International Journal of Engineering Research and Development
e-ISSN: 2278-067X, **p**-ISSN : 2278-800X, www.ijerd.com
Volume 4, Issue 9 (November 2012), PP. 43-46

Pattern Recognition System using MLP Neural Networks

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Abstract :- Many machine vision researchers are working on the area of pattern recognition, a wide variety of approaches have been proposed to attempt to achieve the recognition system. These approaches generally fall into two categories: statistical method and syntactic method. MLP is an ideal means of tackling whole range of difficult tasks in pattern recognition and regression because of its highly adaptable non-linear structure. The trend of using multi-layer perceptron neural network for the solution of pattern recognition problem is understandable due to their capacity to accommodate the nature of human brain learning capacity, and the fact that their structure can be formulated mathematically. The learning process takes place through adjustment of weight connections between the input and hidden layers and between the hidden and output layers. The number of output nodes in the proposed work are circle, half circle, equilateral triangle, square and hexagon and the number of nodes in the hidden layer are chosen based on trial and error method. The different parameters like mean radius, Standard Deviation of Radii, Normalized Area, Perimeter, Mean of Max. Radii & Mean of Min Radii are considered to check the effectiveness of the proposed algorithm.

I. INTRODUCTION

Layered neural networks involve a set of input cells connected to a collection of output cells by means of one or more layers of modifiable intermediate connections [1]. The most natural use of this architecture is to implement associatively by associating an input pattern, the representation of a concept or a situation, with another item, either of the same kind or totally different. For this reason, networks with multiple layers are described as associative networks. Pattern recognition is the primary use of this mechanism. Pattern recognition is a popular application in that it enables the full set of human perceptions to be acquired by a machine. In the context of image processing, the different stages are: acquisition, concern with digitizing the data coming from a sensor such as camera or scanner, localizing, which involves extracting the object from its background, and representation. Some features are extracted from the input pattern and that becomes the input to neural network. The final stage, the decision stage, consists of dividing the set of object representations into number of classes. The last two phases, representation and decision, are the associative phases. Layered neural networks can play a part in each of these phases.

II. BRIEF LITERATURE SURVEY

Multilayer Feed-forward Neural Networks (MFNNs) is an ideal means of tackling a whole range of difficult tasks in pattern recognition and regression because of its highly adaptable non-linear structure. The trend of using multi-layer perceptron neural network [1] for the solution of pattern recognition problem is understandable due to their capacity to accommodate the nature of human brain learning capacity, and the fact that their structure can be formulated mathematically. The functionality of the topology of the MLP is determined by a learning algorithm able to modify the parameters of the net. The algorithm of back propagation, based on the method of steepest descent [4] in the process of upgrading the connection weights, is the most commonly used by the scientific community. Multi-Layer Perceptrons (MLP) are fully connected feed forward nets with one or more layers of nodes between the input and the output nodes. Each layer is composed of one or more artificial neurons in parallel.

III. FEATURE EXTRACTION

Feature extraction is a process of studying and deriving useful information from the input patterns. In image recognition, the extracted features contain information about statistical parameters and are computed about the centre of gravity of input pattern. The statistical parameters used in neural network training process are: Perimeter, Area, Maximum and Minimum radii in each quadrant, Intercepts on axes, Mean Radius, Standard Deviation and Figure Aspect. All the parameters discussed here are normalized with respect to the mean radius. The normalization step make the parameters size independent. The statistical parameters so computed above are also made rotation independent using the orthogonal transformation of the coordinates.

IV. METHODOLOGY

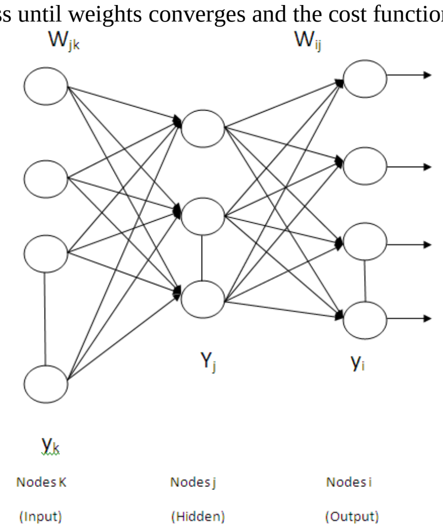
An input pattern is presented to the first stage of the forward paths, the input layer K, which consists of a two-dimensional array of receptor cells. The second stage of forward paths is called the hidden layer J. The third stage of the forward paths is the recognition layer I as shown in below figure. After the process of learning ends, the final result of the pattern recognition shows- in the response of the cells of FA. Let x1,x2,…,xn be the input signals and w1, w2, w3, ,…, wn be the synaptic weights, and u the activation potential, & the threshold and y the output signal and f the activation function:

$$u = \sum_{i=1}^{N} w_i \, x_i$$

MLP learn through an iterative process of adjustments applied to their free parameters. The most common learning algorithms are the standard back-propagation and faster-learning variations . They use a gradient search technique to minimize a cost function equal to the mean square error (MSE) between the desired and the actual net outputs.

$$MSE = \frac{1}{l} \sum_{i=1}^{l} (y_i - \hat{y}_i)^2$$

The net is trained by initially selecting small random weights and internal thresholds, and presenting all training data repeatedly. Weights are adjusted after every trial using
Information specifying the correct class until weights converges and the cost function is reduced to an acceptable value.



Typical Architecture of a MLP Neural Network System

V. EXPERIMENT

The learning process takes place through adjustment of weight connections between the input and hidden layers and between the hidden and output layers. The number of input nodes at the input layer was set at 17 according to the statistical features discussed in section II. Followings are the input nodes:

1. Mean Radius
2. Standard Deviation of Radii
3. Normalized Area
4. Perimeter
5. Mean of Max. Radii
6. Mean of Min Radii

The number of output nodes in this study was set at 6 as circle, half circle, equilateral triangle, square and hexagon. The number of nodes in the hidden layer was chosen based on trial and error. Each pattern presentation is tagged with its respective label as shown in below table. The maximum value in each row (0.9) identifies the corresponding node expected to secure the highest output for a pattern to be considered correctly classified. The output values are denoted as O_1, O_2, O_3, O_4, O_5 and O_6.

Target Class	Des.	Nodes					
		1	2	3	4	5	6
1	Square	0.9	0.1	0.1	0.1	0.1	0.1
2	Circle	0.1	0.9	0.1	0.1	0.1	0.1
3	Half Circle	0.1	0.1	0.9	0.1	0.1	0.1
4	Eq. Triangle	0.1	0.1	0.1	0.9	0.1	0.1
5	Reg. Hexagon	0.1	0.1	0.1	0.1	0.9	0.1
6	Reg. Pentagon	0.1	0.1	0.1	0.1	0.1	0.9

The activation functions used were hyperbolic tangent for the hidden layer and sigmoid for the output layer. The hyperbolic tangent function is given by:

$$f(x) = e^x - e^{-x}/e^x + e^{-x}$$

The sigmoid function is given by:

$$f(x) = 1/1 + e^{-x}$$

The input node parameters are normalized to the level [0, 1]. 30 no. of patterns (5 from each category) data sets are used to train the NN with a target of MSE < 0.01 as acceptable criteria for stopping of the training process.

VI. RESULTS

The NN is trained using the ANN tool box in MATLAB. The set of statistical parameters used are extracted using the feature extraction process. Table-2 gives the set of parameters for the respective shapes. Following results are obtained after the training is complete and new test pattern data sets are provided for testing of the classifier:

Target Class	Percentage Correct Classification	MSE
1 - Square	96.78	0.0099
2 - Circle	97.45	0.0098
3 – Half Circle	98.34	0.0101
4 – Eq. Triangle	96.64	0.0090
5 – Reg. Hexagon	97.34	0.0092
6 – Reg. Pentagon	98.56	0.0097

VII. CONCLUSION

Pattern recognition can be done both in normal computers and neural networks. Computers use conventional arithmetic algorithms to detect whether the given pattern matches an existing one. It is a straight forward method. It will say either yes or no. It does not tolerate noisy patterns. On the other hand, neural networks can tolerate noise and, if trained properly, will respond correctly for unknown patterns. Neural networks may not perform miracles, but if constructed with the proper architecture and trained correctly with good data, they will give amazing results, not only in pattern recognition but also in other scientific and commercial applications.

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Table - 2 for Input Statistical Parameters

S.No.	Parameters	Circle	Square	Semi-Circle	Reg. Hexagon	Eq. Triangle	Reg. Pentagon
1	Perimeter	6.28	7	6.49	6	7	6.13
2	Area	3.14	1	0.12	3.14	2.8	3.20
3	Mean Radius	1.00	1.0	1.00	1.0	1.0	1.00
4	Standard Deviation	0.00	0.25	0.43	0.15	0.35	0.20
5	Figure Aspect	1.00	1	0.56	1	1.50	1.00
6	Max R1	1.00	1.25	1.20	1.15	1.5	1.20
7	Max R2	1.00	1.25	1.20	1.15	1.5	1.20
8	Max R3	1.00	1.25	1.47	1.15	1.4	1.12
9	Max R4	1.00	1.25	1.46	1.15	1.4	1.12
10	Mean of Max R	1.00	1.25	1.33	1.15	1.45	1.15
11	Min R1	1.00	0.85	0.74	0.90	0.7	0.90
12	Min R2	1.00	0.85	0.74	0.90	0.7	0.89
13	Min R3	1.00	0.85	0.59	0.90	0.8	0.86
14	Min R4	1.00	0.85	0.59	0.90	0.8	0.86
15	Mean of Min R	1.00	0.85	0.67	0.90	0.75	0.88
16	Intercept on +ve X-Axis	1.00	0.90	1.20	1.0	0.8	1.02
17	Intercept on -ve X-Axis	1.00	0.90	1.20	1.0	0.8	1.02
18	Intercept on +ve Y-Axis	1.00	0.90	0.76	1.0	1.5	1.06
19	Intercept on -ve Y-Axis	1.00	0.90	0.59	1.0	0.8	0.86