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MODELING ON THYROID DIAGNOSIS USING MACHINE LEARNING APPROACHES – A REVIEW

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ABSTRACT

Diagnosis is a crucial task in bioscience attributable to its criticality, potency and accuracy in determining whether or not a patient encompasses a specific illness. This shall decide the foremost appropriate line of treatment. The diagnosis naturally may be a complicated and a fuzzy cognitive technique, and soft computing ways, like neural networks, has shown nice potential to be applied within the development of the medical support systems (MDSS). There has been an outsized increase within the range of thyroid cases over the past few years. Since thyroid encompasses a complicated relation with metabolism and weight, it's extraordinarily necessary to diagnose thyroid disease as early as attainable. Diagnosis of thyroid disease is one among the necessary problems to develop a medical decision support system which is able to facilitate the physicians to require effective decisions. This paper presents Associate in nursing complete survey of work done in the past with relation to thyroid disease diagnosis. A survey on completely different computing ways employed by researchers for the applying of diagnosis or predicting thyroid illness is mentioned during this paper.

KEYWORDS: **Artificial Neural Networks, Expert Systems, Machine Learning, Medical Decision Support Systems, Statistical Methods.**

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INTRODUCTION

Thyroid disease diagnosis is one of the most important problems among the classification problems. Two normal diseases of the thyroid gland, which discharges thyroid hormones for managing the rate of body's metabolism, are hypothyroidism and hyperthyroidism. Classification of these thyroid diseases is a right smart task. The thyroid is a crucial endocrine gland that controls the body's metabolism. It is a little butterfly-shaped gland settled in the front of the neck just under the Adam's apple. Together, these hormones regulate how our cells use energy. Our body's general metabolism determines pressure level, heart rate, and weight. The thyroid gland produces the hormones T3 is triiodothyronine, and T4's full name is tetraiodothyronine or thyroxine. Hypothyroidism is a condition where our thyroid organ does not sufficiently deliver thyroid hormone. Low levels of thyroid hormone interfere with the body's ability to perform normal metabolic functions such as effective utilization of energy from food items, regulation of numerous substance responses within the body, and maintenance of healthy cells, bones and muscles. Hyperthyroidism is a condition where an excessive amount of thyroid hormone is discharged into the blood because of over dynamic of the thyroid. At the point when the level of thyroid hormone is too little, the pituitary organ secretes a hormone known as thyroid simulating hormone (TSH) which simulates the thyroid to provide more thyroid hormone. When the extent level of thyroid hormone goes back to normal, the pituitary gland ceases producing further TSH. The pituitary gland is stimulated by the hypothalamus to provide TSH by secreting thyrotropin releasing hormone (TRH). This whole system is named the hypothalamic-pituitary-thyroid axis because of the feedback loop between the pituitary gland and the thyroid gland that maintains normal levels of T4, T3 and TSH. When thyroid gland fails to keep up the normal levels of TSH there arises mainly two types of the thyroid related diseases referred as hyperthyroidism and hypothyroidism. Although there are many data mining approaches to model the prediction, Artificial Neural Networks can be used for the disease diagnosis, so as to improve the quality of diagnosis. Self-learning, associative memory, high parallelism strength, high speed and error tolerance against noises are the advantages of ANN[18,19] enabling the usage of ANN as a prominent model for disease diagnosis.

LITERATURE SURVEY

- In 2015, Sorama Aoki et al.[1] evolved a prediction model for PTD by adopting pattern recognition techniques employing a aggregate of six routine laboratory tests, and known 21 new PTD using screening technique. Time series variations are introduced in ordinary tests with extra parameters in order to enhance the model. Self-organizing maps (SOM) using the statistic traceable data was constructed for 13 PTD and 45 healthy individuals.

- In 2014, Baydaa S. B. Alyas[2] designed an intelligent system which can diagnosis the thyroid glands patients with minimum execution time and high performance. This system is supposed to help the health care practitioners to answer queries that relate to endocrine gland disease thereby enable them to make intelligent clinical decisions.

- In 2013, Ms.Wrushali Mendre Dr.Ranjana D.Raut[3] investigated the potentiality of neural network to discriminate the two subtypes, hypothyroid and negative form, of thyroid disorder, on the premise of laboratory medical data base. The best parameters are identified for the neural networks like Multilayer Perceptron(MLP),Radial Basis Function(RBF) and Principal Component Analysis (PCA).

- In 2013, Z. Omiotek et al.[4] presented models to classify examined patients as either sick or healthy. Decision tree induction and a multilayer perceptron neural network are used to build classification models. The proposed methods are used to split a reasonably large group of incorrectly classified cases. Test results showed that the proposed techniques can provide a support system within the process of medical diagnosis.

- In 2011, Esin Dogantekin et al.[5] presented a Generalized Discriminant Analysis and Wavelet Support Vector Machine System (GDA_WSVM) technique for diagnosis of thyroid diseases. The proposed system comprises of three steps feature extraction – feature reduction phase, classification phase, and test of GDA_WSVM for proper diagnosis of thyroid diseases phase. The suitable diagnosis of overall performance of the GDA_WSVM expert system for diagnosis of thyroid diseases is estimated by using classification accuracy and confusion matrix strategies.

- In 2011, Edgar Alfonso et al. [6] developed a model with demographic and clinical variables using general surgeons as experts. A Bayesian analysis was designed to predict the risk of malignancy of a thyroid nodule associated with the casual relationship among the demographic and clinical risk factors.

- In 2010, Esin Dogantekin et al.[7] introduced an automated diagnosis system associated with thyroid gland(ADSTG). Principle Component Analysis (PCA) approach is employed for feature reduction, Least Square Support Vector Machine (LS-SVM) classifier is enforced for classification and performance analysis of the system is expected by using classification accuracy, k-fold cross-validation, and confusion matrix methods. 97.67% classification accuracy was acquired by the ADSTG diagnosis system.

- In 2009, Feyzullah Temurtas[8] in his study a comparative thyroid disease diagnosis have been found out by using multilayer, probabilistic, and

learning vector quantization neural networks. In order to perform the study, the UCI machine learning database that is incredibly usually used among the other classification systems was used.

- In 2009, Halife Kodaz et al. [9] proposed an information gain based artificial immune recognition system (IG-AIRS) that minimizes the negative effects of taking into consideration all attributes in calculating Euclidean distance in shape-space example which is used in several artificial immune systems. Thyroid disease data set was used in the performance analysis of the proposed system. The system reached 95.90% classification accuracy with 10-fold Cross Validation method.

- In 2008, Ali Keles and Ayturk Keles[10] proposed an intelligent system for thyroid disease diagnosis (ESTDD) using neuro fuzzy method. ESTDD could diagnose the thyroid disease with 95.33% accuracy.

- In 2008, Rizvan Erol et al. [11] investigated Multilayer Perceptron Neural Network (MLPNN) and Radial Basis Function Neural Network (RBFNN) for structural classification of thyroid diseases. Experimental results show that the predictions of each neural network models are very satisfying for learning data sets.

- In 2005, Kenji Hoshi et al. [14] analyzed the thyroid data by statistical method, multivariate analysis and by two neural networks. One is the self-organizing map approach that clusters the patients and displays visually a characteristic of the distribution according to laboratory tests. SOM separated the data into three clusters corresponding to hyperthyroid, hypothyroid and normal. To analyze the QSAR problem within the thyroid data, a classification method is applied i.e., Bayesian regularized neural network (BRNN) and found that its prediction accuracy is better than statistical approach.

- In 2009, Alexander Stojadinovic et al.[16] designed a Bayesian model to predict malignancy in thyroid nodules based on variable dependence relationships between independent covariates. Ten-fold cross-validation was carried out to estimate classifier error. A receiver-operating-characteristics (ROC) curve of these predictions and area under the curve (AUC) were calculated to determine model robustness for predicting malignancy in thyroid nodules.

- In 1998, Guoqiag(Peter) Zhang and Victor L. Berardi[13] investigated the potential of neural networks in thyroid disorder analysis. They illustrated the comparison between neural networks and conventional Bayesian classifiers.

- In 1993, Peter K. Sharpe et al.[15] studied potential benefit of using artificial neural networks(ANNs) for the diagnosis of thyroid function by using Multilayer Perceptron trained by back-propagation and a Learning Vector Quantization Network(LVQN) and concluded that both the network architectures were efficient irrespective to the type of training data.

- In 2013, Ahmad Taher Azar et al.[17] proposed a comparison between hard and fuzzy clustering algorithms for thyroid diseases data set so as to find the optimal number of clusters. Different scalar validity measures are employed in comparing the overall performance of the proposed clustering systems. To find the optimal number of clusters, elbow criterion is applied. The clustering results for all algorithms are then visualized by the Sammon mapping method to find a low-dimensional (normally 2D or 3D) representation of a collection of points distributed in a very high dimensional pattern space.

RELATED WORK

Table 1
Related work for thyroid disease diagnosis studies

Reference	Method	Accuracy (%)
Yip and Webb [22]	Function attribute finding algorithm (FAFA) + C4.5 (Pruned)	94.38
	FAFA + C4.5 (Rules)	94.38
	Einstein	91.91
	FAFA + Einstein	93.34
Serpen et al.[23]	Multi-layer perceptron (MLP)	36.74
	Learning vector quantizer (LVQ)	81.86
	Radial basis function (RBF)	72.09
	Probabilistic potential function neural network (PPFNN)	78.14
Zhang and Berardi[13]	Multi-layer feed forward neural network	98.55
Cheong and Yoon [24]	*K*-NN (*K*-nearest neighbors)	96.90
	RPA (recursive partition averaging)	96.10
Ozyılmaz and Yildirim[20]	Multi-layer perceptron with back-propagation (MLP with BP)	86.33
	Radial basis function (RBF)	79.08
	Adaptive conic section function neural network (CSFNN)	91.138
Pasi [25]	Linear discriminant analysis (LDA)	81.34
	C4.5 with default learning parameters	93.26
	C4.5 with parameter *c*equal to 5	92.81
	C4.5 with parameter *c*equal to 95	92.94
	Multi-layer perceptron (MLP)	96.24
	Discretized interpretable multi-layer perceptron (DIMLP)	94.86
Myles and Brown[26]	Single-model multigroup classifier (SMC) {partial least squares discriminant analysis (PLS)–quadratic discriminant analysis (QDS)}	97.20
	One-vs-all classifier (OAC) (PLS-QDA)	93.80
	Pairwise classifier (PWC) (PLS–QDA)	97.20
	Decision pathway model (DPM) (PLS-QDA)	98.20
Hassan et al. [27]	HMM (hidden Markov model)	87.91
	Self-organizing map (SOM)	88.84
Pechenizkiy et al. [28]	3NN-Par (parametric)	94.20
	FEDIC (feature extraction for dynamic integration of classifiers) – plain	96.10
	Bayesian classifier	94.80
Polat et al. [21]	The artificial immune recognition system (AIRS)	81.00
	The artificial immune recognition system (AIRS) with fuzzy weighted pre-processing	85.00
Sun et al. [29]	C4.5 base	91.57
	C4.5 AdaBoost	91.12
	Base high-order pattern and weight of-evidence rule based classifier (HPWR base)	91.66
	HPWR AdaBoost	88.17
Keles and Keles [10]	Expert system for thyroid disease diagnosis with neuro fuzzy classification (ESTDD with NEFCLASS-J)	95.33
Luukka[30]	Kukkurai and Level set classifier	96.44
Temurtas[8]	Multilayer neural networks (MLNN) with Levenberg–Marquardt (LM)	92.96
	Probabilistic neural network (PNN)	94.43
	Learning vector quantizer (LVQ)	89.79
	MLNN with LM	93.19
	PNN	94.81
	LVQ	90.05
Kodaz et al. [9]	Artificial immune recognition system (AIRS)	94.82
	Information gain based artificial immune recognition system (IG-AIRS)	95.90
Dogantekin et al. [7]	Automatic diagnosis system based on thyroid gland: ADSTG	93.77
Dogantekin et al. [5]	GDA-WSVM (generalized discriminant analysis and wavelet support vector machine)	91.86
Chen et al. [43]	FS-PSO-SVM (feature selection-particle swarm optimization-support vector machines)	97.49
Liu et al. [46]	Fuzzy *K*-nearest neighbor (FKNN)	98.82
Li et al. [47]	Extreme learning machine	97.73

OTHER APPROACHES

Other types of methods which are widely employed in the diagnosis of thyroid disease are

- Bayesian Regularized Neural Network (BRNN): Bayesian regularized artificial neural networks (BRANNs) [12] are more robust than standard back-propagation nets and can reduce or eliminate the need for long cross-validation. Bayesian regularization is a mathematical process that converts a nonlinear regression into a "well-posed" statistical problem in the manner of a ridge regression. The advantage of BRANNs is that the models are robust and the validation process, which scales as O (N2) in traditional regression methods, such as back propagation, is unnecessary. These networks provide solutions to a number of issues that arise in QSAR modeling, like selection of model, robustness of model, selection of validation set, size of validation effort, and optimization of network architecture.

- Self-organizing Map (SOM): The SOM [12] is well known for its ability to perform clustering while preserving topology. The basic SOM consists of a set of neurons typically organized in a two-dimensional (2-D) structure. After completion of training, each and every neuron is attached to a reference vector of the euivalent dimension as the input space. By assigning each input vector to a neuron with the closest reference vector, the SOM is able to divide the input space into regions with common nearest reference vectors.

- Ontology based Systems: Ontology describes some domain in the form of concepts and relationships among them [31]. It has an advantage of being computer and human legible. The acceptance of ontology in medical field has facilitated the domain specialists and non-experts to execute the job of knowledge representation easily.

- Support Vector Machines and K-Nearest Neighbor: SVM does some extremely complicated data transformations and it separates our data, based on the labels or outputs that we have outlined. K-Nearest Neighbors algorithm [34] is a non-limitation, technique used for classification. The input consists of the k nearest instructing instances within the characteristic space. The output depends on whether or not KNN is used for classification or regression.

- Particle Swarm Optimization- Back Propagation: PSO-BP [39] is an optimization algorithm combining PSO with BP. The PSO algorithm [9] is a global algorithm that encompasses a strong ability to find the global optimistic result. However, this algorithm has a disadvantage that the search around the global optimum is extremely slow. In distinction, the BP algorithm has a strong ability to find the local optimistic result, however its ability to find the global optimistic result is weak.

- Krill Herd algorithm: KHA is one of the latest optimization procedures that go together with a heuristic character. Its main inspiration lays in following and imitating the biological swarming behavior of the Antarctic Krill (Euphausia superba), found in the Southern Ocean. The Krill[40] metaheuristic is employed in solving optimization tasks.

- Probabilistic Neural Networks: PNN [51] is in truth a training tool or network that is used in subjects like pattern recognition, nonlinear planning, estimation of each class data probability, and similarity proportion.

- Genetic Algorithm: GA [53,54] is a search technique to find approximate solutions to optimization issues. It is a global search technique and a particular class of evolutionary algorithms.

- Adaptive Neuro-Fuzzy Inference System: Adaptive network based fuzzy inference system (ANFIS)[48,49] is a neuro fuzzy technique where the fusion is created between the neural network and the fuzzy inference system. This ANFIS methodology contains of a hybrid system of fuzzy logic and neural network technique.

- Principal component analysis (PCA): Principal component analysis is an unsupervised linear technique of feature extraction [51].

- Gradient Descent, Scaled Conjugate Gradient and Levenberg Marquardt: Gradient descent technique is also called steepest descent. Gradient descent is a kind of iterative method that is provided with an initial point and it follows the negative of the gradient so as to move the point toward a critical point. Scaled Conjugate algorithm is a supervised learning algorithm. This works for feed forward neural networks. It is a member of class of Conjugate Gradient Methods (CGM)[37]. It works with second order data from neural network. The Levenberg-Marquardt (LM) algorithm is the most widely used optimization algorithm. Its performance is much better than simple gradient descent and other conjugate gradient methods in a very big variety of problems. Nonlinear Least Squares is the issue for which the LM algorithm provides a solution. This method works on second order derivative. It works on curvature similarly as on gradient of surface.

CONCLUSION

This study carried out a literature review of comparative studies on artificial neural networks, machine learning techniques and traditional statistical techniques used for prediction and classification purpose of the thyroid disease. The review points out the potential of artificial neural networks being employed for classification and prediction of thyroid disease. A quick glance of the table shown in the paper would reveal the performance of the most of the methods utilized in the diagnosis of thyroid

disease. In recent years, an overlap of certain aspects is seen in any two competing model building methods. It has also been suggested in several studies to combine the features of three techniques to enhance the overall prediction or classification performance. In this regard, these techniques become complementary methods for model building instead of competing methods.

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