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Design Simulation and Assessment of Computer Based Cancer Diagnosis Accuracy using ART 1.0 Algorithm

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ABSTRACT

Today Cancer is spreading heavily and become the most dangerous disease in the world. This disease causes death if not diagnoses before the major stage. Small changes or illness in the human body may transform to the cancer in the body. The main thing in this disease is it is not easily detected in its earlier stage. So this causes the aim to design a computer operated system that can make distinguish between benign (non-cancerous) and malignant (cancerous) mammogram. The proposed system helps doctors to increase the diagnosis accuracy. The above propose system shall be simulated by MATLAB. The ART 1.0 algorithm shall be studied and modified to improve the accuracy of existing ART 1.0 system. The simulation shall be done by obtaining cancer data set from UCI repository. The reason behind choosing ART algorithm because of its characteristic to work on three phases i.e., **Recognition, Comparison, Search Phase.** The winning neuron is obtained by finding the dot product of input and weight vector. The neuron having largest dot product be the winner.

***Key words:** Cancer, Cancer Staging, Artificial Intelligence, ART, MATLAB, NNTOOL*

1. INTRODUCTION

Research work in this M.Tech dissertation report is study of different variant of Adaptive Resonance Theory (ART) algorithm implemented by using *modified Weight updation function*, which results to improved classification in the existing algorithm.

Before moving on to the classification method, we shall carry out data classification on the Cancer dataset using the aforementioned Network Clustering Tool of MATLAB, which internally uses the ART Network. In order to carry out the pattern classification, the algorithm in both the types of networks is run in analog manner with linear data scaling method. Conclusion shall also be inferred basis on the performance of the algorithmic implementation with each of these functions individually.

Cancer Tumor is a collection of ailments, including strange cell development and the possibility of attacking or spreading on different parts of the body. These are not identical tumors, which do not spread to different parts of the body. Credible side effects incorporate dependency, unusual death, delayed hack, unexplained weight reduction, and solid spill adjustment. While these side effects may occur, they may have different causes. More than 100 types of tumors affect humans.

Tobacco use represents about 22% of growth. Another 10% is due to mobility, less than stellar eating, lack of physical activity, and unwise drinking. The various elements include certain impurities, the representation of ionizing radiation and poisons in the environment. On stage, nearly 20% of malignancies are due to diseases as an example hepatitis B, hepatitis C and human papillomavirus infection. In any case, these

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elements are basically a demonstration by changing the qualities of the cell. Usually, many inheritance changes are needed before growth can be created. About 5-10% of the growth is due to inherited deformities acquired by human beings. Malignancy can be identified by specific signs and side effects or screening tests. It is usually then scanned with restorative images and determined by biopsy.

In 2015, regarding 90.5 million people suffered from cancer. About 14.1 million new cases occur annually (excluding skin malignancy nevertheless melanoma). It caused about 8.8 million steps (15.7% of the past). The foremost common sorts of growth in males are lung malignancy, prostate disease, colorectal cancer, and stomach malignancy. In women, the most recognized writings are breast disease, colorectal malignancy, lung growth and cervical growth. If skin growth other than melanoma has been incorporated to feature new diseases each year, it represents about 40% of cases. In children, severe lymphocytic leukemia and brain tumors are a lot of basic with the exception of continent wherever non-Hodgkins lymphoma happens a lot of frequently. In 2012, regarding 165,000 children underneath the age of fifteen were determined to possess a tumor. The danger of growth will increase essentially with age and plenty of tumors occur more regularly in developed countries. [11] Fees are increasing as more people live to maturity and as life changes occur within the growth scene. Expenses regarding the disease are calculable at $ 1.16 trillion annually since 2010.

1.1 Introduction to Artificial intelligence

Man-made cerebral forces (AI, as well as car understanding, MI) is knowledge acquired by machines that are familiar to people with normal knowledge (NI), which have been shown by different creatures. In the software, the AI scene is described as a "smart operator" study: any gadget sees its position and performs actions that increase the risk of achieving a specific goal. The phrase "computer thinking" is added when the machine is describing the "subjective" features associated with other people, such as "learn" and "solve the problem". See Glossary of Brain Artificial Power. The degree of AI is debated: as progressive expertise is displayed for machines, commands deemed to require "insight" are regularly dropped from the definition, a wonder known as AI influence, which prompts the joke "AI is all not done." For example, optical character recognition as often as possible is forbidden from "counterfeit consciousness", becoming a routine technology. Generally referred to as AI capabilities starting in 2017 include effective understanding of human speech, bidding abnormally in vital routing frameworks (e.g., chess and Go), independent cars, smart routing in content transfer systems, military renewals, and decryption of complex information, including pictures and shots.

1.2 Detection using ANN ART 1 Network

ART 1 network needs to emerge to control the similarity index of patterns or grouping of patterns in the same cluster. Weight vector can be the factor that helps in finding the similarity in the context of using input vector difference. In the concept, the network is trained by feeding output as input in multiple epoc. Patterns for the first time be placed in one cluster unit and later can be presented on a different cluster. The network which is stabilized ideally should not return the pattern to an earlier cluster. Stability can be achieved by reducing the rate of learning since refeeding pattern itself does not help the network to learn fastly.

The ability of the network to recognize and learn the new pattern well at any of stage is called plasticity. Art 1 nets are programmed to be both stable and plastic.

1.3 ART Processing Methods

There are three-phase ways to process classification.

A. **Recognition Phase**

In this phase, all the components of vector X are set to 0 zero. In this phase, recognition is done based on the dot product and weight of the neuron. Each neuron has the weight, so the perfect match the input vector computes the dot product of the input vector, and weight wins the competition and fires inhibiting. All other output from this ART layer stores the set of patterns in the weight associated with the recognition layer neuron one for each classification category.

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B. **Comparison Phase**

The input vector recognized in step 1 is then again passed back to the comparison layer. Now as per the two-third rule, the input vector x and p from the recognition phase generates the output. If any difference detected or mismatch occurs between x and p few neurons in the comparison layer will fire while x contains over. The overall step of passing output as input is repeated until a degree of similarity is less as compared to the vigilance parameter. And as the condition matches the rule network weight is reset to 0 to make disable the input vector for the scope of the current classification loop.

C. **Search Phase**

This step goes until no matching pattern is found. In this case, the output pattern generated is then fed to generate a new pattern. Now after continuing this searching phase, a condition arrives when no signal for disabling input is generated, and in this situation, the classification process is supposed to be is finished. This process repeats, only when any of the below conditions match.

1.4 Objective of Dissertation:

The dissertation objective is to classify the group as per highly level of accuracy by training different train test ratios by using the proposed weight updating solution

2. LITERATURE REVIEW

2.1 Introduction

In this chapter we start by reviewing the descriptive learning model of Neural Network (NNs), historical evolutions in learning of Neural Networks(NNs),learning algorithms in Neural Network and their tasks, data mining techniques with ANN are using to improve the accuracy and relevancy of the data. We then review work implemented on algorithm for the purpose of research and result for pattern classification on Medical Dataset. Next, we cover work regarding the use of distance in distance retrieval. Finally, we review ANN algorithms for pattern classification.

2.2 Fundamental Models of Artificial Neural Network

Development of neural network was started with the development of most famous model **McCullochPitts model** and learning in the network system was first introduced by Hebbs known as "**Hebbian Learning Rule**" and these model were considered as most prilimary model .[1]

2.2.1: Mc- Cullous-Pitts Neuron Model :

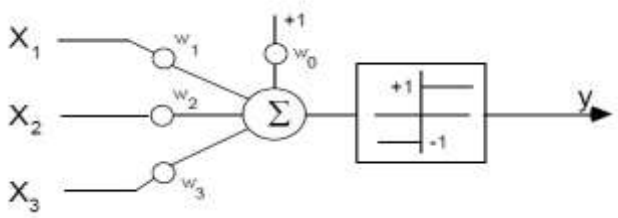

Fig 2.1 Architecture of McCulloch-Pitts Neuron.

[Courtesy: Hagan, M.T., Demuth, et. al., "Neural network design."]

The most commonly and popularly used neuron model is based on McCulloch and Pitts' work. This model allows binary 0 and 1 state. In this model neuron are connected by weighted path. This weighted path can be excitatory or inhibitory. Excitatory connected path is path having positive value and Inhibitory connected path is path having negative value. The neurons in this model are connected to threshold value [2].

In above diagram shown Y is a McCulloch-Pitts Neuron, which receive signal from any other neuron. Neurons having connections weight ware excitatory and connections weight on neurons from x_n to x_{n+m} are inhibitory as denoted by -p. Then Y has the activation function $f(y_m) = 1$ if $y_{-in} \geq \geq \Omega$, $f(y_m) = 0$ if $y_{-in} < \Omega$

2.2.2: Multilayer Perceptron Learning Rule

Learning is a process by which neural network inherits the knowledge and use this knowledge for making decision. For the solution of a specific problem, we have some learning rule. These rules called **learning algorithm.** [3]

A. **Hebbian Learning Rule:** This is also called correlation learning. As name, this rule states that if two neurons are activated simultaneously or asynchronously, then strength of that joint is increased or weakened[3].

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B. **Perceptron Learning Rule:** The Perceptron learning rule converges if the two classes can be separated by the linear hyperplane. However, if the classes cannot be separated perfectly by a linear classifier, it could give rise to errors. **Delta Learning Rule:** Role of Delta learning rule is to update the weight of inputs.

$$\Delta W_{ij} = \eta (t_j - y_j) g'(h_i) x_i$$

where η is learning constant.

t_j is target neuron. y_j is the actual output. h_i is the weighted sum of neuron.

x_i is the i th input

C. **Competitive Learning Rule:** A unsupervised type of learning in which every node competes to respond to subset of input data. The 3 main keynotes of this rule are stated below [3]

a. A **set of neurons** that are same except for some randomly distributed synaptic weights, but some neurons respond differently as per according to weight parameter.

b. The threshold is provided on the weight/strength of each neuron.

A procedure which allows the neurons to take part in competition to respond to a given subset of inputs, such that only one output neuron per group is active at one time. The neuron that wins the competition is called a "winner-take-all" neuron [4].

D. **OutStar Learning Rule:** In this rule, the weight on node is equal to desired output for neurons associated to weight.

$$\Delta W_{ij} = c(d_j - w_{ij})$$

E. **Error Correction Learning Rule:** This learning rule compare the system output with expected output. The main feature of rule is to use an error for training the system. This algorithm aims to minimize the error at each training level. Error can be defined as difference between desired and system output [5].

$$e = d - y$$

F. **Boltzman Learning:** This is similar to error-correction learning algorithm. The only feature in this algorithm to take state of neuron with system output to compare with desired response of training [6].

G. **Memory Based Learning: Memory Based Learning (MBL)** work on the theory of making prediction for output by searching similarity index or similar points in the memory and if the point detected in the memory then it fits the local model of input vector to those points and prediction is based on the model [7].

2.3 Historical Development of Architectures and Algorithm

1. **1943-McCulloch and Pitts: First in 1943, McCulloch and Pitts** develop a model that allows binary status only. Binary state 1 denotes the binary activated state. This model work based on the concept of threshold value of neuron. In this model each neuron has a synaptic weight parameter on them. The neuron fires only when weight is greater than threshold value [9].
2. **1949-Hebb's book: After that Hebb's also** proposed a law stated as "if two neurons are found to be active simultaneously the strength of connections between the two neurons should be increased" [10].
3. **1958- Perceptron Networks: After a lap of 10 years,** Rossenblatt stated that "if two linearly separable classes are used to draw the patterns (vector) that are used to train the perceptron's, and then the perceptron algorithm converges and positions the decision surface in form of a hyper-plane between the two classes [11].
4. **1960- ADALINE: Widrow and Hoff introduces** the model for developing weight on neurons by a mathematical model. Motive behind the rule is to adjust the weight so as to reduce the difference between the netinput to the output and desired output [2].
5. **1972-Kohonen's Self-Organizing Maps (SOM):** This is the model after a long lag of 12 years widely used in recognition problems. There are many applications based on SOM. It represents the way in which the output layer can pick up the correlational structure in terms of spatial arrangements of units.[13]

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6. **1982-Jhon Hopfield's Network:** Again after 10 years, by using idea of energy functions and there uses in associative memory nets developed HopeField Net's. This model has a set of neurons with their corresponding set of unit delays, which result in the formation of a "multiple loop feedback system". [13].
7. **1985-86-Back propogation Networks (BPN):** Back propagation Network propagates the error information to the hidden units by means of a generalized delta rule. This network is characterised by feed-forward network and multilayer properties which is trained using the Back propagation algorithm [14].
8. **1988- Outstar learning-Counter-propagation Network (CPN):**
   Learning process in this network occurs for all the units in particular layer. They don't possess self-competition amongst each other. CRT is a feedforward Networks [14].
9. **1987- Adaptive Resonance Theory (ART)-** Feedback kind of network focus on design of both binary and continuous valued inputs. ART1 known for the design for binary and ART2 is known for the design of continuous valued input. [14] This was developed by **Carpenter and Grossberg**.
10. **1988-Radial Basis Function (RBF):** Broomhead and Lowe developed a model similar to Back Propogation Network (BPN) .[14]
11. **1990- Support Vector Machines (SVMs): Vapnik proposed SVM in 1990 which are** supervised learning algorithms which produce classification or regression functions as a result from a given set of labelled training datasets

2.3 Development of a Neural Network

Assuming that the preliminary steps of generic system development, such as determining information requirements, conducting a feasibility analysis, etc. have been completed successfully, the process for development of a Neural Network based system is given as follows:

Step No.	Description
1	Collection of data for testing and training purposes.
2	Segregate the collected data into different sets for training and testing activities.
3	Structure of network is defined accordingly.
4	Choose an appropriate algorithm for learning.
5	Determine the network parameters and corresponding values, initialize weights.
6	Convert the data into corresponding network inputs.
7	Begin the training and re-determine and re-assign the weight values for the interconnections.
8	Stop the training procedure and test the network.
9	Execution: Use the Neural Network with modified cases.

2.4 MATLAB

MATLAB, short for Matrix Laboratory, is a clear and versatile programming condition for a broad assortment of issues, for instance, signal taking care of, streamlining, coordinate programming, et cetera. The crucial MATLAB programming pack can be extended by using additional toolboxes.

Instances of this instrument stash are Signal Processing, Filter Design, Statistics, and Symbolic Mathematics. The whole documentation for MATLAB is open. There is also an uncommonly unique news amass for requests related to MATLAB, PC programming structure MATLAB is a deciphered vernacular. This recommends the source code isn't totaled yet rather interpreted in and. This is both a use and an obstacle. MATLAB grants straightforward numerical figuring and a view of results without the necessity for front-line and repetitive programming. The disadvantage is that it can be direct, especially when shocking programming hones are associated.

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extended by using an additional apparatus stash. There is in like manner a to a great degree dynamic newsgroup for requests related to MATLAB, PC programming structure MATLAB is an interpreted lingo. This induces the source code isn't gathered but instead interpreted in and. This is both inclination and damage. MATLAB licenses straightforward numerical computation and portrayal of results without the prerequisite for front-line and monotonous programming. The obstruction is that it can be direct, especially when shocking programming rehearses are associated. MATLAB is utilized as a part of a variety of routes by bunches of individuals in occupations you may not consider with regards to a math item. Truth be told, math is utilized as a part of ways that many individuals don't consider.

3. PROPOSED METHODOLOGY

3.1Problem Formation

ART networks are designed to allow a user to control the degree of similarity of structure on the homogeneous cluster. Since every input pattern is different from the previous one in similarity ratio. This similarity input pattern is determined by weight vectors for every cluster. As network training start, each pattern is presented many times, if the pattern presented is already present in a cluster then it is placed into the cluster else it is placed on a different cluster. The main feature of a stable network is it does not return the pattern to the previous cluster. The key to achieving stability is to decrease the learning rate but changing learning rate does not allow the network to learn a new pattern immediately or readily which is presented the first time or occur after several training epochs. The ability of a network to adapt and learn new patterns readily at any stage of learning is called Plasticity. The problem is experimented with using pattern classification on Cancer dataset obtained from UCI learning repository. In this problem each and every unit, vector lines in a pattern of class or do not lie in the class pattern. To experiment with ART with modified weight, we have assumed a dataset of training patterns and a known number of correct classifications.

3.2ART Methodology

ART network uses two sorts of learning: Fast and Slow. In fast learning, weight updation is done relative to the length of the pattern is presented at the time of resonance in this way equilibrium condition matched for input vector on each trial in the fast learning mode.

In the slow learning mode, the load changes slowly in context to its learning rate and his is the reason for equilibrium fail in this type of mode. It does not mean that no weight updation is done but weight updation is done based on fewer calculations with a very low learning rate. While in fast learning, not reset is done and network becomes stable when found similarity pattern. ART 1 network uses fast learning feature of weight updation as patterns input are binary in nature and weight stabilize with fast mode

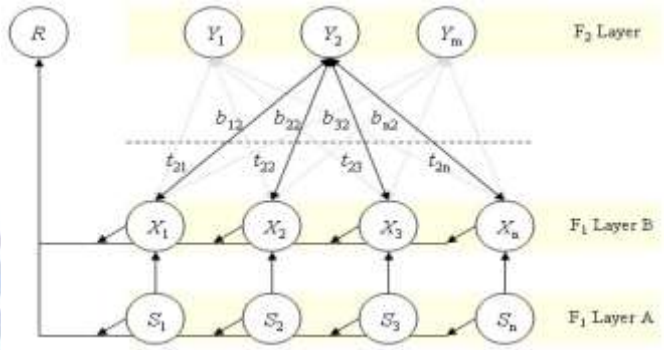

Fig 3.1. ART training

ART1 do its learning in an unsupervised way and make clusters of a binary vector. The main feature of ART algorithm it provides more control to user over the similarity patterns of the same cluster.

The stabilization phase occure in ART1 when no pattern is return to its previous cluster. Reducing learning rate can also cause network to achieve stability. This cause to slow the learning or training speed of network that is presented after many training epho.

The fundamental structure of an ART1 network includes following – An input processor field which is known as F1 layer have 2 parts –

An input & Interface portion (F1(a), F 2 (b) respectively.

The cluster unit(F2)

A method which can handle the similarity index of patterns that resides on same cluster.

Reset option for disabled input vector Weighted condition (bottom up, top down) between F1 and F2

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F_1(b), aggregate the input signals and the F_2 layer use to compare the similarity of the input signal to the weight vector for the cluster unit that has been selected as a candidate for learning.

There are two sets of input vectors having their weights between each unit in the interface portion of the input field and the cluster unit.

All the layers F_1 and F_2 are connected to each other in bottom-up and top-down relation.

The layer with interface property is a competitive layer:

The node to train is decided by its network input and becomes a candidate to learn .and then other units are set to. The interface units, F_1(b), merge the signal by combining cluster unit and input. The decision to find the next step is taken based on the similarity between its topdown weight vector with the input vector. The next step can be to reset input or feeding output as input as per condition s discussed above on ART.

If the cluster unit isn't allowed to find out, it's inhibited, and a replacement cluster unit is chosen because of the candidate vector. If a cluster unit is allowed to find out, it's said to classify a pattern class.

There is also a possibility of a tie situation for the winning neuron within the interface F2 layer and in this situation, winner is decided based on arbitrary rule by searching for primary among search parameters.

A short term memory pattern is generate between input and interface layer during the operation of an ART1 net.

3.3 ART Training Steps

1. Parameters initialization.
2. Apply steps 3 to 10 when the stopping condition is false.
3. For each step vector do steps 4-9.
4. F_1 layer process starts.
5. Apply steps 6 to 8 While the reset condition is true.
6. Find a unit to learn current input patterns i.e F_2 unit with the largest input.
7. F_1 (b) units combine their input from F_1 and F_2.
8. Test for reset condition.

IF reset is true, then the current candidate's unit is rejected. Return to 5th Step.

IF reset is false, then the current candidate unit is accepted for learning, then do step.

9. Learning start and weight updation occurs as per the differential equations.

$$Wij = \frac{Lxi}{1+|x|}$$

where L = learning rate, xi = activation vector

10. Test for stopping conditions.

ART 1 network does not require pattern similarities between same order.

3.3 Data Representation Schemes

The data to be tested is present in the form of analog values ranging from 0-10. While testing for data, a given set of patient data are converted to their equivalent digital form. Scaling has the advantage of mapping the desired range of variables ranging between a minimum and maximum range of network input.

3.4 Digital Conversion

Before feeding data for test, data is converted to its binary form. There are 10 attributes (1 class category and 9 numeric features). The 9 numerical attributes are in analog form scaled in the range between 0 and 1. In step 1. New Value = (current value-Min value)/ (Max value –Min value)

The new value obtained after truncating are converted into binary form by the following scaling. Grouping is done on the basis range, the value in the range of 0-5 is assigned as 0, and values between 5-10 are assigned as 1. These attributes can be feed to the NN tool for training and testing.

3.5 Data Description

This dataset was obtained from the UCI learning repository. The data set contained 699 number of instances as total, out of them 16 are with missing attributes values removed from the database, leaving 683 instances. The dataset also has 11 attributes out of them one is a class attribute and the class instance has two possible value benign (458) or malignant (241) instances. The obtained dataset is limited as it does not

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have enough instances so 100% accuracy can't be achieved.

Table 3.1 Attributes of Cancer Dataset

SNO	PARAMETERS(Cancer Dataset)	
	Parameter Name	***Value***
1	Sample code number	Numeric
2	Clump thickness	Numeric
3	Uniformity of cell size	Numeric
4	Uniformity of cell shape	Numeric
5	Marginal adhesion	Numeric
6	Bare nuclei	Numeric
7	Bland chromatin	Numeric
8	Normal nucleoi	Numeric
9	Mitosis	Numeric
10	Class	2,4

4. RESULT ANALYSIS

4.1 Algorithm Execution using Modified Weight Formula

In this section we have shown the simulation and analyse of above experimental analysis.

Here we have use 0.4 as value of alpha also called as Vigilance Parameter.

Table 4.1 Comparison result of Conventional ART model

Training Vector	Tessting Vector	Training Time	Efficiency
10	90	0.76	45.2
20	80	0.70	45.5
30	70	1.11	46.0
40	60	1.86	48.7
50	50	1.81	52.0
60	40	2.24	52.0
70	30	3.00	53.3
80	20	3.05	51.0
90	10	4.22	**56.0**

Table 4.2 Comparison result of Modified ART model

Training Vector	Tessting Vector	Training Time	Efficiency
10	90	0.76	50.0
20	80	0.70	68.4
30	70	1.11	51.0
40	60	1.86	53.3
50	50	1.81	54.8
60	40	2.24	55.3
70	30	3.00	56.3
80	20	3.05	54.0
90	10	4.22	**57.0**

4.2 Artificial Neural Network MATLAB Tool Experimental Analysis

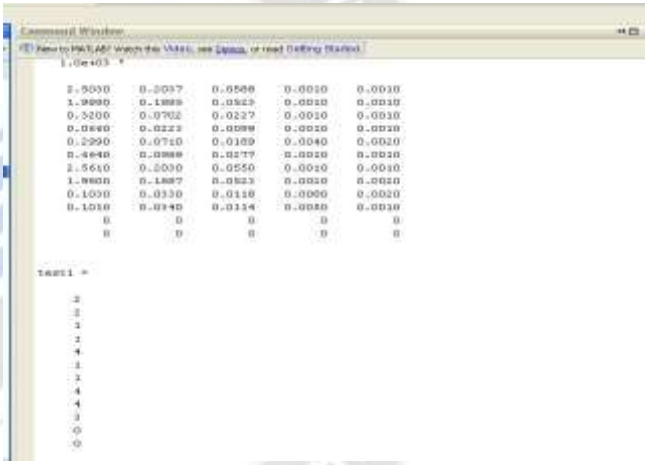

Fig 4.1 ANN MATLAB Data

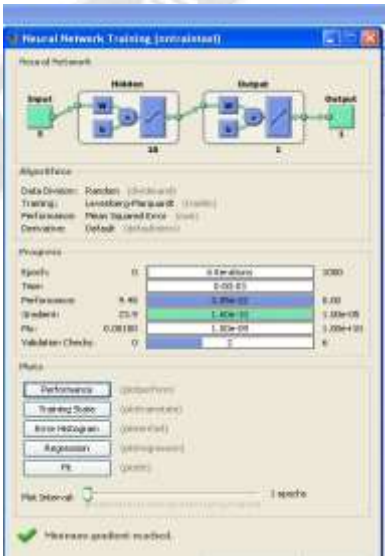

Fig 4.2 ANN Neural Network Training

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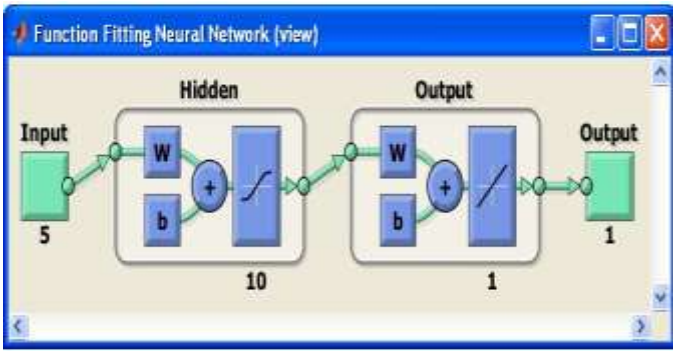

Fig 4.3 Function Filtring Neural Network

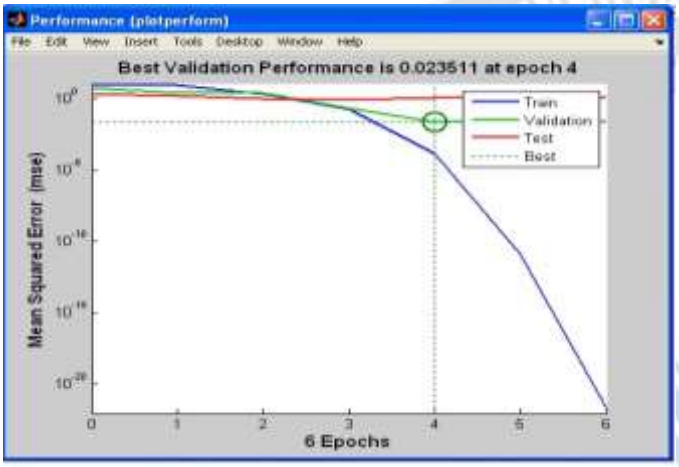

Fig 4.4 Performance Plot Of ANN

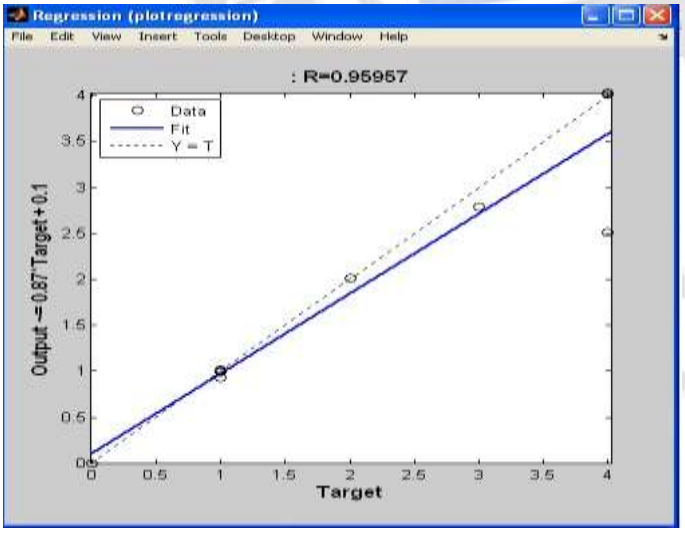

Fig 4.5 Plot Regression

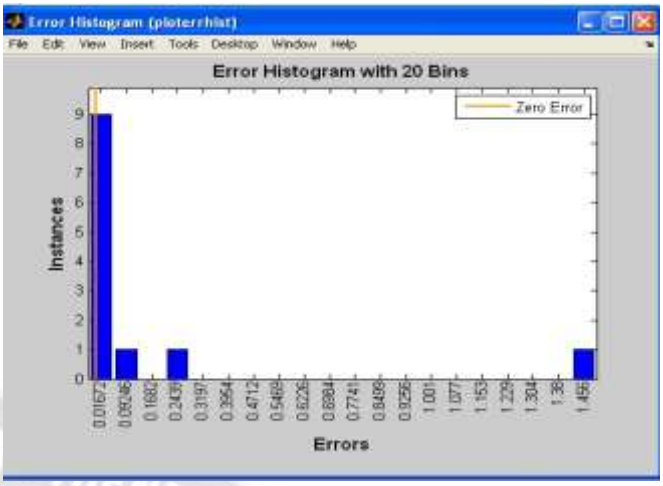

Fig 4.6 Error Histogram

5. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

Classification of a group for cancer dataset using artificial intelligence ART network. is implemented and modified in this dissertation. This experiment has been completed based on high-level accuracy on a different training-testing ratio. Changing the weight updation technique in standard ART technique gives better results as compared to the old weight updation theory as provided with ART. This modified algorithm proves to be a better tool to check. An artificial neural network is trained using parameters such as average area, clump thickness cell size, etc. The resultant neural network is highly efficient & can be concluded that ART 1 with the proposed change in weight updation is the best suited for pattern classification.

5.2 Future scope

Further development can be obtained by more training patterns that will provide high-level accuracy. The existing simulation performed in the thesis is for pattern classification of breast cancer data using ART1 learning and testing algorithm.

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