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An Innovative Method for Finding Out The Disease of Tuberculosis Of Human Lungs Based On Neural Networks - Adaptive Resonance Theory (ART)

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Abstract – Artificial Neural Network in the field of Artificial intelligence, attempts to mimic the network of neurons of human brain. The computers, after programming will have an option to understand things and make decisions in a human-like manner. .This research work makes use of the ART neural network and algorithms which maintain the plasticity required to learn new patterns without disturbing or modifying the patterns which have been already learned. The human brain is able to record continuously a series of information without disturbing the old memories. Similarly, the ART networking system is possessing the same characteristics. The Adaptive Resonance Theory (ART) neural networks are possessing the special type of characteristics that they can maintain the stability to learn new things without erasing or unnecessarily modifying the patterns which have been already learned. The research work is to input the binary vector of the image of human lungs and then the system has to find out whether the lungs is healthy or affected by TUBERCULOSIS (TB). If it is affected, whether it is starting stage or serious one can also be known with help of this system.

Keywords – Tuberculosis, plasticity stability, recognition layer, comparison layer, top down bottom up weights

I. INTRODUCTION

A. Artificial Neural Networks

The Artificial Neural Network is derived from Biological neural networks. Artificial Neural Networks develop the structure of a human brain. The neurons are interconnected to one another in the brain. Similar to human brain, artificial neural networks also have neurons that are interconnected to one another in various layers of the networks. These neurons are known as nodes the diagram is given below.

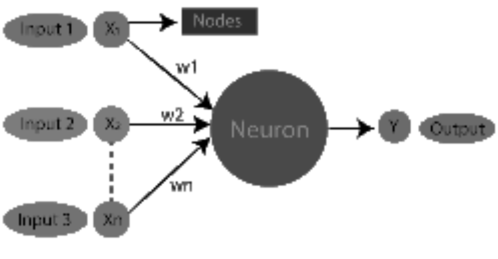

Fig. 1. Structure of Artificial Neural Networks

An Artificial Neural Network in the field of Artificial intelligence, it attempts to mimic the network of neurons which are making up a human brain. Hence, computers will have an option to understand things and make decisions in a human-like manner. The artificial neural network is designed by programming computers to behave simply like interconnected brain cells.

To understand the artificial neural network with an example, consider a digital logic gate that takes an input and gives an output. "OR" gate, which takes two inputs. If one or both the inputs are "On," then we get "On" in output. If both the inputs are "Off," then we get "Off" in output. Here the output depends upon input. Our brain does not perform the same task. The outputs to inputs relationship keep changing because of the neurons in our brain, which are "learning".

II. THE ARCHITECTURE OF AN ARTIFICIAL NEURAL NETWORK

To understand the concept of the architecture of an artificial neural network, we have to understand what a neural network consists of. In order to define a neural network that consists of a large number of artificial neurons, which are termed units arranged in a sequence of layers. Let us look at various types of layers available in an artificial neural network.
Input Layer: It accepts inputs in several different formats provided by the programmer.
Hidden Layer: The hidden layer presents in-between input and output layers. It performs all the calculations to find hidden features and patterns.
Output Layer: The input goes through a series of transformations using the hidden layer, which

finally results in output that is conveyed using this layer.

The artificial neural network takes input and computes the weighted sum of the inputs and includes a bias. This computation is represented in the form of a transfer function.

$$\sum_{i=1}^{n} Wi * Xi + b$$

It determines weighted total is passed as an input to an activation function to produce the output. Activation functions choose whether a node should fire or not. Only those who are fired make it to the output layer. There are distinctive activation functions available that can be applied upon the sort of task performing.

A. How do artificial neural networks work?

Artificial Neural Network can be best represented as a weighted directed graph, where th artificial neurons form the nodes. The associatic between the neurons outputs and neuron inputs ca be viewed as the directed edges with weights. Th Artificial Neural Network receives the input sign from the external source in the form of a patter and image in the form of a vector. These inputs are then mathematically assigned by the notations x(n) for every n number of inputs.

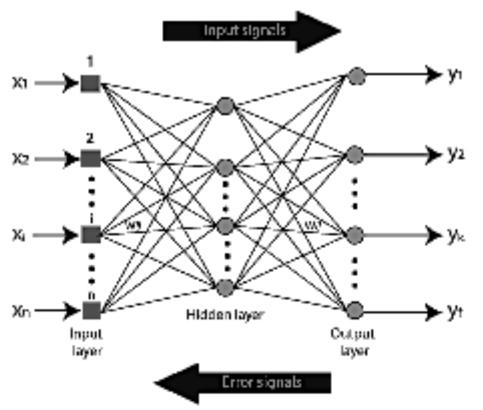

Fig. 2 Artificial Neural Networks

Afterwards, each of the input is multiplied by its corresponding weights. All the weighted inputs are summarized inside the computing unit. If the weighted sum is equal to zero, then bias is added to make the output non-zero or something else to scale up to the system's response. Bias has the same input, and weight equals to 1. Here the total of weighted inputs can be in the range of 0 to positive infinity. Here, to keep the response in the limits of the desired value, a certain maximum value is benchmarked, and the total of weighted inputs is passed through the activation function. The activation function refers to the set of transfer functions used to achieve the desired output. There is a different kind of the activation function, but primarily either linear or non-linear sets of functions. Some of the commonly used sets of activation functions are the Binary, linear, and Tan hyperbolic sigmoidal activation functions.

B. Tuberculosis (TB)

Tuberculosis (TB) is an infectious disease caused by bacteria that most often affects the lungs. It spreads through the air when people with TB cough, sneeze or spit. Tuberculosis is preventable and curable. Those who are infected but free of disease cannot transmit it. TB disease is usually treated with antibiotics and can be fatal without treatment. In certain countries, vaccine is given to babies or small children to prevent TB. The vaccine prevents deaths from TB and protects children from serious forms of TB.

Certain conditions can increase a person's risk for TB disease:

- diabetes (high blood sugar
- weakened immune system
- being malnourished
- tobacco use
- harmful use of alcohol.

Common symptoms of TB are:

- prolonged cough (sometimes with blood)
- chest pain
- weakness
- fatigue
- weight loss
- fever
- night sweats

The symptoms people get depend on which part of the body is affected by TB. While TB usually affects the lungs, it can also involve the kidneys, brain, spine and skin.

III. THE ADAPTIVE RESONANCE THEORY NEURAL NETWORK SYSTEM (ART)

This research work makes use of the ART neural network and algorithms which maintain the plasticity required to learn new patterns without disturbing or modifying the patterns which have been already learned. The human brain is able to record continuously a series of information without disturbing the old memories. Similarly, the ART networking system is possessing the same characteristics. This capability has stimulated a great deal of interest in developing various applications. The fundamental ideas and implementations are easy for solving various problems. The researchers understand the basic ideas to solve various problems using the characteristics of this useful neural network. The

Adaptive Resonance Theory (ART) neural networks are possessing the special type of characteristics that they can maintain the stability to learn new things without erasing or unnecessarily modifying the patterns which have been already learned. The research work is to input the binary vector of the image of human lungs and then the system has to find out whether the lungs is healthy or affected by TUBERCULOSIS (TB). If it is affected, whether it is starting stage or serious one can also be known with help of this system.

IV. STORAGE OF NEW SENSORY INFORMATION

The human brain receives a continuous series of sensory information from the environment and records them in the correct order so that the human is able to explain what happened first, second and next. The surprising characteristics of human brain is how it could remain plastic and retain the stability to store continuously new sensory information without erasing or disturbing the old memories. Conventional artificial neural networks do not maintain stability-plasticity property. Mostly, it erases or modifies previous pattern while learning a new pattern. If it is required to train a fixed set of training vectors, the network can be cycled through these set of training vectors repeatedly and may finally learn them all. In the case of backpropagation network, the training vectors are applied sequentially until the network has learned the entire set. But, a fully trained network, while learning a new vector, it may disturb the previous weights so badly and it may require the complete retraining. So, the backpropagation neural network also has failed to possess stability-plasticity property.

V. THE ART ARCHITECTURE

Adaptive resonance theory is divided into two paradigms, Each defined depending upon the form of the input data and its processing. ART-I is designed to accept only binary input vectors, whereas ART-2, A later development that generalizes ART-I, can classify both binary and continuous inputs. Only ART-I is presented here for this research paper.

VI. AN OVERVIEW OF ART

The ART network is a vector classifier. It accepts an input vector and classifies it into one of a number of categories. The classification is done depending upon the most resemblance of one of the stored patterns. The neuron which fires in recognition layer indicates the classification. If the input pattern does not match with any of the stored pattern a new pattern of the input category will be created and stored. In ART classification, three categories are considered.

Case 1. The input vector is given and finds a perfect match with any one of the stored pattern. It indicates that the input pattern belongs to that category.

Case 2. The input vector is given and does not find match with any one of the stored pattern. It indicates that the input pattern does not belong to any one of the stored category. In this case, a complete new pattern of the input type is created and stored.

Case 3. The input vector is given and finds more resemblance with any one of the stored pattern and the difference between the input pattern and stored pattern is within a limited value called vigilance parameter, the stored pattern will be adjusted (trained) to make it still more like the input vector IN() .

A. Important Result

In this fashion, the stability—plasticity dilemma is resolved. New patterns from the environment can create additional classification categories if they are entirely new. But a new input pattern is not perfect matching with the existing stored pattern and difference is within the vigilance parameter, the existing pattern is slightly adjusted to make it perfect matching.

VII. A SIMPLIFIED ART ARCHITECTURE

ART network has five functional modules. It consists of two layers of neurons labelled as (i) Comparison, (ii) Recognition, (iii) Gain, (iv) Gain and (v) Reset. The Reset provides control functions needed for training and classification.

A. Comparison Layer

The Input to comparison layer is X. Initially, the comparison layer passes the unchanged input vector X as binary input vector C to the recognition layer. The recognition layer produces binary vector R modifying the vector C in a later phase as follows.
Each neuron in the comparison layer receives three binary inputs (zero or one)

- a component Xi from the input vector X
- the feedback signal Pj, the weighted sum of the recognition layer outputs
- an input from the gain signal Gain I (the same signal goes to all neurons in this layer).

To output a one, at least two of a neuron's three inputs must be one, otherwise, its output is zero. This is called as the "Two Thirds Rule". Initially, gain signal Gain I is set one, providing one of the needed inputs, and all components of the vector R are set to zero. The vector C starts out identical to the binary input vector X.

B. Recognition Layer

The recognition layer is used to classify the input vector. Each recognition layer neuron has an associated weight vector B. Only the neuron with a weight vector best matching the input vector fires, all others are inhibited.

When the vector C is given as input to recognition layer, the neuron with a weight vector in the recognition layer matches its set of weights responds maximally. These weights constitute a stored pattern or exemplar, for a category of input vectors. A binary version of the same pattern is also stored in a corresponding set of weights in the comparison layer. This set consists of those weights that connect to a specific recognition-layer neuron, one weight per comparison-layer neuron.

Each neuron in the recognition layer computes a dot product between its weights and the incoming vector C. This dot product value will be maximum for the neuron which has its weight vector most like the vector C. That neuron is taken as winning neuron which will emit an output of 1and inhibiting all other neurons in the layer from firing and they produce output of 0 only.

A lateral-inhibition network is connected with all the neurons in recognition layer. This is done as each neuron in the recognition layer will be connected with a negative to the input of all other neurons and a positive weight from its output to its own input. By this lateral-inhibition network, if a neuron's output is at a one level, this feedback will make the output of that neuron to reinforce and sustain it.

Gain I: Like G 2, the output of Gain 1 is one if any component of the binary input vector X is one; however, if any component of R is one, Gl is forced to zero.

Table1. Relationship between gain I and gain II

X Component	R Component	Value of G2
0	0	0
1	0	1
1	1	0
0	1	0

Gain 2: G2, the output of Gain 2, is one if input vector X has any component that is one. More precisely, G2 is the logical "or" of the components of X.

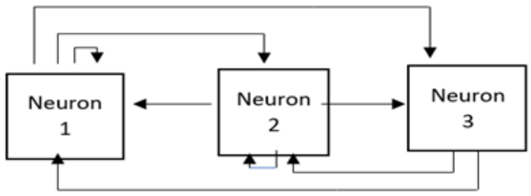

Fig.3 Lateral – inhibition network

Reset: The reset module calculates the similarity between vectors X and C. If the difference is more than the vigilance parameter, a reset signal will be sent. This signal will disable the firing neuron in the recognition layer. The reset module calculates similarity as the ratio of the number of ones in the vector C to the number of ones in the vector X. If this ratio is below the vigilance parameter level, the reset signal will be issued.

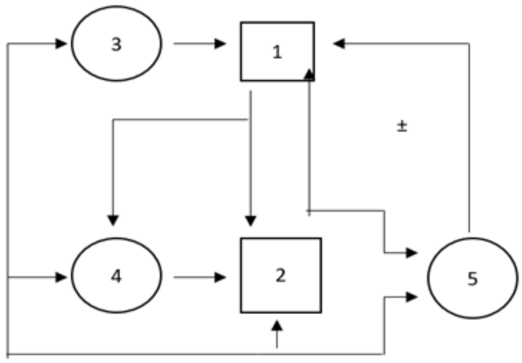

Fig.4 Recognition Layer, Comparison, Gain, Reset

VIII. ART CLASSIFICATION OPERATION

The ART classification process consists of three major phases Recognition, Comparison, and Search.

A. The Recognition Phase

No input vector is applied initially. Hence, all components of input vector X are zero. This sets G2 to zero, thereby disabling all. Apply the vector X to be classified. It must have one or more components that are one, thereby making both Gl and G2 equal to one. This "primes" all of the comparison-layer neurons, providing one of the two inputs required by the two-thirds rule, thereby allowing a neuron to fire if the corresponding component of the X input vector is one. Thus, during this phase, vector C is an exact duplicate of X.

Next, for each neuron in the recognition layer a dot product is formed between its associated weight vector Bj and the vector C The neuron with the largest dot product has weights that best match the input vector. It wins the competition and fires, inhibiting all other outputs from this layer. This makes a single component of vector R equal to one, and all other components equal to zero.

B. The Comparison Phase

The single neuron firing in the recognition layer passes a one back to the comparison layer on its output signal ry. This single one may be visualized as fanning out, going through a separate binary weight tji to each neuron in the comparison layer, providing each with a signal Pi, which is equal to the value of t (one or zero).The initialization and training algorithms ensure that each weight vector TJ consists of binary valued weights; also, each weight vector. The initialization and training algorithms ensure that each weight vector TJ consists of binary valued weights; also, each weight vector Bj constitutes a scaled version of the corresponding weight vector T. This means that all components of P, the comparison-layer excitation vector, are also binary valued. Since the vector R is no longer all zeros, Gain 1 is inhibited and its output set to zero. Thus, in accordance with the two-thirds rule, the only comparison-layer neurons that will fire are those that receive simultaneous ones from the input vector X and the vector P. In other words, the top-down feedback from the recognition layer acts to force components of C to zero in cases in which the input does not match the stored pattern, that is, when X and P do not have coincident ones.

C. The Search Phase

The similarity between the stored vector and the present input vector is calculated. This is done as the number of 1s in C vector which is taken as the value of N and the number of 1s in the input vector X is calculated and that value will be assigned to D.

Then, the similarity S is calculated as S=N/D. For example:

X = 1101011 D = 5
C = 1001011 N = 4
S = N/D =4/5 = 0.8

The value of S lies between 1 (perfect match) and 0 (worst match).

IX. THE ADAPTIVE RESONANCE THEORY NETWORK SYSTEM OPERATION

A. Initialization of Weights and Vigilance Parameter. Before starting the network training process, all weight vectors Bj and Tj as well as the vigilance parameter p must be set to initial values.

B. Recognition

Apply an input vector X will initiate the recognition phase. There is no output from the recognition layer initially, Gl is set to 1 This time, the vector C will be identical to X.

C. Training

In the training process, a set of input vectors are presented sequentially to the input of the network, The network weights are so adjusted that similar vectors activate the same recognition layer neuron. This network training is unsupervised training. It does not require a teacher and no target vector to indicate the desired neuron in the recognition layer.

X. ART NEURAL NETWORK SYSTEM AND FINDING OUT TUBERCULOSIS

This research work starts with the training of the Adaptive Resonance Theory Neural Network System to find out the condition of the human lungs. The human lungs may be healthy or sometimes it has been affected by the disease, Tuberculosis. There will be an indication for three cases of the condition of the lungs. The first indication is for healthy lungs. The second one is for affected, starting stage and curable. The third one is the lungs is affected more and takes more time for its cure. The fourth case is an indication for serious affect and it requires intensive care and very long time for its cure. To achieve this research network system, the neural network has to be imparted training process. After having trained the network system, if the binary vector of the lungs to be tested is given, the system will indicate whether the lungs is healthy or affected by tuberculosis. If it is affected by tuberculosis, then the condition of the lungs can be known.

A binary image is one in which there are only two values 0s and 1s only. The is converted into binary vector using various software.

Table 2. Sample images of Lungs Sample binary vector.

1	.	.	.	.	0
.					
.					
.					
.					
0	.	.	.	.	1

Fig.5 Healthy Lungs

Fig.6 TB affected Lungs

Table 3. TB Affect and Condition of Lungs

Category	Input Vectors	TB Affect And Condition Of Lungs	Recognition Layer Neuron To Be Activated
TYPE 1	H_1, $H_2 \ldots H_n$	Healthy – No TB	N_1
TYPE 2	$B_1, B_2 \ldots B_m$	Beginning of TB	N_2
TYPE 3	M_1, M_2, M_i	Middle Stage of TB	N_3
TYPE 4	$S_1, S_2 \ldots\ldots S_J$	Serious Stage TB	N_4

XI. ALGORITHM

Step 1: *Setup the Adaptive Resonance Theory Neural Network System with five functional modules.*
Step 2: *Initialize the weight vectors Bottom up weights Bj, Top down weights Tj, according the predetermined procedure and assign the value for Vigilance parameter.*
Step 3: *Collect and categorize the images of lungs into four sets of lungs namely healthy, tb affected starting stage, tb affected more but medically curable, serious condition of tb affect.*
Step 4: *Convert all images into binary vectors using any software.*
Step 5: *Sequentially apply four sets of binary vector, adjust the network weights and activate the corresponding neuron in the recognition layer as given in the Table 3.*
Step 6: *During training, after some vectors have been trained, applying a new vector.*

(i) finds perfect match, activates the same neuron, no creation of new vector.
(ii) no matching is found, no activation of neuron, then creation of that binary vector.
(iii) matching is not perfect, but difference is within the vigilance parameter, that neuron with binary vector is adjusted and stored.

XII. RESULT

Using the above algorithm, the network is trained for different category of binary vectors of the images of lungs. During training, when a new vector is applied, the system will create a new vector of that type. If a vector is applied and there is a perfect matching, activating the same neuron in the recognition layer, new vector will not be created. If a new vector finds a matching, there is a difference in the existing vector, but difference is within the vigilance parameter, then the existing vector will be adjusted to match with it. After training if you apply binary vector of lungs image, depending upon the category the respective neuron in recognition layer will be activated, and indicates the condition of the lungs.

XIII. CONCLUSION

The following characteristics the Adaptive Resonance Theory network systems are the most important and these characteristics are very useful in finding out the disease of tuberculosis (TB). In the recognition layer, there are four neurons. The first neuron indicates the healthy lungs and is not affected by the disease, second one indicated, it is the starting stage of TB. The third one indicates it is affected more but curable condition. The fourth one indicates, the lungs is affected, in a serious condition and shows it needs intensive care for its cure.

After training has been imparted the ART network system stabilized so that application of one of the training vectors or one with the similar features of the category will activate the correct recognition-layer neuron without searching. This "direct-access" characteristic implies rapid access to previously learned patterns. The search process is over and the winning recognition layer neuron is recognised, the system will not switch from one neuron to another. Similarly, training is also stable and training will not cause a switch from one recognition-layer neuron to another. After the training process is over, any sequence of arbitrary input vectors will produce a stable set of weights. After imparting training for a number of times, the same input or another similar input will cause the same recognition layer neuron to be activated.

XIV .REFERENCES

[1] Carpenter, G.A. & Grossberg, S. "Adaptive Resonance Theory", Archived 2006-05-19 at the Wayback Machine, In Michael A. Arbib (Ed.), The Handbook of Brain Theory and Neural Networks, Second Edition (pp. 87-90). Cambridge, MA: MIT Press, 2003.

[2] D. Devaraj, P.Ganesh Kumar, "Mixed Genetic Algorithm approach for Fuzzy Classifier Design",International Journal of ComputationalIntelligence and Applications, Vol.9, No.1, pp.49-67, 2010.

[3] Gálvez, A.; Iglesias, A.; Cobo, A.; Puig-Pey, J.; Espinola, J. Bézier curve and surface fitting of 3D point clouds through genetic algorithms, functional networks and least-squares approximation. Lect. Notes Comput. Sci., 4706, 680–693, 2007.

[4] Gail Carpenter, Stephen Grossberg and David Rosen "Fuzzy ART: Fast Stable Learning and Categorization of Analog Patterns by an Adaptive Resonance System", Technical Report CAS/CNS-1991-015,June 1991.

[5] Haykin, S. Neural Networks: A Comprehensive Foundation, 2nd ed.; Prentice Hall: Hoboken, NJ, USA, 1998.

[6] Jacquin, A.E. Image coding based on a fractal theory of iterated contractive image transformations. IEEE Trans. Image Process, 1, 18–30, 1992.

[7] Philip D. Wasserman, "Neural Computing: Theory and Practice", Van Nostrand Reinhold, 1989.

[8] S. Rajasekaran, G. A. Vijayalakshmi Pai, " Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis And Applications ", PHI Learning Pvt. Ltd., Jan 2003.

[9] Rehman, M., G.M. Khan and S.A. Mahmud, Foreign Currency Exchange Rates Prediction using CGP and Recurrent Neural Network. In Proceedings of 2014 International Conference on Future Information Engineering, pp: 239-244, Elsevier, 2014.

[10] Verikas, A. and M. Bacauskiene, Feature Selection with neural networks. pp: 1323-1335, Elsevier, 2002.

[11] Zhao, Z., and H. Liu, 2009. Searching for interacting features in subset selection. Intelligent Data Analysis, 13(2): 207-228.

[12] https://www.who.int/news-room/fact