Chronic Kidney Disease Prediction by Using Different Decision Tree Techniques

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Abstract. Early detection and proper management of Chronic Kidney Disease (CKD) are solicited for augmenting survivability due to fact that CKD is one of the life-threatening diseases. The UCI’s CKD dataset which is selected for this study is consisting of attributes like age, blood pressure, specific gravity, albumin, sugar, red blood cells, plus cell, pus cell clumps, bacteria, blood glucose random, and blood urea. The main purpose of this work is to calculate the performance of various decision tree algorithm and compare their performance. The decision tree techniques used in this study are DecisionStump, HoeffdingTree, J48, CTC, J48graft, LMT, NBTree, RandomForest, RandomTree, REPTree, and SimpleCart. Hence, the results show that RandomForest serves the highest accuracy in identifying CKD.

1. Introduction
Chronic Kidney Disease (CKD) is a termed generally to describe disorders affecting kidney structure and function[1]. CKD becomes a major health problem for the underdeveloped countries of southeast Asia, home to more than 2 billion people [2]. CKD may be triggered by diabetes, high blood pressure and other disorders. Early detection and treatment can often keep CKD from getting worse to save human life.

This paper aims to compare the decision tree algorithms such as DecisionStump, HoeffdingTree, J48, CTC, J48graft, LMT, NBTree, RandomForest, RandomTree, REPTree, and SimpleCart in predicting CKD. The CKD dataset are analyzed using above decision tree algorithms and compare their performance with respect to seven performance metrics (FACC, MAE, PRE, REC, FME, Kappa Statistics and Runtime).

2. Related Works
Subashini, et al. [3] measured the performance of classification techniques using classifier such as Artificial Neural Network (ANN), K-Nearest Neighbors (KNN), Support Vector Machine (SVM), Naïve Bayes, Decision Tree, and Fuzzy. Using Matlab R2016a as analyzing tool, they validated and tested the classification parameters of six methodologies such as Accuracy, Precision, Recall, Specificity, and F-Measure on 400-instances CKD dataset. From the evaluation parameters, they concluded that the fuzzy technique serve the best performance for CKD classification.
P. Sinha, et al. [4] compared two data mining techniques in predicting CKD by using Support Vector Machine (SVM) and K-Nearest Neighbors (KNN) classifier. The experimental analysis performed by Matlab tool showed that SVM classifier outperforms three of four evaluation parameters than KNN classifier. E. Celik, et al. [5] diagnosed and estimated of CKD using J48 and Sequential Minimal Optimization (SMO) algorithm in Weka tool. They proposed to compare Decision Tree to Support Vector Machine (SVM) technique in predicting CKD. The classification stage revealed that Decision Tree has more successful than SVM recognition in correct classification.

K.R. Lakshmi, et al. [6] performed a comparative study in predicting kidney dialysis survivability by using thee data mining techniques such as Artificial Neural Network (ANN), Decision Tree, and Logistic Regression. Data analysis used AVF data of 193 under-hemodialysis patients in Hashimenejad Kidney Center (HKC) of Tehran. Using 10-fold cross validation fold, they concluded that ANN show the high level compare than other two techniques in accuracy and sensitivity parameter. S. Ramya, et al. [7] compared Back-Propagation Neural Network (BPN), Radian Basis Function (RBF), and RandomForest (RF) in diagnosing CKD. The dataset including 1000 instances and fifteen attributes were obtained from medical reports of patients from different laboratories in Combatore. Using R tool, the experimental results revealed that the RBF gains the highest accuracy than other two algorithm.

Sunil D., et al. [8] addressed the use of two data mining techniques in Rapidminer tool for CKD prediction such as Naïve Bayes and Artificial Neural Network (ANN). The results show that Naïve Bayes outperform ANN in classification accuracy. A. Subas, et al. [9] compared five data mining classifiers such as Artificial Neural Network (ANN), Support Vector Machine (SVM), K-Nearest Neighbors (KNN), C.45 Decision Tree, and RandomForest (RF) Decision Tree in Weka tool. The evaluation parameters show that RF serves the highest accuracy than other three techniques. S. Vijayarani, et al. [10] used Support Vector Machine (SVM) and Artificial Neural Network (ANN) to classify kidney disease such as Acute Nephritic Syndrome, Chronic Kidney Disease, Acute Renal Failure, and Chronic Glomerulonephritis. From the results of classification accuracy and execution time, SVM can be considered as better classifier compared to SVM.

3. Method and Framework
Main objective of this study is to identify that whether the patient has CKD or not. Some of the parameter are used for predicting the CKD and compare the performance of the various decision tree techniques using Weka. Weka is a data mining tool which is written in Java and developed at Waikato University [11]. The result found from the CKD dataset by using Weka tool are in section 4. 10-fold cross validation performed on the dataset.

The objective of this study is CKD prediction using data mining tool. The main task in this study is (1) various decision tree techniques are used for the prediction of the CKD; (2) comparing different decision tree techniques; and (3) finding best decision tree for the CKD prediction.

3.1. Decision Tree
Eleven decision tree techniques have been used in this study are DecisionStump, HoeffdingTree, J48, CTC, J48graft, LMT, NBTree, RandomForest, RandomTree, REPTree, and SimpleCart. Their performance was analyzed using Accuracy (ACC), Precision (PRE), Recall (REC), Mean Absolute Error (MAE), F-Measure (FME), Kappa Statistic and Runtime.

3.2. Dataset
The data are collected from UCI Machine Learning Repository and it predicts CKD based on the given attributes [12]. The dataset has twenty four attributes which predict the CKD. The dataset is built on both numerical and nominal data types. As per the UCI’s CKD dataset, this contains the attribute such as age, blood pressure, specific gravitivity, albumin, sugar, red blood cells, plus cell, pus cell clumps, bacteria, blood glucose random, blood urea, serum creatine, sodium, potassium, hemoglobin, packed cell volume, white blood cell count, red blood cell count, hypertension, diabetes mellitus, appetite, pedal edema, and anemia.
Table 1. Attribute Description

| Attribute Name  | Attribute Type | Attribute Values | Attribute Code |
|----------------|----------------|-----------------|----------------|
| Age            | numeric        | years           | age            |
| Blood Pressure | numeric        | mm/Hg           | bp             |
| Specifc Gravity| numeric        | 1.005, 1.010, 1.015, 1.020, 1.025 | sg             |
| Albumin        | numeric        | 0, 1, 2, 3, 4, 5 | al             |
| Sugar          | numeric        | 0, 1, 2, 3, 4, 5 | su             |
| Red Blood Cells| nominal        | normal, abnormal | rbc            |
| Plus Cell      | nominal        | normal, abnormal | pc             |
| Plus Cell Clumps| nominal  | present, notpresent | pcc           |
| Bacteria       | nominal        | present, notpresent | ba             |
| Blood Glucosa Random | numeric | mgs/dl | bgr |
| Blood Urea     | numeric        | mgs/dl          | bu             |
| Serum Creatine | numeric        | mgs/dl          | sc             |
| Sodium         | numeric        | mEq/l           | sod            |
| Potassium      | numeric        | mEq/l           | pot            |
| Hemoglobin     | numeric        | gms             | hemo           |
| Packed Cell Volume | numeric | - | pcv |
| White Blood Cell Count | numeric | cells/cumm | wbcc |
| Red Blood Cell Count | numeric | millions/cumm | rbcc |
| Hypertension   | numeric        | yes, no         | htn            |
| Diabetes Mellitus | numeric | yes, no | dm |
| Coronary Artery Disease | nominal | yes, no | cad |
| Appetite       | nominal        | good, poor      | appet          |
| Pedal Edema    | nominal        | yes, no         | pe             |
| Anemia         | nominal        | yes, no         | ane            |
| Class          | nominal        | ckd, notckd     | class          |

Figure 1. Dataset for CKD Prediction

4. Results and Discussion
The comparison of various decision tree algorithms performed on CKD data is shown in Table 2. RandomForest has the highest accuracy rate. The accuracy rate of this algorithm is 100%. It is seen that RandomForest is the most powerful classifier for this dataset. This result shows that the CKD of a new patient is predicted successfully with an acceptable ratio 100%. J48, J48graft and NBTree has the accuracy rate as 99%, 98.75% and 98.5%. It is also seen that DecisionStump has the worst accuracy rate with 92%. The comparison of decision tree algorithm with respect to accuracy shown in Figure 2.
The comparison of decision tree algorithm with respect to kappa statistics and runtime is shown in Figure 3 and Figure 4 respectively. RandomTree, DecisionStump and J48 are faster than other algorithms. NBTree algorithm takes a long time even though a small dataset is used.

| Techniques   | Tree Size | ACC  | MAE  | PRE  | REC  | FME  | Kappa Statistics | Runtime |
|--------------|-----------|------|------|------|------|------|------------------|---------|
| DecisionStump| Single Level | 92%  | 0.1362 | 0.926 | 0.920 | 0.921 | 0.8338 | 0.01    |
| HoeffdingTree| 1         | 95.75% | 0.043 | 0.962 | 0.958 | 0.958 | 0.9113 | 0.07    |
| J48          | 14        | 99%  | 0.0225 | 0.990 | 0.990 | 0.990 | 0.9786 | 0.01    |
| CTC          | 9         | 97%  | 0.0387 | 0.972 | 0.970 | 0.970 | 0.937  | 0.03    |
| J48graft     | 14        | 98.75% | 0.0244 | 0.987 | 0.988 | 0.987 | 0.9733 | 0.03    |
| LMT          | 1         | 98%  | 0.0222 | 0.981 | 0.980 | 0.980 | 0.9577 | 0.72    |
| NBTree       | 15        | 98.5% | 0.0289 | 0.985 | 0.985 | 0.985 | 0.9682 | 2.99    |
| RandomForest | -         | 100% | 0.0414 | 1     | 1     | 1     | 1     | 0.14    |
| RandomTree   | 67        | 95.5% | 0.045 | 0.956 | 0.955 | 0.955 | 0.905  | 0       |
| REPTree      | 8         | 96.75% | 0.0634 | 0.968 | 0.968 | 0.967 | 0.9302 | 0.02    |
| SimpleCart   | -         | 97.5% | 0.037 | 0.975 | 0.975 | 0.975 | 0.9462 | 0.22    |

Figure 2. Comparison of The Decision Tree Algorithm According to Accuracy

Figure 3. Comparison of The Decision Tree Algorithms According to Kappa Statistics
5. Conclusion

The research employed some decision tree algorithm such as DecisionStump, HoeffdingTree, J48, CTC, J48graft, LMT, NBTree, RandomForest, RandomTree, REPTree, and Simple Cart to predict the CKD at an earlier stage. These algorithm provide various experimental result based on Accuracy, Mean Absolute Error, Precision, Recall, Kappa Statistics and Runtime. These techniques were evaluated and their performance was compared. From the analysis, RandomForest outperforms well than other algorithms and its achieved accuracy is 100%. The application of decision tree in predicting CKD will benefit in maintain the health. However, in future, we will collect the very recent data from various regions across the world for CKD diagnosis. The results of this study will encourage us to continue developing other advanced decision trees algorithm.

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