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Proposing Efficient Neural Network Training Model for Kidney Stone Diagnosis

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Abstract-*One of the major challenges in giving proper treatment is always fast and accurate diagnosis of the disease. A lot of works have been done in medical diagnosis using different neural network techniques. But it had always been a tough task to identify the best technique for any diagnosis. Like many other diseases neural network techniques had already been applied in Kidney Stone Diagnosis. Different techniques have their own limitations in terms of accuracy and time. In this paper two neural network techniques, Back Propagation Algorithm (BPA), Radial Basis Function (RBF) and one non-linear classifier Support Vector Machine (SVM) have compared in accordance with their efficiency and accuracy. By using WEKA 3.6.5 tool for implementation the best technique for Kidney Stone Diagnosis among the above three has been identified. The main purpose of this thesis work is to propose the best tool for medical diagnosis, like kidney stone identification, to reduce the diagnosis time and improve the efficiency and accuracy.*

Key words: *Artificial Neural Network, Back Propagation Algorithm, Radial Basis function, Support vector machine, Diagnosis.*

I. INTRODUCTION

Kidney stones are hard, solid particles that form in the urinary tract. In many cases, the stones are very small and can pass out of the body without any problems. However, if a stone (even a small one) blocks the flow of urine, excruciating pain may result, and prompt medical treatment may be needed. Some symptoms of kidney stone disease are pain, blood in the urine, gravel, nausea or vomiting, pain with urination. Kidney stones are among the most common—and painful—disorders of the urinary tract. Each year, thousands of Americans are diagnosed with kidney (renal) stone disease, a condition that develops when the urine becomes overly saturated with certain microscopic substances. They form crystals that eventually bind into hardened mineral deposits, known as calculi or stones. Kidney stones are hardened clumps of microscopic crystals that can develop anywhere in the urinary, **[13]. K**idney stone are diagnosed by culturing the report of lymphoctyes, monocytes, eosinophils, neutrophil, s. creatinine. These attributes have some ranges in term of value as shown in table 1. From the data, collected from Hospitals, it is found that the patients, who were diagnosed with Kidney Diseases, had the blood attributes as below:

Table 1 Medical report

ATTRIBUTES	WEIGHT	RANGE OF ATTRIBUTES
LYMPHOCTYES	30 gms	20- 50%
MONOCYTES	01 gms	1 - 6%
NEUTROPHIL	02 gms	1-4 %
S. CREATININE	61 gms	50 - 70 %
EOSINOPHIS	3 gms	4-10%

In this paper two neural network techniques, Back Propagation Algorithm (BPA), Radial Basis Function (RBF) and one non-linear classifier Support Vector Machine (SVM) applied for diagnosing kidney stone disease. In this paper first the above mentioned two Artificial Neural Network Algorithms and SVM classifier are applied to classify the patients with the Kidney Stone disease and then comparing their accuracy finally the best model for diagnosis has been proposed. The proposed model is supposed to predict each class of data and will be able to recognize the kidney stone diseases with higher accuracy in less time.

The simulation tool that has been used in this paper is weka 3.6.5 tool. This is a java based language tool. Weka contains tools for data pre-processing, classification, regression, clustering, association rules, and visualization. It is also well-suited for developing new machine learning schemes **[12]** Weka is the collection of different types of techniques i.e. back propagation, radial basis, SVM etc. In this paper the classification technique is used for training the network .0

Since last two decades researches had proposed many medical diagnosis models based on Neural Networks.

The Diagnosis of Thyroid disease in this paper the author compare the three back propagation, RBF, LVQ algorithm and find the best accuracy for diagnosis **. [1]**

The Diagnosis of Hepatitis diseases by Support Vector Machines and Artificial Neural Networks in this paper the author design various networks including RBF, GRNN, PNN, LVQ and SVM. The performance of each of them has studied and the best method is selected for each of classification tasks **[2].**

The Artificial Neural Networks in Medical Diagnosis The goal of this paper is to evaluate artificial neural network in disease diagnosis. [3]

The knowledge based approach for diagnosis of breast cancer. In this paper three algorithm back propagation, RBF and LVQ are compare for find best accuracy for diagnosis. [4]

3 Techniques used for kidney stone diagnosis in this paper:

Back propagation network

Back propagation is a supervised learning network. It requires a dataset of the desired output for many inputs, for creating the training set. There are two type of transfer function can be used by the back propagation algorithm is sigmoid and log sigmoid **[5]**. Back propagation algorithm is also known as multilayered feed forward network. The performance function used was mean sum- squared error (MSE) **[6]** Back propagation is a form of supervised learning for multi-layer nets, also known as the generalized delta rule. Error data at the output layer is "back propagated" to earlier ones, allowing incoming weights to these layers to be updated**.** It is most often used as training algorithm in current neural network applications. The back propagation algorithm was developed by Paul werbos in 1974 and rediscovered independently by Rumelhart and parker. Since its rediscovery, the back propagation algorithm has been widely used as a learning algorithm in feed forward multilayer neural networks**.[7]** The commonest type of artificial neural network consists of three groups, or layers, of units: a layer of "input" units is connected to a layer of "hidden" units, which is connected to a layer of "output" units. The architecture of a back propagation network shown in fig 1.

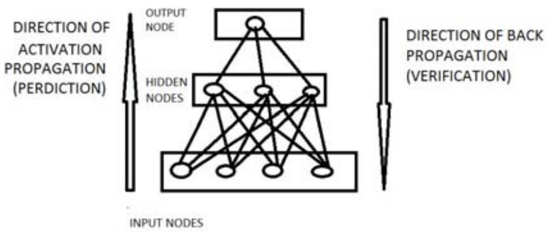

Figure 1 Architecture of back propagation

Radial basis network

Radial basis function network is an artificial neural network that uses the radial basis function as an activation functions.

A Radial Basis Function (RBF) neural network has an input layer, a hidden layer and an output layer. The neurons in the hidden layer contain Gaussian transfer functions whose outputs are inversely proportional to the distance from the centre of the neuron. The Gaussian function responds only to a small region of the input space where the Gaussian is centered **[8].** Radial Basis Functions (RBFs) have their *o*rigins in approximation theory, where they are used to produce approximations to unknown functions, based on sets of input-output data representing the unknown function **[9].** In network representation of a Multi-Input RBF, the input layer distributes each element of the input vector to all the hidden nodes. . The architecture of RBF network is shown in fig 2

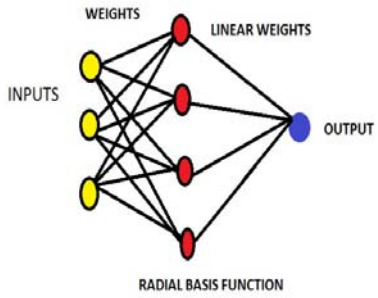

Figure 2 Architecture of radial basis network

Support vector machine

Support vector machine is a supervised learning network that analyses data and recognize pattern, used for classification. SVM is a non probabilistic binary linear classifier. Kernel-based techniques Support Vector Machine (SVM) is part of a group of kernel based methods which are used for pattern classification and regression. In SVM, a separator hyperplane between two classes is chosen to minimize the structural risk of misclassifying by maximizing the functional gap between two classes, the training data on the marginal sides of this optimal hyper plane called support vectors**.** A classifier takes an input pattern called feature vector, and determines to which class it belongs to [**10].** Support vector machines (SVM) are a group of supervised learning methods that can be applied to classification or regression. The support vector machine introduced in 1992 and can be used as a supervised learning algorithm and solve the linear and non linear classification problem.

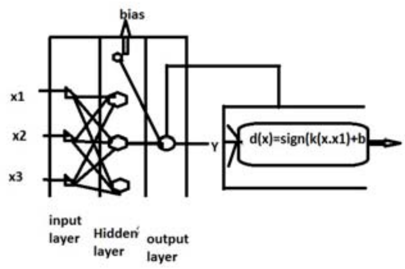

Figure 3 Architecture of support vector machine

4 **Description of dataset**

The dataset for kidney stone disease is obtained from medical reports of the patients collecting from different hospitals. In this paper the 1199 patients data have been used i.e. 1199 instances have been used and each instance has 7 attribute: are age, sex, lymphoctyes, monocytes, eosinophis, neutrophil, s. creatinine

Table 2 Sample of kidney stone dataset

Age	Sex	LYMPH.	MONOC.	EOSINP.	NEUTRO.	S.CREAT
48	F	YES	YES	NO	NO	YES
40	M	NO	YES	YES	YES	NO
51	M	YES	NO	NO	NO	YES
23	F	YES	NO	YES	NO	NO
57	F	YES	NO	YES	NO	NO

This is the dataset for kidney stone disease. In this data set the attribute mention above are shown is in table 2. There are 5 attributes can be used in this dataset. These attributes contain the two values either YES or NO. These attributes have some particular range as discuss in table 1. If the patient report value in this range its mean that person suffering from kidney stone disease and contain the value YES, otherwise its contain NO. The same experiment procedure is used as suggested by WEKA. The 75% data is used for training and the remaining is for testing purposes. In WEKA, all data is considered as instances and features in the data are known as attributes. The simulation results show several items for easier analysis and Evaluation. the first correctly and incorrectly classified instances will be partitioned in numeric and percentage value and subsequently Kappa statistic, mean absolute error and root mean squared error will be in numeric value only. We also show the relative absolute error and root relative squared error in percentage for references and evaluation.

4(a) Diagnosis using back propagation network

```
Time taken to build model: 35.26 seconds

=== Evaluation on training set ===
=== Summary ===

Correctly Classified Instances         976               81.4012 %
Incorrectly Classified Instances       223               18.5988 %
Kappa statistic                          0.6253
Mean absolute error                      0.2418
Root mean squared error                  0.3532
Relative absolute error                 48.8801 %
Root relative squared error             71.0169 %
Total Number of Instances             1199

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area
                 0.81      0.183      0.783     0.81      0.796      0.904
                 0.817     0.19       0.841     0.817     0.829      0.904
Weighted Avg.    0.814     0.187      0.815     0.814     0.814      0.904
```

Figure 4 Training window for BPA

The **fig 4** shows the results after training neural networks with back propagation algorithm. The results shows that back propagation algorithm is able to correctly classified the 976 instances out of 1199 instances that we provides to neural networks as inputs and showing the accuracy 81 % to diagnosis the disease. Time taken to build model is 35.26 seconds. The Kappa statistic for the model is 0.6253. **Kappa statistic** is used to assess the accuracy of any particular measuring cases, it is usual to distinguish between the reliability of the data collected and their validity **[11]. The mean absolute error (MAE)** is the average of the difference between predicted and actual value in all test cases; it is the average prediction error. The mean absolute error for back propagation is 0.2418 and root mean squared error is 0.3532. **Root-mean-square error (RMSE)** the mean-squared error is one of the most commonly used measures of success for numeric prediction. The root mean-squared error

is simply the square root of the mean-squared-error. The root mean-squared error gives the error value the same dimensionality as the actual and predicted values. **Relative absolute error** is very similar to the relative squared error in the sense that it is also relative to a simple predictor, which is just the average of the actual values. The relative absolute error for back propagation is 48.8801 %. **Root Relative squared error** is the total squared error made relative to what the error would have been if the prediction had been the average of the absolute value. The root relative squared error for back propagation network is 71.0169 %.

.Performance curve

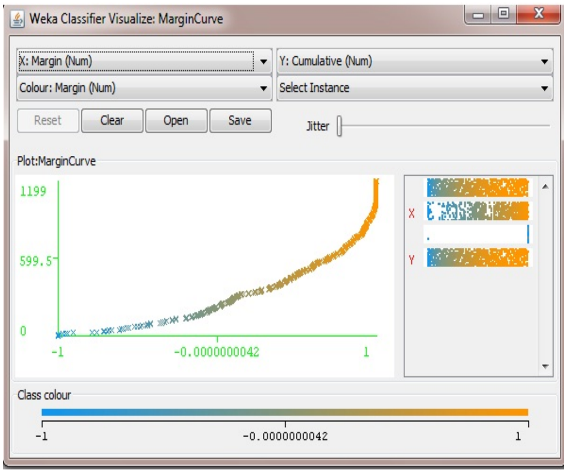

Figure 5 Performance curve for BPA

Figure 5 showing performance curve that we obtain after successful training and testing of Neural Networks. Curve shows as we keep on increasing numbers of instances the classification accuracy of Backpropogation algorithm starts on increasing.

4(b) Diagnosis using radial basis network

```
Time taken to build model: 0.17 seconds

=== Evaluation on training set ===
=== Summary ===

Correctly Classified Instances         746               62.2185 %
Incorrectly Classified Instances       453               37.7815 %
Kappa statistic                          0.2131
Mean absolute error                      0.4506
Root mean squared error                  0.4748
Relative absolute error                 91.0842 %
Root relative squared error             95.4695 %
Total Number of Instances             1199

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Are
                 0.42      0.213      0.616     0.42      0.499      0.666
                 0.787     0.58       0.625     0.787     0.697      0.666
Weighted Avg.    0.622     0.415      0.621     0.622     0.608      0.666

=== Confusion Matrix ===
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Figure 6 training window for RBF network

shows the results after training neural networks with radial basis function algorithm. The results shows that radial basis function algorithm is able to correctly classified the 746 instances out of 1199 instances that we provides to neural networks as inputs and showing the accuracy 62 % to diagnosis the disease. Time taken to build model is 0.17 seconds. The accuracy of RBF network is less than back propagation network. The Kappa statistic for the model is 0.2131. The mean absolute error for radial basis network is 0.4506 and root mean squared error is 0.4748. the relative absolute error for RBF network is 91.0842 %.. and root relative squared error is 95.4695 %.

Performance curve for RFB Network

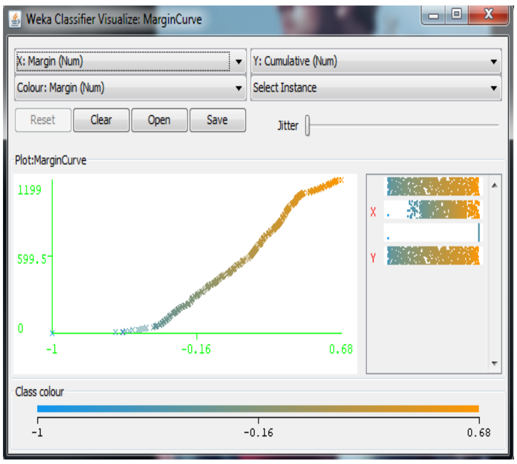

Figure 7 performance curve for RBF

Figure 7 showing performance curve that we obtain after successful training and testing of Neural Networks. Curve shows as we keep on increasing numbers of instances the classification accuracy of RBF Network starts on increasing after that it go to decrease.

4(c) Diagnosis using support vector machine

Shows the results of support vector machine. The results shows that support vector machine is able to correctly classified the 722 instances out of 1199 instances that we provides to neural networks as inputs and showing the accuracy 60 % to diagnosis the disease. Time taken to build model is 0.53 seconds. The root mean square error is 0.6307 and kappa statics is 0.1775. The root relative squared error is 126.8168 and relative absolute error is 80.4111.

```
Time taken to build model: 0.53 seconds

=== Evaluation on training set ===
=== Summary ===

Correctly Classified Instances         722               60.2168 %
Incorrectly Classified Instances       477               39.7832 %
Kappa statistic                          0.1775
Mean absolute error                      0.3978
Root mean squared error                  0.6307
Relative absolute error                 80.4111 %
Root relative squared error            126.8168 %
Total Number of Instances             1199

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Are
                 0.437     0.263      0.575     0.437     0.496      0.587
                 0.737     0.563      0.616     0.737     0.671      0.587
Weighted Avg.    0.602     0.429      0.598     0.602     0.593      0.587
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Figure 8 Training window for SVM

Performance curve for SVM

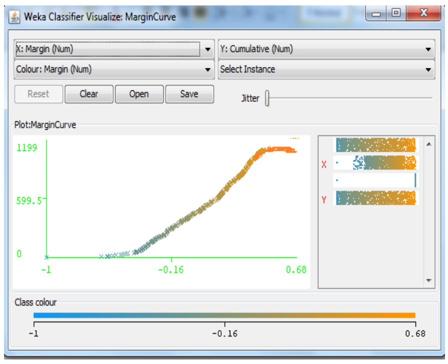

Figure 9 performance curve for SVM Network

Figure 9 showing performance curves that we obtain after successful training and testing of Support vector machine. Curve shows as we keep on increasing numbers of instances the classification accuracy of Support vector machine starts on increasing after that it go to decrease. In this case the decreasing level of SVM curve is more than RBF Network

5 Comparison

Table 3 Comparisons of all algorithms

Techniques	Correctly classified data	Incorrectly classified data	Time taken	accuracy
BPA	81.4012%	18.5988%	35.26 sec	81%
RBF	62.2185%	37.7815%	0.12 sec	62%
SVM	60.2168%	39.7832	0.56 sec	60%

6 Conclusions

As a conclusion, I have met my objective to find the best model for kidney stone disease. The back propagation is the best model for kidney stone disease. Its accuracy is 81% to diagnosis the kidney stone disease . It correctly classified the 976 instances from 1199 instances. The time taken to build a model is 35.26 second. The accuracy of RBF and SVM is less than BPA. The accuracy of RBF is 62% it correctly classified the 746 instances from 1199 instances. Time taken to build a model is 0.15 second. And the accuracy of SVM is 60%. It correctly classified the 722 instances from 1199 instances. Time taken to build a SVM model is 0.56 . Back propagation has lowest error rate 0.2418 than the RBF and SVM. And also the kappa statistic of back propagation is greater than RBF and SVM . Hence the back propagation (BPA) significantly improves the conventional classification technique for use in medical field.

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