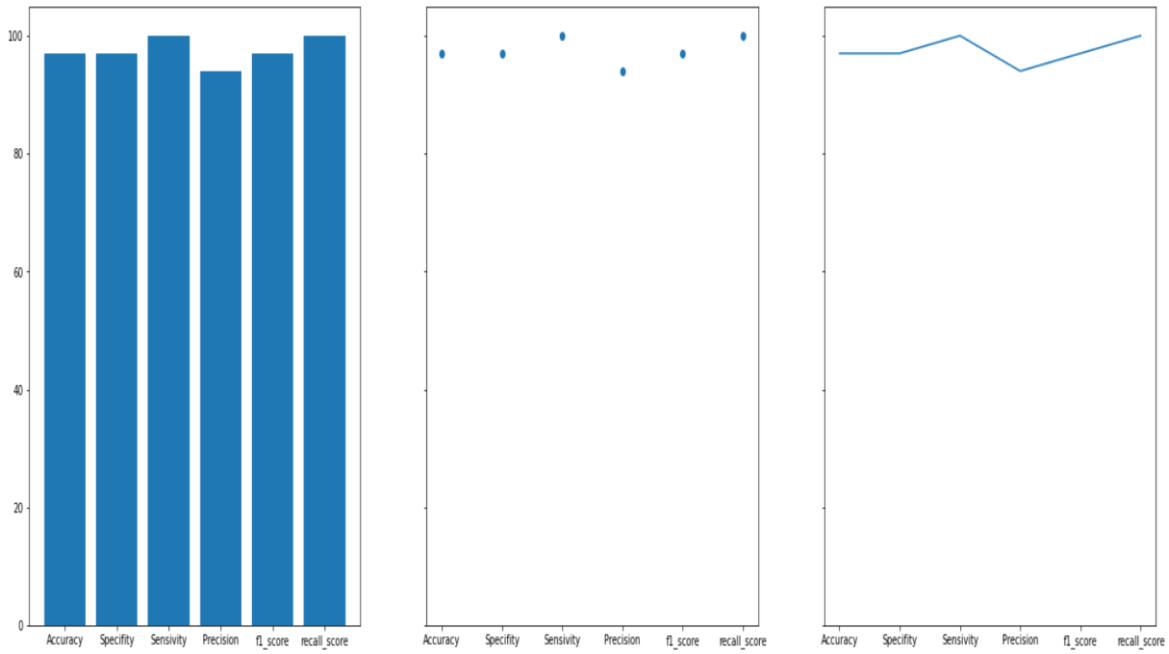

Figure 5. "Comparative Plotting"

Conclusion

In the work that is being presented, chronic kidney disease is diagnosed using neural networks. We were able to find the ideal model for diagnosing CKD with the help of the given data. With a 99.56% accuracy rate, the multilayer perceptron in ANN is an excellent model for the diagnosis of CKD. Additionally, the error rate is quite low. As a result, we have concluded that MLP training is one of the best and most effective algorithms for diagnosing kidney illness. Due to the size of the data collection and the absence of attribute values, the application's disadvantage is the lack of strong data.

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