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An Assessment of Machine Learning Methods for The Diagnosis of Thyroid Disease

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Abstract: *An infection of the thyroid is a persistent and complicated condition that may be caused by abnormal levels of TSH (Thyroid Simulating Hormone) or may be brought on by problems inside the thyroid organ itself. Hashimoto's thyroid disease is the cause of hypothyroidism that is now the most commonly recognized. During this condition, the body produces antibodies that pulverize the thyroid organ. This condition is considered to be auto-safe. The mechanism that is responsible for the progression of the thyroid condition is not yet fully understood by the medical community. Methods and Investigation: The neural network models that explain the elements connected to the non-functionality of the thyroid gland, its autoimmunisation status, and the many characteristics of thyroid illness have been investigated. The repercussions that are associated with thyroid illness are expanding at a fast rate, and this gives fresh insights into the molecular process that is involved, as well as assistance in the treatment of thyroid disease. In this article, the contribution of several neural network modeling techniques to the identification of thyroid dysfunctionality throughout the course of the last twenty years has been evaluated and reviewed. The findings indicate that a number of different parameter estimate approaches and the execution of the various neural system models have been investigated. Furthermore, in the most recent decades, there has been discussion about the usage of separate brain system models for the purpose of separating the disfunctionalities of thyroid illness.*

Keywords: Machine Learning, Statistical Methods

I. INTRODUCTION

The thyroid is a small organ that resembles a butterfly and is located near the base of the neck, just below the voice box. It is a component of the endocrine system. Both of the hormones that include iodine are produced by the thyroid.

1. Thyroxine (T4)
2. Triiodothyronine (T3)

The regulation of the digestive system facilitates the proper operation of organs such as the heart. In any event, the thyroid condition needs to release an appropriate amount of hormones into the bloodstream. The pituitary gland, which is in charge of producing TSH (thyroid stimulating hormone), regulates this movement, which stimulates but does not activate the release of T4 and T3. The numbers 3 and 4 refer to how many iotas of iodine are present in the hormones. Hyperthyroidism is a disorder where the thyroid overproduces and secretes excessive amounts of hormones (overactive thyroid). Hypothyroidism is the opposite condition that results from insufficient production and release of hormones (under dynamic Thyroid). Most bodily functions are slowed down by hypothyroidism, which also increases the risk of heart attack by raising cholesterol levels. The thyroid is an organ that is part of the endocrine system, and it has a role in the more common hormonal problem. This framework describes the collection of organs that specifically release substances into the circulatory system known as hormones.

Thyroid Functioning

In the very unusual case when the blood has an excess of T4, the pituitary lowers the amount of TSH it produces, which lowers thyroid function. Thyroxin is the primary thyroid hormone secreted by the thyroid gland. Because it has four atoms of iodine, it is frequently referred to as T4. To exert its effects, iodine is ejected from T4 and converted to

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triiodothyronine (T3). This mostly happens in the liver and in areas where T3 is activated, such as the mind. The pituitary gland at the base of the brain generates thyroid invigorating hormone (abridged TSH), which controls the amount of T4 that the thyroid produces. The quantity of TSH that the pituitary releases into the circulation is determined by the amount of T4 that it detects. In the improbable case that the pituitary detects very little T4, it increases TSH production, telling the thyroid to increase T4 production. Beyond a particular threshold, the blood system's T4 level causes the pituitary to cease generating TSH. To be honest, the thyroid and pituitary operate similarly to a radiator and an indoor regulator, although in opposite ways. When the radiator is off and the temperature begins to drop, the internal thermostat senses the cold and turns on the warmer. When the temperature reaches a comfortable level, the interior regulator detects it and turns off the radiator. The pituitary and thyroid regulate on and off, much like an indoor heater and regulator.

Artificial Neural Networks

A neural network, or ANN, is a machine learning technique that models the structure of the human brain by assembling a network of connecting neurons. The weights of the connections are linked to the neurons and indicate the information that the network has learned3. The layer of a neural network that houses the system's neurons is called a layer. The network consists of three distinct levels. The first layer is the input layer, which serves as a conduit between the system and network users, and the final layer is the output layer, which produces output in response to a given input. Between the input and output layers, there may be one or more hidden layers. Multiple hidden layer neural systems are referred to as multilayer perceptrons. To identify the confusing instances in the input data, the hidden layer collaborates. In general, neural networks have been used to solve a broad range of issues. Among the well-known and widely used neural systems that fall under the category of feed forward neural systems are stream-based neural systems, fuzzy neural systems, backpropagated neural systems, distributed premise capacity systems, and Bayesian neural systems. There should be two avenues for learning.

- Supervised Learning
- Unsupervised Learning

Using supervised learning, instructor information is linked with the network's output. There are several supervised learning algorithms available, with the backpropagation technique being one of the most often employed for various applications. Self-organizing neural networks employ unsupervised learning. Unsupervised learning does not need an instructor, in contrast to direct learning. The input vectors are compared and combined in this learning process to create a group with similar characteristics. proposed4 a model that uses Artificial Neural Networks (techniques) to identify thyroid dysfunction.

(1) The classification technique of cross validation
(2) The technique of Variable Selection
(3) The technique based on regression

Results: The most accurate and precise findings in detecting thyroid dysfunction have been shown using neural networks.

Limitation: For large number of characteristics there is a need to build up a variable determination technique.

presented a significant classification issue for the diagnosis of thyroid function using multivariate analysis and two noteworthy methods: self-organizing maps (SOM) and Bayesian regularized networks.

Different neural networks with different enactment capacity were used to compare the networks' performance in the Thyroid Illness Finding 6. To determine which networks performed best overall, each N/W was compared.

suggested seven machine learning techniques, one of which is the artificial intelligence-based insusceptible acknowledgment framework (AIRS), a framework for organizing and analyzing terrorist threats.

Results: In previous applications, the thyroid illness detection data set provided an 85% accuracy rate, which was improved to 20% accuracy when using hybridized frameworks.

suggested8 a technique for diagnosing thyroid illness using an expert system. The Expert System Thyroid illness Diagnosis (ESTDD) approach is used to diagnose thyroid illness. Thyroid illness is accurately diagnosed by ESTDD 95.33% of the time.

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investigated nine different neural network techniques for thyroid illness diagnosis. For this, Multilayer Perception (MLP) with adaptive Conic Section Function Neural Network (CSFNN), Radial Basis Function (RBF), and Back-Propagation (BP) and Fast-Back-Propagation (FBP) have been used.

Results: The system can be trained faster and with higher classification rates thanks to the CSFNN. RBF's categorization accuracy is not very excellent. MLP performs well on average, but since it uses random weight initialization during training, it cannot guarantee the same performance for a single run.

Compared10 learning vector quantization (LVQ-NN), probabilistic (NN), and multilayer (NN) neural networks for the study of thyroid diseases.

Results: The results show that the probabilistic neural system has the greatest grouping accuracy for identifying thyroid infections.

reviewed11 on conventional quantifiable techniques and feed forward simulated neural systems used for expectation and organization in restorative diagnostics.

examined 12 different ANN design types and assessed how effective they were in determining thyroid capacity. Procedures have been designed and tested using the Multilayer Perceptron, which is created using learning vector quantization and back propagation algorithms.

suggested13 a method with 95.90% order accuracy for analyzing the thyroid data set employing a different simulated insusceptible framework, known as the data-based improved counterfeit invulnerable acknowledgment framework (IG-AIRS). When compared to other machine learning computations, the IG-AIRS classifier architecture makes sense.

Research on the feed forward neural system and its application to the management of thyroid illness by backpropagation computation is available [14]. They demonstrated the accuracy of neural network technology for thyroid dysfunction diagnosis using cross validation methods.

modified fuzzy hyper line section grouping neural system (MFHLSCNN) was proposed15 as a means of characterizing thyroid disease findings. It makes sense to calculate the MFHLSCNN for bunching and characterisation. When the suggested model is compared to the Multi-Layer Perceptron (MLP), it is found that the MLP requires more learning time per example.

examined16 a few methods for emphasizing the selection and sequencing of thyroid illness analysis. They proposed a crucial element for nonlinear streamlining problems termed the choice procedure, or heredity calculation. The thyroid illness is analyzed using a Bolster Vector Machine classifier; the results show that Support Vector Machine performs better than Bolster Vector Machine.

Results: SVM's observed classification rate is 98.62%, with an accuracy of 99.6% for testing and preparation.

explains17 how manufactured neural networks are used to analyze thyroid problems and build systems employing learning vector quantization (LVQ), radial basis function (RBF), and back propagation algorithm (BPA). They were used together with MATLAB to examine the thyroid condition. RBF has been shown to be the most effective neural system technique for identifying thyroid issues out of the three.

examined a few ANN structures and compared 18 with the thyroid disease result. RBF, LVQ, and SVM system models are used in the analysis of thyroid illness. RBF Networks is discovered to have produced the greatest results when used to determine thyroid organ capacity. In the analysis of thyroid illness, RBF Networks performed better than other methods.

suggested19 the use of a hybrid approach to diagnose thyroid conditions. This method replicates non-cross breed structures as well as MAT lab – ANFIS structures. The results demonstrate that the suggested mixing plan performs better than both ANFIS and non-crossover plans in terms of execution. In addition, the suggested mixing plan executes faster than both ANFIS and non-crossover plans.

investigated the fuzzy neural network (fuzzy NN) and contrasted its performance with that of Support Vector Machine (SVM) in identifying thyroid illness. The prediction of thyroid illness is reported to be between 95.4% and 99.5% using the fuzzy NN, which has excelled the previous classifications by taking into account particular factors like HYPO, Hyper, Sub–clinical hyperthyroid, Sub–clinical hypothyroid, and no thyroid.

examined21 the semi-automated procedures for the diagnosis of thyroid illness. To identify and organize thyroid illnesses, a variety of neural networks are used, including K-mean NN, fuzzy framework different classifiers including

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naive Bayes, support vector machines, and decision trees. Analogous research provides clarity about the early diagnosis of thyroid disease.

suggested22 a method for diagnosing diseases using the Learning Vector Quantization (LVQ) model. The results show that compared to other neural systems, the LVQ model operates faster.

Suggested23 a classification technique for diagnosing illness that outperforms probabilistic neural systems and support vector networks. It has been noted that SVM performs better than other networks.

Suggested24 a three-stage SVM-based expert system for the detection of thyroid illness. In order to accomplish classification, the suggested model has been compared with other models, such as SVM based on GRID-Search Engine.

Looked at 25 neural network methods for MLPNN-based thyroid illness detection. Using MLPNN, the thyroid picture has been taken into account in this study. Model sensitivity is 89.62% for a 10-fold increase and 93.12% for a 3-fold increase.

Hypo-echogenic pattern and thyroid ultrasonography to determine the thyroid auto immune illness (26).

Examined27 a specialized framework for the diagnosis of thyroid dysfunction using an expert system technique. Considering the unpredictable nature of the field, the master framework's current implementation, according to its authors, is quite promising.

created a system for diagnosing thyroid infections using CAD, Principal Component Analysis (PCA), and Extreme Learning Machine (ELM). The optimal ELM model is a method that the authors have suggested for diagnosing thyroid illness. The PCA-ELM technique outperformed the other approaches, according to observations.

Presented a neural fuzzy classifier with chosen feature (LHNFCSF) that uses linguistic hedges to identify thyroid infections. It was discovered that the testing and training classification accuracy was more than 95%. For thyroid diagnosis, a variety of Neural Networks30 were utilized, along with heuristic algorithms such the migrating birds optimization method and SWARM optimization. NNs have successfully been used to computer-aided diagnostics in order to identify the illness.

Suggested31 a novel approach to thyroid diagnostics with data mining tools and a fuzzy cognitive map. In order to diagnose the condition, the authors have created a thyroid disease management system based on FCM.

Suggested32 a method for using wavelet support vector machines and generalized discriminant analysis to identify thyroid disease.

Results: Physicians find the GDA-WSVM master structure to be very helpful. With this approach, the characterisation accuracy for the diagnosis of thyroid infection was found to be 91.86%.

Created33 a NN model utilizing GA to diagnose thyroid disease. The NN is simulated using MATLAB, and the results of testing and training ranged from 96% to 98%.

Investigated 34 There have been proposals for fuzzy cognitive maps based on decision support systems and other techniques. Their study focuses on choosing and extracting the characteristics that provide the best categorization results.

A technique for diagnosing thyroid illness has been developed35, and it makes use of decision tree attribute splitting rules. Five distinct requirements, namely: 1. Increased information 2. Ratio of Gain 3. Index Gini 4. Chi-squared chi-proportion insights, 5. The tree was constructed using separation measures.

suggested36 a classifier that uses random forest and C4.5 algorithms to classify thyroid data. This suggested model is contrasted with other classifiers currently in use.

developed37 a classifier using information mining techniques such as Bayes net, Multi-layer perceptron, RBF Network, C4.5, CART, and REP tree, and simulated using WEKA instrument for the diagnosis of hypothyroid illness. It was discovered that the accuracy for determining thyroid infection was 99.60%.

created 38 more simulated neural system approaches that use a BP algorithm to identify thyroid problems. It is discovered that the BP algorithm has excellent sensitivity and specificity. Error convergence was observed to take longer. It was also discovered that the BP network's performance deteriorates with an increase in sample size.

suggested39 a model of the brain system to identify the thyroid disease. The BP algorithm, RBF, and LVQ networks are utilized with the neural system, and it has been shown that these networks are more accurate in illness diagnosis.

Proposed 40 MLPNN was shown to have 98.6% accuracy when used in conjunction with the BP algorithm to identify thyroid illness.

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discovered41 a NN system that uses the BP algorithm to identify thyroid illness. When trained using the Lavenberg-Marquert method, NN outperformed the radiant descent technique in terms of accuracy.

created42 a self-organizing map (SOM) based multi-disease diagnostic model. There are two levels in the suggested SOM-based model. The suggested model worked well in identifying the several illnesses, allowing for an accurate conclusion to be reached.

studied43 the Multilayer Perceptron neural system and Radial Basis Function (RBF) neural network for the categorization of thyroid illness. These systems were used to describe the fundamental subset of euthyroidism and hyperthyroidism. In clinical research, RBFNN is shown to be a better model for classification than the other two models.

investigated44 several ANN-based machine learning methods. In comparison to other decision support systems, several ANNs, including MLP, BPN, RBFNN, LVQ, and SOM, were studied and shown to be appropriate for illness detection.

studied45 the preprocessing techniques and the Progressive Learning Vector Quantization Neural Network (PLVQNN) for automated thyroid segmentation and volume estimation utilizing PLVQNN and LVQNN. The results show that the suggested method is capable of accurately dividing the thyroid organs and estimating the thyroid volume.

examined46 how well the MLP performed in differentiating between infants who were suffering hypothyroidism and newborns based alone on their screams. According to the suggested method, the MLP is better than other strategies.

examined47 an intelligent control approach for administering treatment drugs to patients with primary hypothyroidism who do not have a thyroid gland. Blood hormones TSH and T4 were predicted using MLPNN algorithms.

In order to diagnose thyroid gland illness, a decision-making system was developed48. It was discovered that logistic regression provided an accuracy of 98.7%.

Proposed49 two ANNs and discovered that the Livenberg Marquardt and scaled conjugate gradient back propagation techniques work better in differentiating between infected and non-infected individuals after training.

MLP and RBF networks, two neural system models, were proposed50 for the detection of thyroid illness. RBF was trained and tested using SPSS software, whereas MLP is trained and tested using the BP method. The result shows that MLP and RBF have both done as well as possible in diagnosing the illness.

presented51 a TIRDS model with biopsy findings and classifications. The research's objective is to use neural network learning algorithms to include learning capabilities into the DSS static model and transform it into a dynamic model.

presented52 three neural system prediction techniques for thyroid illness. Of these, the scientists have suggested the most effective method for identifying thyroid illness, which also speeds up diagnosis and improves accuracy.

examined53 the differences between the existing approaches and the present autonomous tools for classifying thyroid nodules utilizing thyroid ultrasound images. Three-dimensional ultrasonography, according to the creators, provides more comprehensive information about the thyroid nodule than two-dimensional imaging. In order to evaluate the thyroid organ in the future, the component extraction and order techniques for thyroid knob detection may be fixed.

suggested54 a cutting-edge approach for evaluating thyroid nodules in ultrasonography images for malignancy. The suggested method was divided into four stages: segmentation, classification, feature extraction, and preprocessing. For the classification challenge, a neural system based on Support Vector Machines (SVM) is used. Grey level co-occurrence is used in the feature extraction process. The scientists discovered that the SVM classifier outperforms the ANN in terms of distinguishing between benign and malignant nodules after evaluating the results using precision, affectability, and specificity.

Comparison55 of three artificial neural networks for the detection of thyroid disease: Radial Basis Function (RBF), Learning Vector Quantization (LVQ) network, and multilayer Back Propagation Network (BPN). It was discovered that RBF offered the greatest PSNR values and the best accuracy with the fewest iterations.

Using pictures of medical conditions, studies56 of various thyroid ailments, thyroid diagnoses, and thyroid problems are evaluated. An overview of the thyroid segmentation accuracy of several researchers studying various thyroid illnesses was also provided by the study.

Observed57 the thyroid data-driven PNN (probabilistic neural system) classifier. The Statistical PCA approach was used to extract features from the dataset, which was classified into three classes: high efficiency, poor efficiency, and normal. For this, the accompanying mathematical models are used.

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$$F_k, i(X) = \frac{1}{(2\pi\sigma^2)^{n/2}} \exp\left(-\frac{\|X - X_{k,i}\|^2}{2\sigma^2}\right.$$

suggested58 using many classifications to diagnose thyroid illness. It consists of a step for classifying and detecting attacks. Using reliable and efficient data, a multi-layer thyroid detection technique addresses the issues encountered by previous multiple classifier systems.

enhanced the accuracy of the prediction of 60 cases of hypothyroid illness by using a data mining approach known as linear discriminant analysis (LDA). The categorization of hypothyroid illness is done using LDA data mining methods. There is a K-fold cross validation. 99.62% accuracy is obtained with the LDA Algorithm with k=6 cross validation.

Using entropy and information gain, a decision tree-based approach was proposed in 61. This model is contrasted with the Naïve Bayes method, KNN, and J48. Compared to other models, the suggested model is more accurate.

Gender-based thyroid cancer research has been studied and analyzed62; the SCI report states that there are more articles on this topic than on cancer and carcinoma.

Identified63 the autoimmune thyroid disease in diabetic patients in order to provide early diagnosis and therapy. The findings point to a close connection between autoimmune thyroid diseases and IDM.

A study (research number 64) examined the diminished impact of radiation exposure and fluid consumption while administering I-131 treatment to individuals with thyroid cancer. Radiation exposure for the two groups A and B in this study was shown to vary by 51% based on the amount of fluid consumed. Table 1 provides an overview of the many neural network models and other models that have been used to predict thyroid illness throughout the years, along with the relevant references.

II. CONCLUSION

Diagnosing diseases is crucial and essential for every working physician. One such condition that is difficult to anticipate without computer technology is thyroid illness. The writers of this survey report have provided a detailed work that was previously completed using artificial neural networks. The authors have attempted to provide future researchers with guidance on how to use artificial neural networks for illness detection based on their use of these networks.

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