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A Multi-layer perceptron based intelligent thyroid disease prediction system

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ABSTRACT

A challenging task for the modern research is to accurately diagnose the diseases prior to their treatment. Particularly in rural areas, the instant diagnosis for a life style disease is rarely available; it becomes necessary to use modern computing techniques to design intelligent prediction systems. A machine learning model is used for solving complex and non-separable prediction problems in different fields like medical diagnosis, decision support systems, biochemical analysis, image processing and financial analysis etc. The accuracy for thyroid diagnosis system may be improved by considering few additional attributes like heredity, age, anti-bodies etc. In this paper, an improved and intelligent thyroid disease prediction system is developed using multilayer perceptron (MLP) machine learning model. The proposed system uses 7 to 11 features of the individuals to classify them in normal, hyperthyroid and hypothyroid classes. The system uses gradient descent backpropogation algorithm for training the machine learning model using dataset of 120 subjects collected from SKIMS Hospital, Jammu and Kashmir. The thyroid prediction system promises excellent overall accuracy of nearly 99.8% for 11 attributes with more number training instances. However, the system results in a lower accuracy of 66.7% using 11 attributes and 70% using 7 attributes with 30 subjects.

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1. INTRODUCTION

Machine learning is a modern way of computing where knowledge alongwith a technique is used to build a model which imitates the behaviour of human being. Once the macine learning model is trained it will start predicting the class of a given feature set. As shown in the Figure1, a variety of machine learning techniques are available which may be categorised broadly into supervised, unsupervised and reinforcement learning. The typical examples of supervised machine learning algorithms includes Nearest neighbour classification, regression, Support vector machine (SVM), Artificial neural networks Naïve base classifiers and decision trees. An Artificial neural network (ANN) is an information processing paradigm that is motivated by the way biological neural system i.e. brain process the data. The neural network constitutes of countless interconnected information handling components called neurons. The key component of the neural network is a novel structure. Neural systems, with their efficient capability to derive meaningful information from imprecise information, can be utilized to separate and distinguish patterns that are too intricate to be noticed by any computer technique or by human.As ANN is a self learning framework, it shows distinctive classes of learning calculations, for example, supervised learning, unsupervised learning and reinforcement learning. ANNs are widely used in the real-world computation applications. The various areas of application include pattern recognition, pattern classification and pattern prediction. The whole paradigm of predicting lifestyle disease is shifting from old conventional method to machine learning based prediction systems.

Thyroid disease is one among the common lifestyle disease. Thyroid organ is a butterfly-molded organ which is present in the neck underneath the mouth of human body. It release hormones that control metabolism like heart rate, body temperature etc. It produces two main hormones T3 and T4. These hormones are responsible for various metabolic activities like body weight, heart rate etc. These activities may get disturbed if the level of these hormones changes. So the diagnosis of thyroid disease is important prior to its treatment. About 32 percent of the total Indian population suffers from thyroid disease. The Thyroid disease may be broadly categorized i.e. hypothyroid and hyperthyroid. When the amount of hormones exceed the amount required by the human body, it causes hyperthyroidism. Hypothyroidism is the inverse of hyperthyroidism; it reduces body metabolism, cause drowsiness and pain in joints.

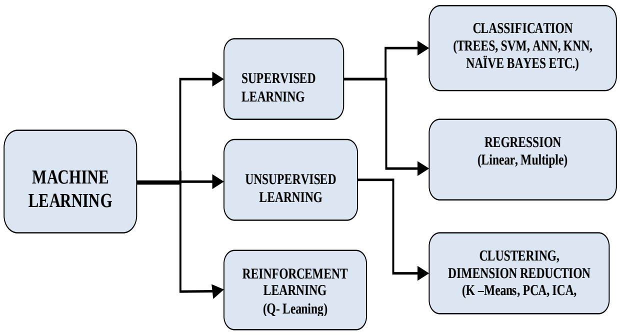

Figure 1. Machine learning taxonomy

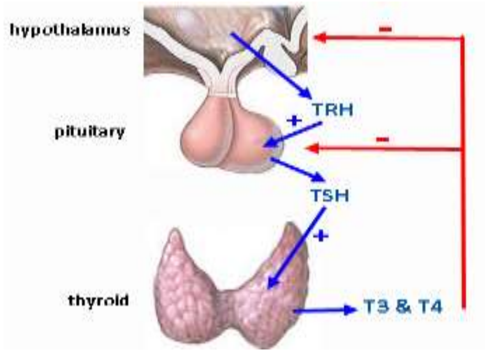

Figure 2.Mechanism of thyroid disease

The rest of the article is organised as follows. The Section 2 of the article presents a brief background of various related life style disease prediction systems. The Section 3 explains about the machine learning based framework and algorithm of the proposed intelligent thyroid prediction system. The training and prediction accuracy of the proposed thyroid system at various levels is computed in the Section 4. The Section 5 of the article provides brief findings and future scope of the presented research.

2. RELATED WORK

Various researchers have used different pattern classifiers for developing lifestyle disease prediction systems. In this section a brief study of thyroid disease prediction system have been presented. I. D. Maysanjaya et.al. (2015) have used six different methods for the diagnosis of thyroid disease. After experimention, the performance of multilayer perception was found highest as compared to that of the other five methods [1]. Mohd.Reza et.al. (2017) have discussed the diagnosis of different types of thyroid disease using ANN by considering the age of an individual. The input to the thyroid prediction system is seven hormone tests including age and the output is the diagnosis of the thyroid. The various ANN structures used includes MLP, PNN, GRNN AND CFNN [2]. Shivaneepanday et al (2016) have proposed various data mining techniques like Bayes net, multilayer perception, RBF network, L4.5, CART, REP tree, decision stump to develop classifiers for diagnosis of hypothyroid disease [20]. After performing the experiments, it is clear that REP tree and L4.5 techniques perform well as compared to others [3]. Mazin Abdul rasoolhameed et.al (2009) have proposed a method of classifying thyroid disease using multilayer feed forward using back propagation learning rule.In this work three inputs have been considered as T3,T4,TSH [4]. SaeedShariati and Mahdi MotanaliHaghighi (2010) have used fuzzy system to diagnosis hepatitis and thyroid disease. The results of fuzzy neural networks with support vector machine and artificial neural network were compared [5].AnupamShukla et.al. (2009) in their work have trained the system using three ANN algorithms, the backpropogation (BPA), the radial basis function (RBF) and the learning vector quantization (LVQ) [6]. Narender Kumar et.al.(2017) have used various data classifications techniques and their accuracy performance to predict chronic kidney disease [7]. Xing et.al. (2017) have proposed a technique which is concerned with the aim to develop a data mining algorithm to predict survival of CHP patients (Coronary Heart Disease). In this work, three algorithm's were used to develop these prediction models [8]. Hsiang et.al. (2006) have Compared Expert Judgment (knowledge based) and Automatic Approachesm (data driven) in this paper, the authors have compared two different features selection techniques to extract features from a given data set. The result suggests that the automatic feature selection approach improve the prediction capability of a classifier while as the domain expert improves the sensitively of a classifier [9]. Rajeebdev et.al. (2008) in theirresearch proposed a binary classification problem for the diagnosis of = diabetes. A person suffering from diabetes fall in class 1 and non diabetic fall in class 2. They used backpropogation algorithm in Multilayer feed forward. In this, the authors used single as well as multi layer perceptron. Both the neural networks have six input nodes and one output node. The network successfully classified patients into diabetic and non diabetic with performance of 92.50% [10]. Canan et.al. (2009) proposed a hybrid structure of neural network and fuzzy logic. The experiment shows that the hybrid schemes have better results over the non hybrid structures [11]. ShradhaDeshmukh et.al. (2017) = proposed two important classification algorithms namely fuzzy min-max and pruning fuzzy min-max algorithms [12]. K Vishwanant et.al. (2014) proposed Multilayer Perceptron and Back Propagation ANN to distinguish the type of the stone. The multilayer perceptron with backpropogation gives high accuracy of 98% when contrasted with Naive Bayes [13]. Muthuselvan et.al (2016) focuses on implementing five different types of data mining techniques using a data mining tool called WEKA in order to predict breast cancer from blood data sets. The five algorithms include Naive Bayes, one R, Zero R, Random tree algorithm and j48. On comparing the performance of the various algorithms, it shows that J48 algorithm performance was highest i.e. 86.36% while as minimum (Zero R) is 56.81% [14].Madhuri et.al. (2013) proposed a computer aided artificial intelligence system used for diagnosis of stress [15-25].

N Ganesan et.al. (2010) used neural networks in the medical field for preclinical study. In this work the author have shown the various ways by which neural networks can be applied on clinical data for the diagnosis of lung cancer [16]-[23]. Sapna (2016) has proposed fusion of big data and neural networks for predicting thyroid. Clinical information is huge in volume, thus conventional data processing applications won't be sufficient to interpret big data, hence it needs innovations techniques to handle and extract important information from it [17]. FengyingXie et.al. (2017) build a novel technique for detecting tumor as amiable or threatening by analyzing images. In this research, they designed an ensemble classifier that combines back propagation neural network with fuzzy neural network [18]. De Araujo et.al. (2017) proposed a classical method for induction motors fault diagnosis do not always provide satisfactory results. The author proposes a hybrid system that uses data obtained from vibration, and current sensors to predict failures at an early stage [20]. The input to the system is based on fuzzy logic is given by processing the signals in the frequency and time domain through short time Fourier transform and multi resolution analysis [21-22]. The technique allows an increase in reliability in the detection and diagnosis in the level of severity as compared to existing techniques [19-24].

3. THYROID PREDICTION SYSTEM USING MACHINE LEARNING

In order to address the major research gaps, the need is to design an improved thyroid disease pattern classifier system by including additional features like age group, heredity, antibodies. The blood test is the poorest and crudest method of determining whether a person is suffering from thyroid or not, so the better solution to solve this problem is to take into consideration more parameters. Moreover, the system may utilize better classifiers in order to improve the overall accuracy of the diagnostic system. The improved thyroid system must using latest machine learning technique to train and then test the machine learning model. In this section the detailed framework and algorithms are presented.

3.1. Proposed Framework

The training and testing phases of the thyroid disease prediction system is clearly shown in the Figure 3. As shown in the Figure 3, the first step is to identify the typical parameters / risk factors which are responsible for the thyroid disease in human beings. In the next step, miscellaneous dataset of various patients of different categories is collected. In the conventional methods of thyroid diagnosis system, majority of authors have used only three factors namely T3, T4 and TSH. In the proposed diagnostic prediction system, more number of risk factors can be included.

In order to classify a particular patient into any of the three classes a dataset of 120 samples has been obtained and preprocessed. In order to remove anomalies, noise and to quantify Boolean values the data set is manually enriched. Once the dataset is prepared, a multilayer pattern classifier model is created and trained with the dataset. The MLP pattern classifier model is stored for the testing phase. In order to check the accuracy of thyroid predictions a sample of randomly chosen patients is applied on the stored MLP prediction system.

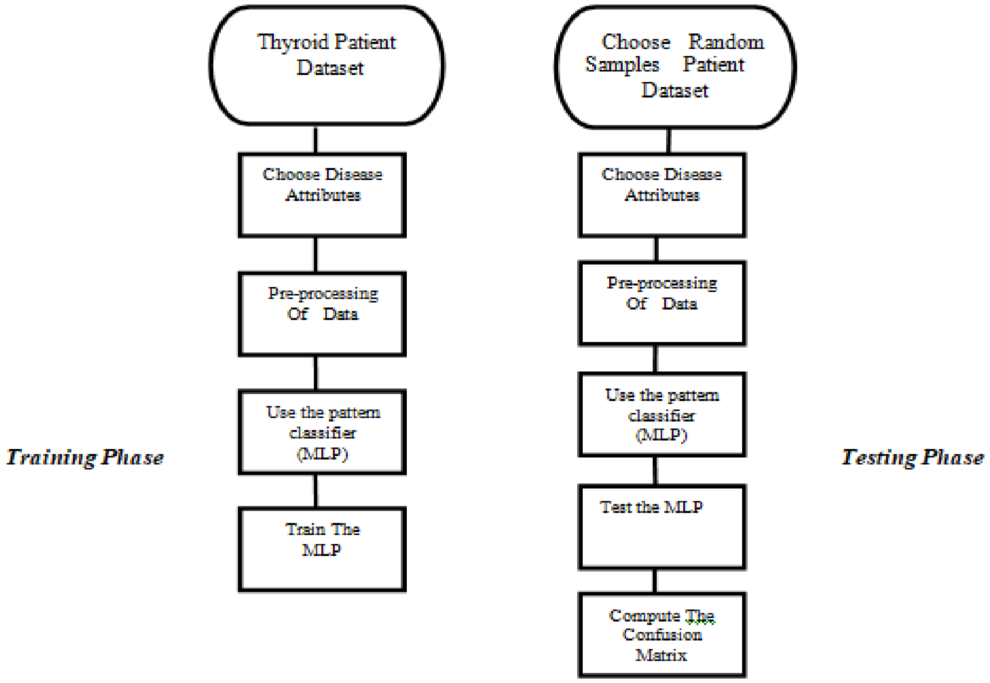

Figure 3. Framework for the proposed system

3.2. Proposed Algorithm

MLP is one of the most common ANN which is widely used for different tasks like pattern classification, pattern recognition etc. One of the most important features of MLP is that we can specify any number of output classes. The network architecture chosen for this problem is MLP having eleven input nodes and three output nodes. Each node present in the input layer is connected to every other node in the hidden layer through some weights. The value of the weighted input sum to a particular node maybe large, therefore it is important to scale down the weighted sum by reducing it before producing the resulted output of that particular node. For this purpose a function is applied on the weighted input. One of the best methods is backpropogation learning which works on the principle of gradient descent rule. The steps of the training and machine learning building algorithm are explained in the following section. The multilayer perceptron is trained with 11 nodes in the input layer of the network.

3.2.1 ThePseudo Code for Training the Thyroid Prediction System Using MLP

1. *Initialize weights and learning rate.*
2. *Perform steps 3 to 10 till condition is false.*
3. *Repeat steps 4 to 9 for each pair to be trained.*
4. *Each input node say X_i receives an input signal and pass it to the next node present in hidden layer.*
5. *Each node in the hidden layer say h_j sums its weighted input to calculate net input as (feed forward phase I) as shown in eq.1.*

$$Zinj = voj + \sum_{i=1}^{n} Xivij \quad (1)$$

Activation function is then applied on the $Zinj$ to calculate the output of the hidden node:

$$Zj = f(Zinj) \quad (2)$$

this output signal is then send as input to the output layer node from hidden node

6. *For each output node O_k, calculate the total input as shown in eq.3.*

$$Oink = W0k + \sum_{j=1}^{p} ZjWjk \quad (3)$$

Now, apply the activation function on $Oink$ to compute the output signal as in eq. 4:

$$Ok = f(Oink) \quad (4)$$

Back-propagation learning rule (Phase II):

7. *Each output node receives the input training vector associated with the target pattern and computes the error using eq.5*

$$\Delta k = (tk - Ok)f'(Oink) \quad (5)$$

On the basis of error calculated, adjust the weights as given in eq.6

$\Delta Wjk = \alpha\ \Delta k\ Zj$ *(6)*
Send Δk *back to the hidden layer*
8. Each hidden node calculate the sum of this delta from the output node using eq.7
$$\Delta inj = \sum_{i=1}^{m} \Delta\ k\ Wjk \quad (7)$$
Error is calculated as per eq.8
$\Delta\ j = \Delta injf'(Zinj)$ *(8)*
Adjust weight and bias as (Phase III):
9. Each output and hidden nodes update bias and weights as:
$Wjk(new) = Wjk(old) + \Delta Wjk$ *(9)*

$W0k(new) = W0k(old) + \Delta W0k$ *(10)*
10. Check whether the actual output equals the target output (stopping condition)

3.2.2 TestingAlgorithm for the Pattern Classification

1. Repeat steps 2 to 4 for each input
2. Set the activation of input unit for X_i.
3. At hidden node say X, calculate the net input and output as shown in eq. 11 and eq. 12 respectively:
$$Zinj = voj + \sum_{i=1}^{n} Xivij \quad (11)$$
$Zi = f(Zinj)$ *(12)*
4. At output node, compute the output as given in eq. 13 and eq.14
$Oink = W0k + \sum_{j=1}^{p} ZjWjk$ *(13)*
$$Ok = f(Oink)$$

4. RESULTS AND ANALYSIS

The experiments were conducted on the real dataset of 120 instances collected from SKIMS Soura, Srinagar, India. The subjects were chosen carefully covering wide range of population including men, women, old and youngsters. The values for eleven attributes were collected for all the 120 instances and some attributes have been quantified and factorized. The preprocessing of the dataset has been done in order to remove ambiguities, anomalies and errors. The pre-processed dataset is used to train the pattern classifier model using the back error propagation algorithm for the multi-layer perceptron. The data set has been split into train and test data instances. The machine learning model has been trained by varying the size of training dataset and then tested on test data set to achieve the cross validation.

The Figure 4 shows the best performance of MLP at epochs 9 on 30 instances with 7 attributes. In the Figure 5, the gradient error graph has been shown on 30 instances and 7 attributes. In the Figure 6 shows the confusion matrix clearly reveals the performance of the pattern classifier (MLP). The green cells in the confusion matrix represent correctly classified instances while as the red cells represent incorrect classification. The blue box represents percentage of both correct as well as incorrect classification classes. ROC with 30 instances and 7 attributes, performance with 120 instances and 7 attributes as shown in Figure 7 and 8.

The proposed model of the diagnostic system has been evaluated at various numbers of training instances and features as shown in the Table1.In the initial step the training of the system has been carried out with 30 instances which used only 9 iterations with gradient error of 0.0314. The Table 2 clearly reveals that the training of the system with 30 samples results in an accuracy of 85% with testing accuracy of 40% and overall poor accuracy of 66.7%. The training of the proposed system with 7 attributes and 30 samples exhibits 14 iterations with gradient error of 9.95e-07. Furthermore, the number of instances were successfully increased for the training of the proposed system and performance is evaluated at 60,90 and 120 instances which is shown in the Table 1 and Table 3.

Table1. Training Performance of the Thyroid System with 11 and 7 Fatures (epochs, gradient errors)

Iterations	Sample Size	Features =11			Features =7		
Attempt	Intances	Epochs	Network Trained	Gradient Error	Epochs	Network Trained	Gradient Error
1	30	9	YES	0.0314	14	yes	9.95e-07
2	60	25	YES	0.00029	13	yes	0.0118
3	90	34	YES	0.000591	21	yes	0.00161
4	120	56	YES	9.23e-07	21	yes	0.0103

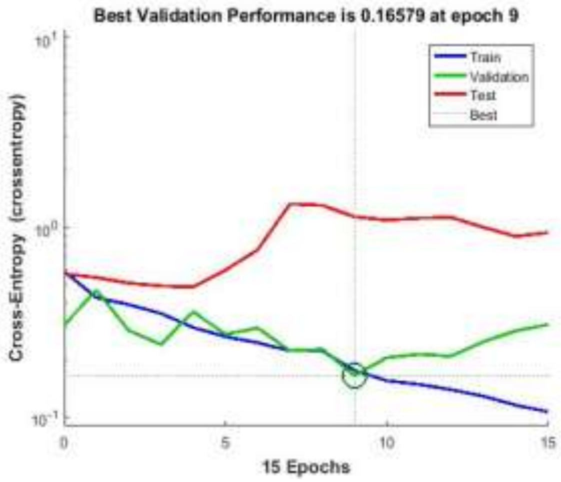

Figure 4. Performance with 30 instances and 7 attributes

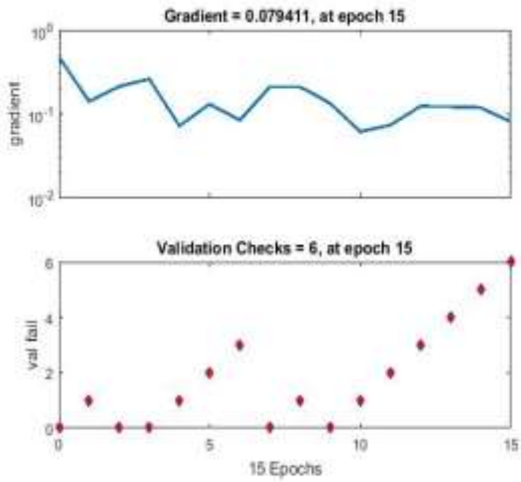

Figure 5. Gradient error with 30 instances and 7 attributes

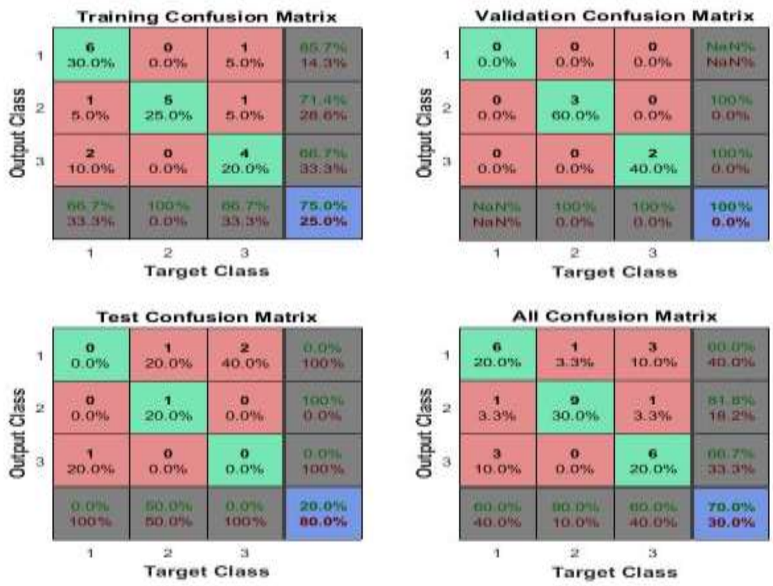

Figure 6. Confusion matrix with 30 instances and 7 attributes

The Table 3 shows the training performance of the proposed system with 7 attributes at different number of instances. The overall accuracy of the proposed diagnostic system is ~100% with 11 attributes where as 99.2% with 7 attributes. On the other hand, the results clearly reveals that the number of attributes for thyroid diagnosis are independent of the number of instances in terms of overall accuracy which is ~99.8 % in both the cases. Surprisingly, with lower number of instances for training the model (e.g. 30), the overall accuracy is better for seven attributes (70%) instead of eleven attributes (66.7%). The number of epochs required for training the model with eleven attributes increases with increment in the samples.

The Table 4 illustrates the performance comparison of the proposed thyroid diagnostic system with the existing similar systems. The results clearly indicate that the numbers of attributes used for building a proposed model are much more than the other systems. I. D. Maysanjaya et.al.(2015) used MLP backpropogation pattern classifiers for thyroid diagnostic system based on 5 attributes with accuracy of 96.7% which is outplayed by the proposed diagnosis system using 11 attributes with overall accuracy of ~100%. The performance of the proposed system is better than the other similar systems proposed by Mazin Abdul Rasool (2009) and SaeedShariati et.al. (2010) in terms of prediction accuracy.

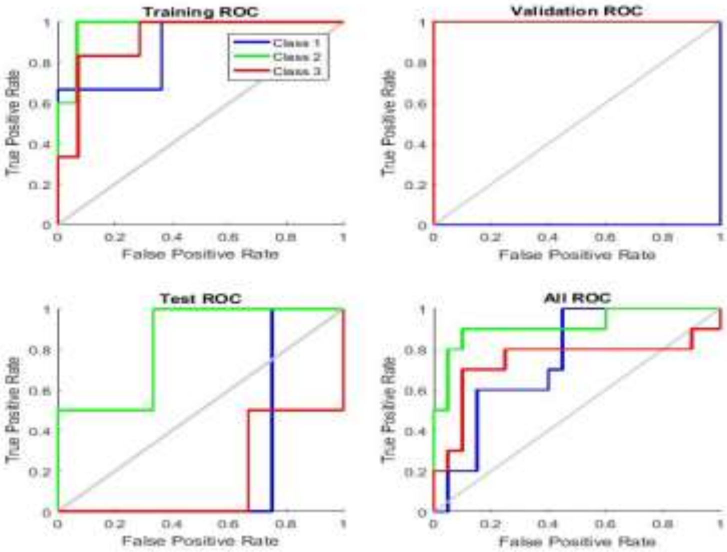

Figure 7. ROC with 30 instances and 7 attributes

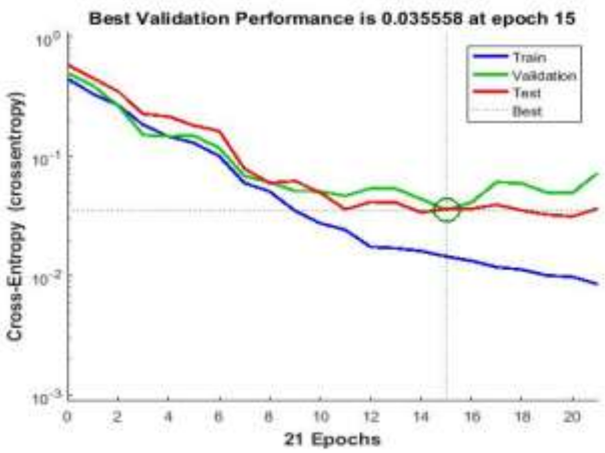

Figure 8. Performance with 120 instances and 7 attributes

Table 2. Performance of the Intelligent Thyroid Prediction System with 11features (training, validation, testing, accuracy)

Iteration No.	Data Size	Performance	Training Accuracy	Validation Accuracy	Testing Accuracy	Overall Accuracy
1	30	0.031	85%	20%	40%	66.7%
2	60	9.87e-05	~100%	77%	~100%	96.7%
3	90	0.000158	~100%	~100%	~100%	~ 100%
4	120	3.10e-07	~100%	~100%	~100%	~100%

Table 3. Performance of theThyroid Prediction System with 7 Features (Accuracy)

Iteration No.	Data Size	Performance	Training Accuracy	Validation Accuracy	Testing Accuracy	Overall Accuracy
1	30	0.00209	75%	100%	20%	70%
2	60	0.0124	95.2%	100%	77.8%	93.3%s
3	90	0.000663	100%	100%	92.9%	98.9%
4	120	0.00852	~100%	94.4%	~100%	99.2%

Table 4. Comparative Analysis of Various Pattern Classifiers for Thyroid Prediction System with Our System

Author	Diagonosis	Features	Machine learning technique used	Performance
I. D. Maysanjaya et.al. (2015)	Thyroid	5	MLP (Back propogation)	Accuracy=96.7 %
Mazin AbdulRasool (2009)	Thyroid	3	MLP	--
Saeedshariati, Mahdi motavali (2010)	Hepatitis and Thyroid	--	Self organized fuzzy system	--
Proposed thyroid predictio system (2018)	*Thyroid*	*7 and 11*	*MLP (Back propogation)*	*Accuracy fwith 7 feature s=99.2% Accuracy fwith 11 Features = 99.8%*

5. CONCLUSION

The intelligent prediction and classification has been achieved by training the MLP model with a mixed dataset of various subjects collected from individuals living in different habitats. The proposed model was successfully tested with random samples including instances of hyperthyroid, hypothyroid and normal individuals. The system exhibits excellent training and testing accuracy of almost 100% with 11 attributes and 99.2% with 7 attributes. The proposed thyroid prediction system exhibits better prediction accuracy of nearly 99.8% with 7 or 11 of features as compared to existing similar systems which used only 3 to5 features. Moreover, comparison has been carried out between the two experiments conducted with different number of decision attributes. As a future research, the ensembles using Random forests, Bagging and Boosting machine learning advanced techniques may be used to improve the accuracy. Furthermore, the proposed machine learning model may be extended to diagnose other types of lifestyle diseases like diabetes, blood pressure and many more. The deep learning techniques like CNN may be used to further incorporate the intelligence in the proposed system.

REFERENCES

[1] I. D. Maysanjaya, H. A. Nugroho, N. A. Setiawan, J. G. No, and K. Ugm, “A Comparison of Classification Methods on Diagnosis of Thyroid Diseases,” *2015 Int. Semin. Intell. Technol. Its Appl.*, pp. 89–94, 2015.

[2] M. R. Obeidavi, A. L. I. Rafiee, and O. Mahdiyar, “Diagnosing Thyroid Disease by Neural Networks,” vol. 10, no. 2, pp. 509–524, 2017.

[3] P. Durga, V. S. Jebakumari, and D. Shanthi, “Diagnosis and Classification of Parkinsons Disease Using Data Mining Techniques,” *ISSNOnline) Int. J. Adv. Res. Trends Eng. Technol.*, vol. 3, no. 14, pp. 2394–3777, 2016.

[4] A. Fabrics, “Artificial Neural Network System for,” no. 2, pp. 518–528, 2009.

[5] S. Shariati and M. M. Haghighi, “Comparison of anfis neural network with several other anns and support vector machine for diagnosing hepatitis and thyroid diseases,” *2010 Int. Conf. Comput. Inf. Syst. Ind. Manag. Appl. CISIM 2010*, pp. 596–599, 2010.

[6] R. Tiwari, A. Shukla, and P. Kaur, “Diagnosis of Thyroid Dicial Neural Networks,” no. March, pp. 6–7, 2009.

[7] N. Kumar and S. Khatri, “Implementing WEKA for medical data classification and early disease prediction,” *2017 3rd Int. Conf. Comput. Intell. Commun. Technol.*, pp. 1–6, 2017.

[8] Y. Xing, J. Wang, Z. Zhao, and andYonghong Gao, “Combination Data Mining Methods with New Medical Data to Predicting Outcome of Coronary Heart Disease,” *2007 Int. Conf. Converg. Inf. Technol. (ICCIT 2007)*, pp. 868–872, 2007.

[9] T. Hsiang, C. P. Wei, and Vc. S. Tseng, “Feature selection for medical data mining: Comparisons of expert judgment and automatic approaches,” *Proc. - IEEE Symp. Comput. Med. Syst.*, vol. 2006, pp. 165–170, 2006.

[10] R. Dey and V. Bajpai, “Application of Artificial Neural Network (ANN) technique for Diagnosing Diabetes Mellitus,” *IEEEexplorer*, no. 155, pp. 8–11, 2008.

[11] Canan Senol and Tülay Yildirim, “Thyroid and breast cancer disease diagnosis using Fuzzy-neural networks,” *ELECO 2009 - 6th Int. Conf. Electr. Electron. Eng.*, pp. 390–393, 2009.

[12] S. Deshmukh and S. Shinde, “Diagnosis of Lung Cancer using Pruned Fuzzy Min-Max Neural Network,” *Int. Conf. Autom. Control Dyn. Optim. Tech. ICACDOT 2016*, pp. 398–402, 2017.

[13] K. Viswanath and R. Gunasundari, “Design and analysis performance of kidney stone detection from ultrasound image by level set segmentation and ANN classification,” *Proc. 2014 Int. Conf. Adv. Comput. Commun. Informatics, ICACCI 2014*, pp. 407–414, 2014.

[14] S. Muthuselvan, K. S. Sundaram, and Prabasheela, “Prediction of breast cancer using classification rule mining techniques in blood test datasets,” *2016 Int. Conf. Inf. Commun. Embed. Syst.*, no. Icices, pp. 1–5, 2016.

[15] V. J. Madhuri, M. R. Mohan, and R. Kaavya, “Stress Management Using Artificial Intelligence,” *2013 Third Int. Conf. Adv. Comput. Commun.*, pp. 54–57, 2013.

[16] N. Ganesan, “Application of Neural Networks in Diagnosing Cancer Disease Using Demographic Data,” *Int. J. Comput. Appl. (0975*, vol. 1, no. 26, pp. 76–85, 2010.

[17] S. Sapna, “Fusion of Big Data and Neural Networks for Predicting Thyroid,” *2016 Int. Conf. Electr. Electron. Commun. Comput. Optim. Tech.*, pp. 243–247, 2016.

[18] F. Xie, H. Fan, Y. Li, Z. Jiang, R. Meng, and A. Bovik, “Melanoma classification on dermoscopy images using a neural network ensemble model,” *IEEE Trans. Med. Imaging*, vol. 36, no. 3, pp. 849–858, 2017.
[19] A. A. G. De Araujo Cruz, R. D. Gomes, F. A. Belo, and A. C. Lima Filho, “A Hybrid System Based on Fuzzy Logic to Failure Diagnosis in Induction Motors,” *IEEE Lat. Am. Trans.*, vol. 15, no. 8, pp. 1480–1489, 2017.
[20] M. Bhargava, A. Selwal, "Association rule mining using apriori algorithm: A review", *International Journal of Advanced Research in Computer Science*, vol. 4, no. 2, 2013.
[21] A. Selwal and S. K. Gupta, “Template security analysis of multimodal biometric frameworks based on fingerprint and hand geometry ☆,” *Perspect. Sci.*, vol. 8, pp. 705–708, 2016.
[22] A. Selwal and S. Kumar, “Fuzzy Analytic Hierarchy Process based Template Data Analysis of Multimodal Biometric Conceptual Designs,” *Procedia - Procedia Comput. Sci.*, vol. 85, no. Cms, pp. 899–905, 2016.
[23] J. Ahmed and M. A. R. Soomrani, “TDTD: Thyroid disease type diagnostics,” *2016 Int. Conf. Intell. Syst. Eng. ICISE 2016*, pp. 44–50, 2016.
[24] S. Abe and R. Thawonmas, “A fuzzy classifier with ellipsoidal regions,” *IEEE Trans. Fuzzy Syst.*, vol. 5, no. 3, pp. 358–368, 1997.
[25] J. Zhang and W. Zhang, “Support vector machine for recogni-tion of cucumber leaf diseases,” in Proceedings - 2nd IEEE In-ternational Conference on Advanced Computer Control, ICACC 2010, 2010, vol. 5, no. 1, pp. 264–266.

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