

Comparative Analysis of Chronic Kidney Disease using Novel Decision Tree Algorithm by Comparing Linear Regression for Obtaining Better Accuracy

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ABSTRACT

Aim: Chronic kidney disease (CKD) is among the main 20 reasons for death worldwide and influences around 10% of the world grown-up populace. CKD is an issue that upsets typical kidney work. The main objective of this study aims to find the best-suited algorithm that will give us the most ideal prediction. We will be comparing Novel Decision Tree with Linear Regression to find out which of these can give us the best accuracy.

Material and Methods: The study used 322 samples with Novel Decision Tree and Linear Regression is executed with varying training and testing splits for predicting the accuracy for kidney disease prediction with the G-power value of 80% and the kidney datasets were collected from various web sources with recent study findings and threshold 0.05%, confidence interval 95% mean and standard deviation. The performance of the classifiers are evaluated based on their accuracy rate using the chronic kidney disease dataset. **Results:** The accuracy of predicting kidney disease in Novel Decision Tree (96.66%) and Linear Regression (85.25%) is obtained. There is a statistical 2-tailed significant difference in accuracy for two algorithms is 0.000 ($p < 0.05$) by performing independent samples t-tests.

Conclusion: This study concludes that the Prediction of Kidney disease using the Novel Decision Tree (DT) algorithm appears to be significantly better than the Linear Regression(LR) with improved accuracy.

Keywords

Chronic Kidney Disease, Novel Decision Tree, Linear Regression, Machine Learning, Classification, Diabetes.

Imprint

Rohith J, Uma Priyadarsini P.S. Comparative Analysis of Chronic Kidney Disease using Novel Decision Tree Algorithm by Com-

paring Linear Regression for Obtaining Better Accuracy. *Cardiometry*; Special issue No. 25; December 2022; p. 1793-1799; DOI: 10.18137/cardiometry.2022.25.17931799; Available from: <http://www.cardiometry.net/issues/no25-december-2022/comparative-analysis-chronic-kidney>

INTRODUCTION

The kidneys are two kinds of organs placed towards the lower back of the abdomen. The kidney's job is to strain the blood by moving out the toxic substance from the body using the bladder through urination (Yildirim 2017). Chronic kidney disease (CKD) is a universal public wellbeing difficulty. 10% of the world's population is affected by CKD (Chowdhury et al. 2021). The prediction of Chronic Kidney disease and to increase the accuracy of predicting the disease using Novel Decision Tree and comparing it with Linear Regression. Both type 1 and type 2 diabetes can cause kidney illness. Kidney infections are the ninth driving reason for death in the United States. Roughly 1 out of 3 grown-ups with diabetes has CKD. In the last decade, Chronic Kidney Disease (CKD), or chronic renal disease remains the primary basis of death around the world (Bandyopadhyay, n.d.). High blood glucose, likewise called glucose, can harm the veins in your kidneys. Whenever the veins are harmed, they don't fill in too. Many individuals with diabetes additionally foster hypertension, which can likewise harm your kidneys. CKD can be caused by diabetes, hypertension, coronary heart disease, lupus, anemia, bacteria and albumin in the urine, complications of some drugs, sodium and potassium deficiency in the blood and family history, and many others (Merchant 2010). This paper proposed a system that uses various data mining techniques like the Random Forest algorithm and Backpropagation Neural Network. Here they compared both of the algorithms and found that the Back Propagation algorithm gives the best result as it uses the supervised learning network called feedforward neural network (Chiu et al. 2021). In this, they proposed the development of a CKD, diabetes prediction system using machine learning techniques such as K-Nearest Neighbor, Logistic Regression, Novel Decision Tree, Random Forest, Naive Bayes, Support Vector Machine, and Multi-Layer Perceptron Algorithm. These are applied and their performance is compared to the accuracy, precision, and recall results. Finally,

the Random Forest is chosen to implement this system (Vagliano, Hsu, and Schut 2022). Diabetes is often diagnosed in later stages when dialysis or kidney transplant are the only options left to save the patient's life. Whereas an early diagnosis can lead to the prevention of kidney failure (Dong et al. 2021).

A lot of research has been done based on the classification of the chronic kidney using machine learning algorithms. More than 180 articles were published in IEEE explore and nearly 1525 articles were found in google scholar. We used Python as a high-level interpreted programming language for developing our system. This study focused on assessing a dataset gathered from 400 patients containing 24 elements (Chiu et al. 2021). The mean and mode factual examination strategies were utilized to supplant the missing mathematical and ostensible qualities (Ilyas et al. 2021). To pick the main elements, Recursive Feature Elimination (RFE) was applied (Sinha, Sinha, and BUIT 2015). The authors proposed half and half models between the GA and the three referenced models. This applied the Union Based Feature Selection Technique (UBFST) to pick the main elements (Li 2022). The chosen highlights were analyzed by a few methods of AI. The point of the review was to diminish symptomatic time and acquire high indicative exactness (Ventrella et al. 2021). After effectively filling out the incomplete data set, six machine learning algorithms (logistic regression, random forest, support vector machine, k-nearest neighbor, naive Bayes classifier, and feed-forward neural network) were used to establish models (Dong et al. 2021). Our team has extensive knowledge and research experience that has translate into high quality publications (Chellapa et al. 2020; Lavanya, Kannan, and Arivalagan 2021; Raj R, D, and S 2020; Shilpa-Jain et al. 2021; S, R, and P 2021; Ramadoss, Padmanaban, and Subramanian 2022; Wu et al. 2020; Kalidoss, Umapathy, and Rani Thirunavukkarasu 2021; Kaja et al. 2020; Antink et al. 2020; Paul et al. 2020; Malaikolundhan et al. 2020)

The existing research study predicts the classification using diabetes prediction but it does not group them. Although an AI model that utilizes the comorbidity and health information acquired from Taiwan's National Health Insurance Research Database to conjecture the event of CKD inside the following 6 or a year prior to its beginning, and consequently its predominance in the populace. Therefore the study aims to increase the accuracy of predicting the likelihood of

kidney failure and improve the prediction model using the Novel Decision tree.

Materials And Methods

This research study was carried out in the Artificial Intelligence Laboratory at the Department of Computer Science and Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai. This research study uses two groups, the Novel Decision Tree algorithm, and Linear Regression Algorithm algorithm. Each sample size was predicted using the g-power tool with version 3.1.10 and resulting in 322 total sample sizes and 161 sample sizes per group with 80% of G power values, 95% confidence (Kumar and Abhishek 2012).

The data set used for this experiment is obtained from the kaggle open-access dataset (https://www.kaggle.com/mansoordaku/ckdisease?select=kidney_disease.csv), one of the most popular if not the most popular online communities for data scientists and machine learning practitioners. It allows users to search and find datasets that they require and also provides a customizable Jupyter notebook environment with free GPU and 6 hours of runtime. Table 1 contains the description of the dataset, The dataset consists of 76 attributes. The attributes are bp, sg, su, RBC, PCC, BGR, and 20 others. The dataset has 401 rows and 26 columns which consists of data for the symptoms that relate to chronic kidney disease which also includes duplicate, null and missing values. Pre-processing of the datasets is done to remove the duplicate and null values with the help of functions that are provided by Microsoft excel. The dataset that is collected consists of all numerical forms; there is no need to convert the data. The unwanted attributes that are not necessary for the prediction are removed.

The testing setup uses Core i5 with 2.25 GHz with 8 gigabytes of random access memory. In this proposed system 50GB hard disk and 8GB RAM for the execution of the Algorithm. The system type used was a 64-bit Operating System, X64 and it is windows operating system. To use a machine-learning algorithm the one of the Integrated Development Environment called Spyder software with pre-installed libraries or Google collab can be used for replacement. The proposed system for the classification of heart disease prediction involves the following steps: correlation between columns, Exploratory data analysis (EDA), feature extraction, and classification.

Novel Decision Tree Algorithm

Novel Decision Tree falls under the category of supervised algorithms. Novel Decision Trees can be used for both classification and regression. In the classification Novel Decision Tree, the decision variable is categorical. For implementing a Novel Decision Tree, the cost function used to evaluate the binary splits called the Gini Index should be calculated. The split creation is done with help of calculating the Gini score, splitting the dataset, and evaluating them all splits. Once this is done and the root node is created It can start building the tree by first deciding when to stop the growth of the tree by creating the terminal node by setting the maximum tree depth and second, by using recursive splitting. The terminal node is used for the final prediction and recursive splitting is a method used to build the tree.

Pseudocode for Novel Decision Tree is shown below:

```
Step 1: from sklearn.tree import DecisionTreeClassifier
Step 2: seed = 7
Step 3: kfold = model_selection.KFold(n_splits=45,
random_state=seed)
Step 4: model = DecisionTreeClassifier()
Step 5: model.fit(X_train,Y_train)
Step 6: accuracy_score(Y_test,model.predict(X_test))
```

Linear Regression

Linear regression is a linear model, e.g. a model that assumes a linear relationship between the input variables (x) and the single output variable (y). More specifically, that y can be calculated from a linear combination of the input variables (x).When there is a single input variable (x), the method is referred to as simple linear regression.When there are multiple input variables, literature from statistics often refers to the method as multiple linear regression.Different techniques can be used to prepare or train the linear regression equation from data, the most common of which is called Ordinary Least Squares.

Pseudocode for Linear Regression is shown below:

```
Step 1: from sklearn.linear_model import LinearRegression
```

```
Step 2: from sklearn.preprocessing import StandardScaler
```

```
Step 3: mlr = LinearRegression()
```

```
Step 4: sc_x = StandardScaler()
```

```
Step 5: X_new = sc_x.fit_transform(x)
```

Statistical Analysis

The statistical analysis is applied using Statistical Package for Social Sciences (SPSS) for descriptive statistical analysis such as mean, standard deviation and standard error were carried out for each group (Ventrella et al. 2021). The test was performed to compare variables across the study groups. Hence the independent variable in this study is mean, entropy, variance, and contrast. The dependent variables are accuracy, bp, rbc. The independent sample t-test is performed to compare the accuracy performance of both Group-1 and Group-2 using the DT and the RF algorithms.

RESULTS

The Novel Decision Tree classifier (DT) takes input in the form of symptoms from the dataset and produces output with an accuracy value of around 96.66%. The mean accuracy and loss values using the T-test for both the algorithms along with the standard derivation are shown in Table 6. Here Novel Decision Tree and Linear Regression algorithms are used. The DT algorithm and LR are compared with 10 samples by applying 70% of training data and 30% of testing datasets. The performances of the classifiers are measured by accuracy value.

Table 1 contains the accuracy for the Novel Decision Tree classifier with N = 10 and Table 2 contains

Table 1

Novel Decision Tree Accuracy and Loss for N = 10.The accuracy of predicting kidney disease using Novel Decision Tree (96.66%) is obtained.

| Iterations | Accuracy(%) |
|------------|-------------|
| 1 | 96.66 |
| 2 | 95.12 |
| 3 | 96.78 |
| 4 | 94.43 |
| 5 | 96.92 |
| 6 | 93.13 |
| 7 | 97.10 |
| 8 | 92.33 |
| 9 | 97.85 |
| 10 | 91.11 |

Table 2

Linear Regression Accuracy and Loss for N = 10. The accuracy of predicting kidney disease using Linear Regression (85.25%) is obtained.

| Iterations | Accuracy(%) |
|------------|-------------|
| 1 | 85.25 |
| 2 | 80.21 |
| 3 | 86.23 |
| 4 | 78.23 |
| 5 | 87.34 |
| 6 | 75.23 |
| 7 | 88.34 |
| 8 | 72.45 |
| 9 | 89.12 |
| 10 | 70.12 |

the accuracy for the Linear Regression classifier with N = 10. The Linear Regression classifier input is taken from the dataset and it gives an output accuracy of 85.25%.

From Table 3 the statistical analysis of Novel Decision Tree and Linear Regression Mean accuracy value

Table 3

Group Statistics results (Mean of Novel Decision Tree Algorithm is 96.66% is more compared to Linear Regression Algorithm 85.25%) and got the highest accuracy and the least error. Standard deviation and Standard Error Mean were also calculated.

| | Group | N | Mean | Std. Deviation | Std. Error Mean |
|----------|---------------------|----|---------|----------------|-----------------|
| Accuracy | Novel Decision Tree | 10 | 95.1430 | 2.31026 | .73057 |
| | Linear Regression | 10 | 81.2520 | 6.97498 | 2.20568 |

and Standard deviation are observed that the DT algorithm performed better than the LR algorithm.

Table 4 it is observed that the Novel Decision Tree has better significance Linear Regression with the value of $p = 0.00$.

Table 5 shows the accuracy values for both the Novel Decision Tree and Random Forest algorithm. The DT algorithm obtained 2.31 standard deviations with 6.97 standard error while the LR algorithm obtained .730 standard deviations with 2.20 standard error.

Table 4

Independent Sample Test for significance and standard error determination. P-value is 0.00 (less than 0.005) considered to be statistically significant and 95% confidence interval was considered.

| | | Levene's test for equality of variances | | T-test for equality means with 95% confidence interval | | | | | | |
|----------|-----------------------------|---|------|--|--------|-----------------|-----------------|-----------------------|---------|----------|
| | | f | Sig. | t | df | Sig. (2-tailed) | Mean difference | Std. Error difference | Lower | Upper |
| Accuracy | Equal variances assumed | 16.954 | .001 | 5.978 | 18 | .000 | 13.89100 | 2.32352 | 9.00946 | 18.77254 |
| | Equal Variances not assumed | | | 5.978 | 10.951 | .000 | 13.89100 | 2.32352 | 8.77418 | 19.00782 |

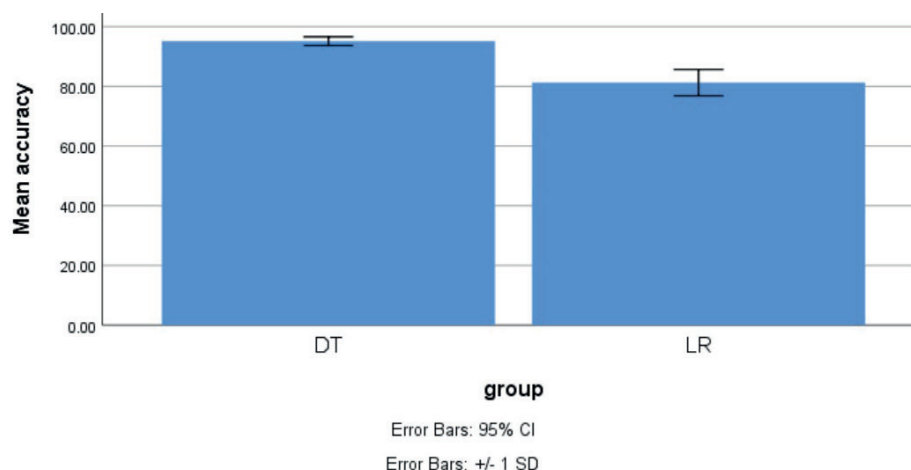


Fig. 1. Bar Chart representing the comparison of Mean Accuracy of Novel Decision Tree Algorithm and Linear Regression algorithms. Mean accuracy of the Novel Decision Tree Algorithm appears to be better than Linear Regression algorithm. The X-axis represents Novel Decision Tree Algorithm and Linear Regression algorithms and Y-axis represents the mean accuracy \pm 1 SD.

Table 5

Comparison of the Novel Decision Tree Algorithm and Random Forest Algorithm with their accuracy

| CLASSIFIER | ACCURACY(%) |
|-------------------|-------------|
| Decision Tree | 96.66% |
| Linear Regression | 85.25% |

Accuracy and the Loss for both the algorithms are presented in a bar graph in Fig 1. From Table 5 it is observed that the Novel Decision Tree proved with better and higher accuracy (96.66%) than Linear Regression(85.25%).

Figure 1 has the mean accuracy of the two algorithms has been shown and compared the mean error and the graph shows that Novel Decision tree is better than the LR algorithm

The Novel DT model obtained 96.66% and the LR algorithm already predicted 85.25%. performance value. Finally, we compared the mean error of DT and LR algorithms as shown in Fig. 1. Therefore the Novel DT is significantly better than the LR algorithm.

DISCUSSION

Novel Decision Tree appears to be significantly better than Linear Regression with improved accuracy. The Novel Decision Tree classifier shows a significant difference in terms of accuracy score, speed, and performance when compared to the Linear Regression classifier.

This finding is similar to (Zelnick et al. 2021) what they have found, with the Novel Decision Tree classifier performing better than the logistic regression classifier. Similar studies that have been made by others such as (Senan et al. 2021) also have similar findings where Novel Decision Tree is better than Logistic Regression and so it can be implemented in real time detection of CKD. (Rashed-Al-Mahfuz et al. 2021) presents a methodology to control the disease using a suitable diet plan. In this research, classifiers are constructed using different algorithms like Multiclass Decision Jungle, Multiclass Decision Forest, Multiclass Neural Network, and Naive Bayes. (Kumar and Abhishek 2012) The classification and regression tree, i.e. RPART model, showing considerably good results. It uses the ratio of information gain for splitting criterion, where the optimal split would decrease impurity of resulting subsets(Bellocchio et al. 2021). Performance of four kernels-based ELM, namely RBF-ELM, Linear-ELM, Polynomial-ELM, Wavelet-ELM

are compared with the performance of standard ELM. The above methodologies were compared on metrics of sensitivity and specificity. Radial Basis Function – Extreme Learning Machine (RBF-ELM) showed higher prediction rates (Chowdhury et al. 2021).

Most of the previous work done is based on the data from the specific dataset. In the proposed work the lack of accuracy in predicting chronic kidney disease is improved by machine learning algorithms(Bradley et al. 2019). In the future, this work can be extended to find how likely nondiabetic people can have kidney failure in the next few years. Artificial intelligence can also be used in the future to predict the severity of kidney failure(Rashed-Al-Mahfuz et al. 2021). Even more, data can be accumulated over the existing data, and also datasets of feature set selection can be used. Deep Neural networks can be used for those datasets which will have a significant difference in terms of accuracy and real-world implementation (Chowdhury et al. 2021).

CONCLUSION

In this research, Chronic kidney disease prediction is performed using the kidney disease symptoms dataset for Novel Decision Tree and Linear Regression regression. The accuracy value of the Novel Decision Tree classifier is 96.66% whereas the accuracy value of logistic regression is 85.25%. The quality of Chronic kidney disease prediction and accuracy using Novel Decision Tree appears to be better than Linear Regression.

DECLARATION

Conflicts of Interests

No conflict of interest in this manuscript.

Authors Contributions

Author RJ was involved in data collection, data analysis, and manuscript writing. Author UP was involved in conceptualization, data validation, and critical review of the manuscripts.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding

We thank the following organizations for providing financial support that enables us to complete the study.

1. CUBE Innovations, Vijayawada, India.
2. Saveetha University.
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

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