Image Texture Classification Using Artificial Neural Network (ANN)

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***Abstract*-Texture classification is an important and challenging factor in image processing system which refers to the process of partitioning a digital image into multiple constituent segments. The goal of segmentation is to simplify and / or change the representation of an image into something that is more meaningful and easier to analyze. Artificial Neural Network (ANN) Based texture classification or Segmentation is an advanced technique providing rich information of an image of interest. As a part the work, an ANN is implemented to segment the image. For that a particular type of ANN is configured and trained so that it becomes capable of segmenting an image. The current work deals with a task where an object of interest is to be segmented out of a background for processes which can be carried out as part of extended applications.**

Keywords: ANN, MLP, MSE, Pixel, Gray level.

I. INTRODUCTION

IMAGE segmentation is an essential preliminary step in most automatic pictorial pattern recognition and scene analysis problems. Segmentation of an image is in practice the classification of each image pixel to one of the image parts. Image segmentation has been the subject of considerable research activity over the last three decades. The goal of image segmentation is to cluster pixels into salient image regions, i.e. regions corresponding to individual surfaces, objects, or natural parts of objects [1] [2]. Image texture classification or segmentation is typically used to locate objects of interest and boundaries like lines, curves in an image. Segmentation of an image into a small number of component objects allows vision algorithms to process the information coming from each of the objects in the scene separately, while ignoring noise introduced by other objects and the background. For model-based object recognition, correctly segmenting an image into component objects greatly reduces the number of hypothesized object / pose correspondences that must be tried to determine which objects are present in the scene [2][3]. This work is related to the formulation of a system based on Artificial Neural Network (ANN) such that images are classified into two broad areas- first the area of interest and the other the background. Some of the relevant works are:

1. A. Osareh, M. Mirmehdi, B. Thomas and R. Markhamb introduced an automatic method for the detection of exudate regions comprising image colour normalisation, enhancing the contrast between the objects and background. The work deals with segmentation of colour retinal image into homogenous regions using Fuzzy C-Means clustering. [4].

2. T. Logeswari and M. Karnan worked on a segmentation method consisting of two phases. In the first phase, the MRI brain image is acquired from patients' database.

   In that film, artifact and noise are removed and after that HSOM is applied for image segmentation [5].

3. M. Spanel and P. Krsek proposed a vector segmentation algorithm based on an adaptive Delaunay triangulation to divide an image into several non- overlapping regions whose characteristics are similar. [6].

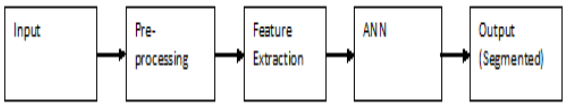

Fig.1: A generic ANN classifier based segmentation system

4. Mrs. Ashwini, T. Sapkal, Mr. C. Bokhare and Mr. N. Z. Tarapore worked on K-means Algorithm and BP Algorithm of ANN for Segmentation and Classification of Satellite images. Wide database of images has been used to test both the algorithms. The paper also shows the comparison of the results obtained by implementing both algorithms [7].

5. D. Davis, S. Linying, and B. Sharp showed how to separate the thigh figure from the background of the X-ray film, to separate hard tissue (bone) from the thigh figure and then to identify irregularities where present. Network typologies investigated include Back Propagation (BP), Counter Propagation (CP), Self-Organizing Feature Map (SOFM) [8] and Bi-directional Associative Memory (BAM) [8] [10].

II. PROBLEM DEFINITION

The work is related to image segmentation using ANN. The work involves collection of samples, pre-processing [9], feature extraction [9], design and training of the ANN and

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testing. Current work deals with separating a region of image from the background and retrieves the original background present. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as colour, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). The problem of carrying out segmentation using ANN is related to the classification

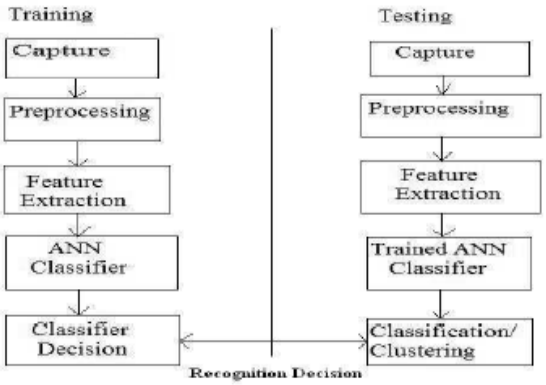

Fig.2: Process Logic Flow Diagram

of pixels as per certain properties similar in nature. A generic block diagram involving segmentation process carried out using an ANN is related to a block diagram depicted in figure 1. The components of the system are:

1. *Signal Capture:* Here an image of an object or a scene is captured by a digital camera or is scanned for use as the input to the system as shown figure 2.
2. *Pre-processing or image enhancement:* These are a series of steps which should be taken for making an image suitable for manipulation and interpretation by subsequent stages. The steps include removal of noise and variation of intensity recorded, sharpening, improving the contrast and strengt5ing the texture of the image. Another important aspect is image restoration which extracts image information from a degraded form to make it suitable for subsequent processing and interpretation.
3. *Feature Extraction:* The next block is the feature extraction. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. Feature extraction is a general term used for methods of constructing combinations of the variables to capture the most relevant details of a given input sample. The feature set provides a simplified and reduced yet necessary set of data through which a sample can be represented [9].

4. Configuration and Training of ANN:

The architecture of a feed forward ANN namely the Multi Layer Perceptron (MLP) [10] is based upon more than one layer of neurons which are also called perceptions.

A. Design Consideration of MLP

A MLP consists of several layers of neurons. The equation for output in a MLP with one hidden layer is given as []:

$$O_x = \beta_i\, g\,(([w]_i.[x]) + b_i)$$

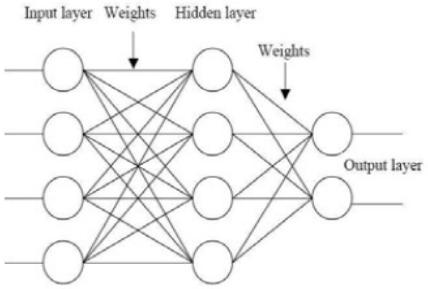

Fig. 3: MLP with one input, one hidden and one output layer

where β_i is the weight value between the i^{th} hidden neuron, [w] is the vector of weights between the input and the hidden layer, [x] is the vector of inputs and [b] is the input bias of the hidden neuron layer. Such a set up may be depicted as in figure 3. The process of adjusting the weights and biases of a perceptron or MLP is known as training. The perceptron algorithm (for training simple perceptrons) consists of comparing the output of the perceptron with an associated target value. The most common training algorithm for MLPs is error back propagation.

B. Application of Error Back Propagation for MLP training

The MLP is trained using (error) Back Propagation (BP) depending upon which the connecting weights between the layers are updated. This adaptive updating of the MLP is continued till the performance goal is met. Training the MLP is done in two broad passes -one a forward pass and the other a backward calculation with error determination and connecting weight updating in between. Batch training method is adopted as it accelerates the speed of training and the rate of convergence of the MSE to the desired value. The steps are as below [9]:

- **Initialization:** Initialize weight matrix W with random values between [0, 1]. W is a matrix of 1x451.
- **Presentation of training samples*:*** Input is

$$p_m = [p_{m1}, p_{m2}, \ldots \ldots p_{mL}].$$

The desired output is

$$d_m = [d_{m1}, d_{m2,} \ldots \ldots d_{mL}].$$

– Compute the values of the hidden nodes as:

$$net_{mj}^{h} = \sum_{i=1}^{L} w_{ji}^{h}\, p^{mi} + \emptyset_{j}^{h} \quad (1)$$

– Calculate the output from the hidden layer as

$$o_{mj}^{h} = f_{j}^{h}(net_{mj}^{h}) \quad (2)$$

where

$$f(x) = \frac{1}{e^{z}} \quad \text{or} \quad f(x) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}}$$

depending upon the choice of the activation function.

– Calculate the values of the output node as:

$$o_{mk}^{o} = f_{k}^{o}(net_{mj}^{o}) \quad (3)$$

- **Forward Computation**: Compute the errors:

$$e_{jn} = d_{jn} - o_{jn} \quad (4)$$

Calculate the mean square error (MSE) as:

$$MSE = \frac{\sum_{j=1}^{M}\sum_{n=1}^{L} e_{jn}^{2}}{2M} \quad (5)$$

An error term for the output layer is:

$$\delta_{mk}^{o} = o_{mk}^{o}(1 - o_{mk}^{o})e_{mn} \quad (6)$$

Error terms for the hidden layer:

$$\delta_{mk}^{h} = o_{mk}^{h}\left(1 - o_{mk}^{h}\right)\sum_{j} \delta_{mj}^{o} w_{jk}^{o} \quad (7)$$

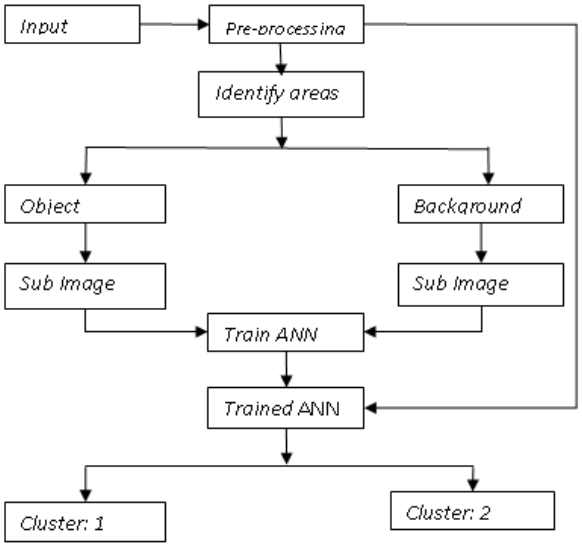

Fig. 4: System model

- **Weight Update:**

– Between the output and hidden layers

$$w_{kj}^{o}(t+1) = w_{kj}^{o}(t) + \eta\delta_{mk}^{o} o_{mj} \quad (8)$$

Where η is the learning rate ($0 < \eta < 1$). For faster convergence a momentum term (α) maybe added as

$$w_{kj}^{o}(t+1) = w_{kj}^{o}(t) + \eta\delta_{mk}^{o} o_{mj} + \alpha(w_{kj}^{o}(t+1) - w_{kj}) \quad (9)$$

– Between the hidden layer and input layer:

$$w_{ji}^{h}(t+1) = w_{ji}^{h}(t) + \eta\delta_{mj}^{h} p_{i} \quad (10)$$

A momentum term may be added as:

$$w_{ji}^{h}(t+1) = w_{ji}^{h}(t) + \eta\delta_{mj}^{h} p_{i} + \alpha(w_{ji}^{o}(t+1) - w_{ji}) \quad (11)$$

One cycle through the complete training set forms one epoch and the number of epochs are counted.

III. ALGORITHMIC STEPS OF PRESENT WORK

To work with the problem mentioned above the image is read into a matrix and small sub images of the image are sampled out. The sample images are used as training data for an ANN. The ANN is trained using the training data. The trained network is then tested on all parts of the image by sampling the entire image as small sub-images.

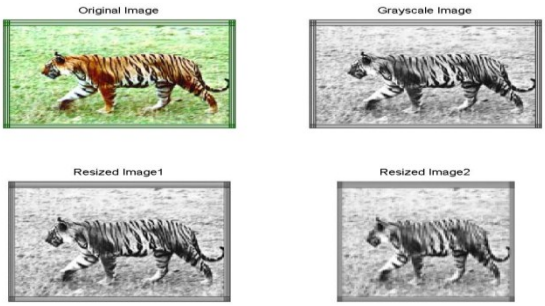

Fig.5:Pre-processed samples (A)

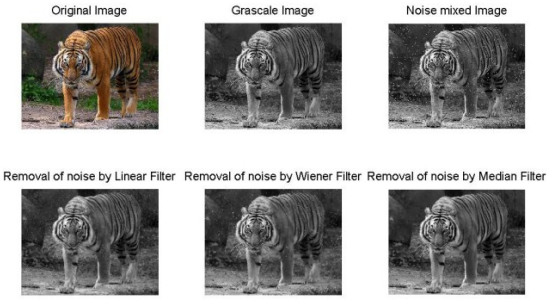

Fig 6: Pre-processed samples (B)

The algorithmic steps may be summarized as below:

1. Read an image and perform pre-processing.
2. Select the region of interest.
3. Two broad areas are identified- background and object. The ANN is configured to classify the inputs into these two areas only.
4. First, from the object form 5 x 5 sub-images. Use these sub-images to train the ANN.
5. Next from the background form 5 x 5 sub-images. Use these sub-images to train the ANN again.
6. Now when the complete image is applied to the trained ANN, the output shows the background and image separately.

The above is repeated for noise mixed inputs as well using the trained ANN.

IV. RESULT AND DISCUSSION

As part of the work, the some of the results are generated as depicted in figures 4 to 6. Figure 4 and figure 5 shows some pre-processing samples, while figure 6 shows the result of segmentation using threshold technique. The ANN used for the work has the parameters as shown in Table I. The training continues so as to attain the desired goal. After the training is over, the trained ANN groups the input pixels into the two clusters which provide the results. It generates the texture classification and segmentation of the applied image.

V. CONCLUSION

The work provides a framework of using ANN for texture classification and image segmentation. It can be applied for a range of areas like medical diagnosis, remote sensing, traffic control etc. The future direction of the work will to carry out an extended ANN based segmentation system capable of dealing with object extraction from complex background irrespective of colour and texture variations.

Fig.7: Segmentation of images

TABLE I. PARAMETER USED FOR TRAINING OF ANN CLASSIFIER

ANN type	MLP
Training Algorithm:	Back propagation
Number of Hidden Layers:	3
Activation Function:	Hidden layer: Tansig and Logsig;, Input Layer: Tansig; Output Layer: Logsig;
Learning Rate:	Between 0.3 to 0.9
Epochs:	Between 3000 and 5000;

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