Multilevel Approach for Color Image Segmentation

Kanchan Deshmukh
M.G.M's College of Sc. & IT,
Nanded
dkanchan_99@yahoo.com

Abhijeet Nandedkar
SGGS C.E.& T.
Nanded
avnandedkar@sggs.ac.in

Yeshwant Joshi
SGGS C.E.&T.
Nanded
yvjoshi@sggs.ac.in

Ganesh Shinde
Yeshwant Mahavidyalaya.
Nanded
shindegn@yahoo.co.in

Abstract

An adaptive neural network system for color image segmentation is proposed here. The system consists of a neural network that performs the segmentation using multilevel thresholding activation function. The supervised neural network used learns with help of back propagation algorithm. The system finds the threshold and target values for the segmentation based on the derivative of histogram of saturation intensity in the HSV color model. The main advantage of this method is that, it segments the color image without priori knowledge of the image.

1. Introduction

The color image segmentation is an important step in image analysis. To analyze the contents of an image, one needs to first locate and isolate objects in it. This process is referred as image segmentation [4][5]. Segmentation extracts the meaningful objects of the image. There are many methods for color image segmentation like histogram thresholding, clustering [3] [7] [10], region growing [1], contour based, region merging and splitting, edge flow [8] etc. Victor Boskovita and Hugo Guterman [2] proposed a multilevel approach for monochrome image segmentation. This algorithm segments the monochrome image without a priori knowledge. The number of clusters and object label are found out automatically by the system. Here we propose a method capable of segmenting the color images. The system is based on the same principle [2], with modification in finding the threshold and target values of a cluster [6]. The clusters are found automatically based upon the threshold and target values. The threshold and target values are used to construct an activation function of neuron. The error of the system is calculated and back propagated to change the weights of neural network. This process continues until a minimum error is achieved. The output of the system at this stage is a colored segmented image. One of the advantages of this method is that it does not require prior information about the number of clusters. The remainder of the paper is organized as follows.

Section II gives the detailed description of the proposed method. Section III presents some experimental results and section IV as conclusion.

2. Adaptive Neural Network System for Color Image Segmentation

The ANNSCIS (Adaptive Neural Network System for Color Image Segmentation) uses the HSV model for color image segmentation. The saturation and intensity planes are utilized for color image segmentation assuming that for a given colored object these are the two parameters that may vary but mainly hue value remains same.

2.1. System Flow

A general flowchart of the proposed method is depicted in Figure 1. The color image is represented in HSV model and is quantized with 256 levels in hue, saturation and intensity planes. Initially histograms of the saturation and intensity planes are found out and then the histograms are smoothed i.e. passed through a low pass filter. This removes the sharp transitions in the histogram. Here first order derivative of histogram is used to find the number of clusters in the saturation and intensity planes. Based on these, derivatives of histogram threshold and target values for each cluster are calculated. The multilevel sigmoid function, which is used as the neural network activation function, is designed using the thresholds and targets values known from the derivative of histogram. This is the most important step in the color image segmentation.

There are two independent neural networks dedicated to saturation and intensity planes. The normalized saturation and intensity values are propagated forward using (Equation 1) to get the output values of the network. The error is back propagated to update the weights (Equation 2). This training continues until a minimum error is achieved. The output of the system at this stage is a colored segmented image. The detailed working of the system is explained in the subsequent sections.

The proposed system consists of two main processing blocks as depicted in (Figure 2)

1) Adaptive threshold block (A).
2) Neural network (NN) Tuning block (B)

The adaptive thresholding block is responsible to find out the number of clusters and computation of multi-level sigmoid function for the neurons in the neural network.

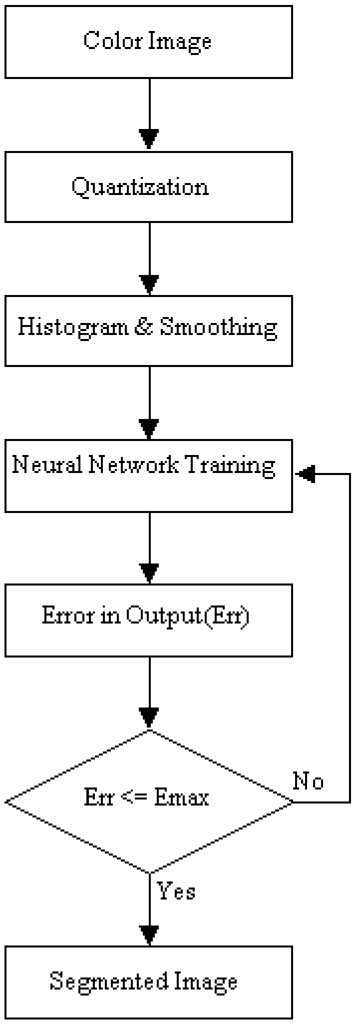


Figure 1: System flow

2.2. Adaptive threshold block

It is necessary to determine the number of clusters in an image so as to segment it properly. The main aim here is to find the number of clusters automatically without prior knowledge of the image. To do this, first the histograms of the given color image for saturation and intensity planes are found out. Consider the figure 5(a) as a simple example to understand the segmentation process. The synthetic image consists of four colored segments. Each segment is having same hue but variations in saturation and intensity. The figure 5(d), figure 6(b) shows the smoothed histograms in the two planes. Figure 5(e), figure 6(c) depicts the derivatives of the smoothed histograms. From the derivative of histogram we can find number of clusters easily in the respective planes, if we trace the transition points (zero crossing).

The first cluster is a region between the first –ve or zero to +ve transition and subsequent +ve to –ve transition. The threshold value is selected where –ve to +ve transition takes place and the target value is the average value of these two transition points. Threshold and target values are used to build a neural network activation function (Equation 1).

The neural network section consists of two independent networks one each for the saturation and intensity planes. The architecture of the network used here is same as in [2]. The neural network consists of three layers as input layer, hidden layer, and output layer (figure 3). The input to a neuron in the input layer is normalized between [0-1]. The output value of each neuron is in between [0-1]. Each layer is having a fixed number of neurons equal to number of pixels in the image. All the neurons are having the initial weight 1. Each neuron in one layer is connected to the respective neuron in previous layer in its d^{th} order neighborhood (figure4).

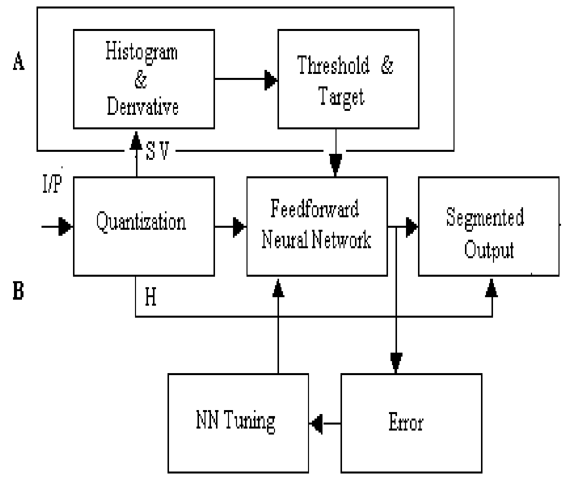


Figure 2: Block diagram of ANNSCIS

Activation function: It is a sigmoid function with a multiple levels. The neuron activation function is defined as [2].

$$f(x) = \sum_k \left(\frac{y_k - y_{k-1}}{1 + e^{-(x-\theta_k)/\theta_0}} + y_{k-1} \right) \times \left[\mu\left(x - y_{k-1} * d^2\right) - \mu\left(x - y_k * d^2\right) \right] \quad (1)$$

Where

μ step function;

θ_k thresholds;

y_k target level of each sigmoid, will constitute the system labels;

θ_0 steepness parameter;

d size of neighborhood

2.3. Neural network (NN) Tuning block:

At every training epoch, the error is calculated by taking the difference between actual output and desired output of neuron. Here desired output of the neuron is its target value. Once the error calculated, it is back propagated [9] to update the weights (equation 2). The aim of neural network system is to minimize the error to obtain a segmented image. This training process continues until a minimum error is achieved. The output of the network is colored segmented image.

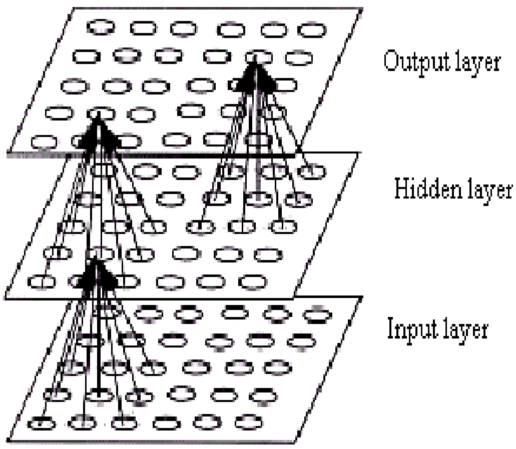


Figure 3: Neural network architecture

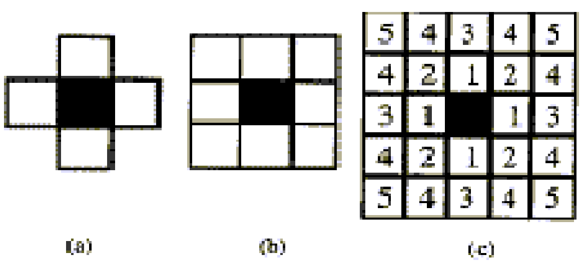


Figure 4: (a) First order neighborhood (b) Second order neighborhood (c) Sequence of neighborhood

Training: A back propagation algorithm [9] is used for training purpose. Error for a neuron is the difference between target value and the actual output. The weights are updated as follows.

$$\Delta wij = n\left(\frac{-\partial E}{\partial o_j}\right)\frac{\partial o_j}{\partial I_j}oi \qquad \text{output layer}$$

$$n\left(\sum k\left(-\frac{\partial E}{\partial o_k}\frac{\partial o_k}{\partial I_k}\omega kj\right)\right)\frac{\partial o_j}{\partial I_j}oi \qquad \text{other layer}$$

(2)

Where

Ii total input to the i^{th} neuron;

ωji weight of link from neuron I in one layer to neuron j in the next layer;

o_i output of the i^{th} neuron i in one layer to neuron j in the next layer;

E Error in the network's output;

n Learning rate;

As the training progresses a pixel gets the color depending upon its surrounding pixel colors. See the output image of example 1 where it can be noted that network tries to label a segment with an even color spread.

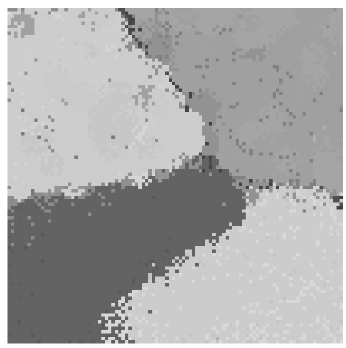


Figure 5(a): Original Image

Figure 5 (b): Output Image

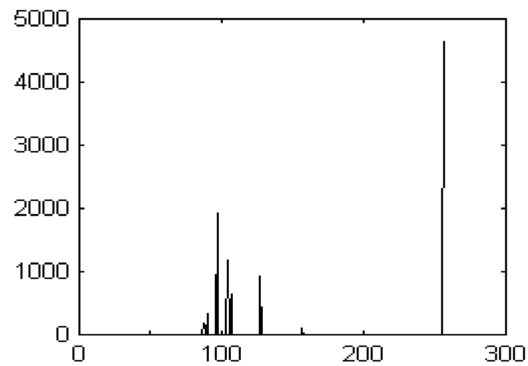


Figure 5 (c): Histogram of Saturation plane

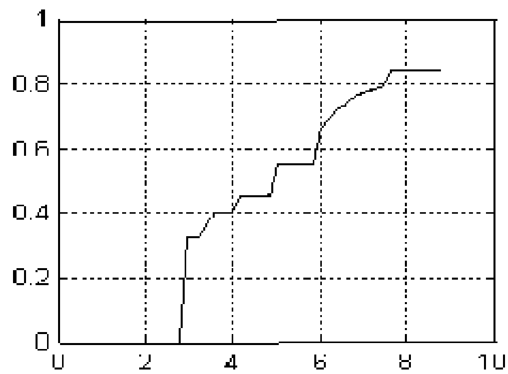


Figure 5 (f): Multisigmoid function.

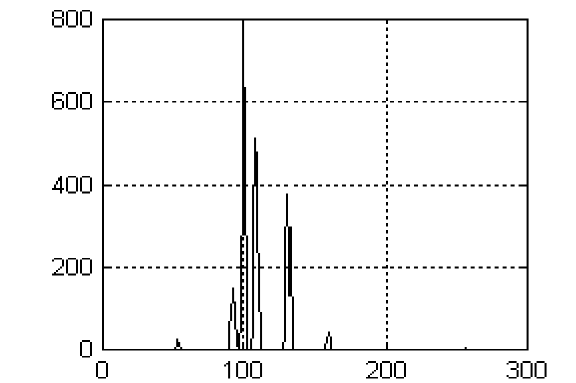


Figure5 (d): Smoothed Histogram of Saturation Plane

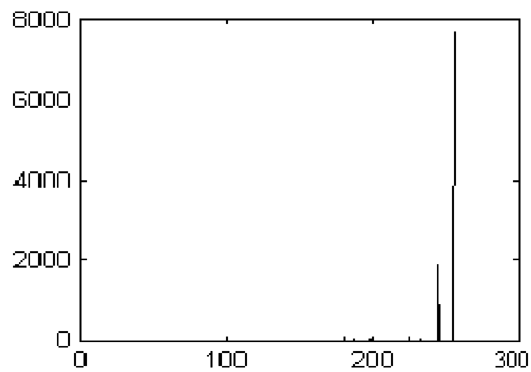


Figure 6: (a) Histogram of the image in intensity Plane

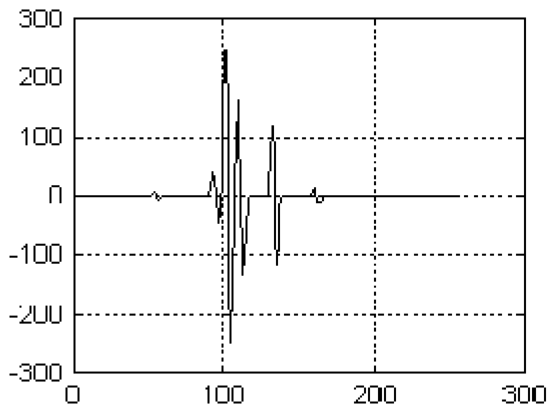


Figure 5(e): First order Derivative of figure 5(d)

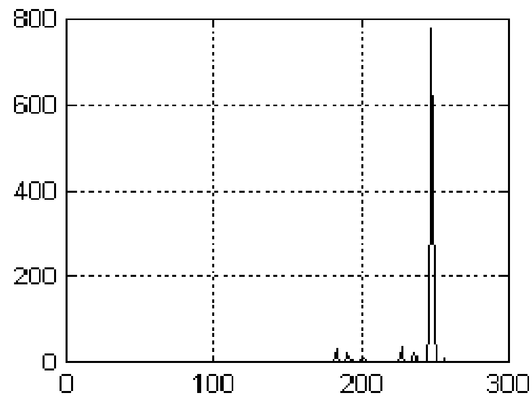


Figure 6 (b): Smoothed Histogram of Intensity Plane

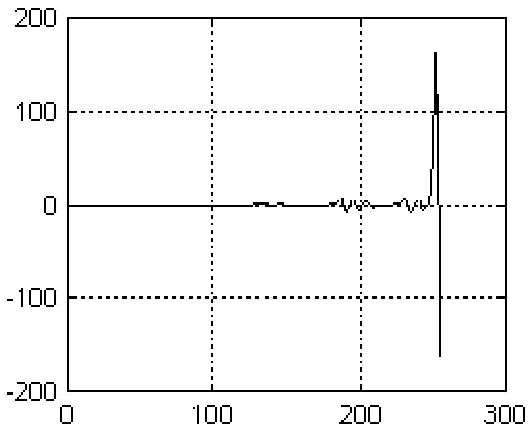


Figure 6 (c): Derivative of Histogram Figure 6(b)

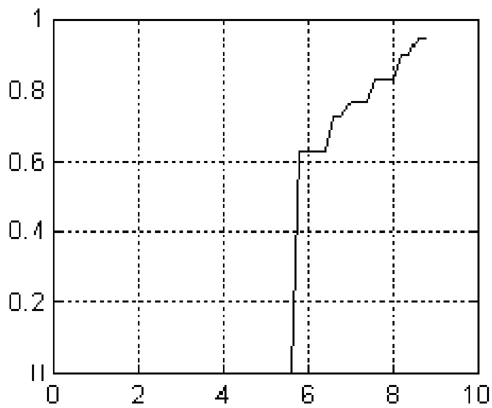


Figure 6 (d): Multisigmoid function for Intensity Plane

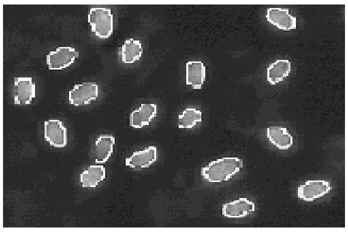
3. Experimental Results

To demonstrate performance of the proposed method the system was tested on several images of different types. The method uses a second order (3x3) neighborhood for neuron input connection scheme. A third order FIR filter with cutoff frequency 0.0001 was used to smooth the histogram. It can be observed that each color segment is labeled with an average color of it. These labels (color) are selected automatically by the system. The results after 3 epochs for different color images are shown in the figures (7-10).

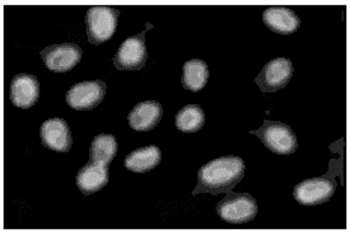
The system capability to label a segment with proper color can be seen from the figure 7(b). Note that the whitish edge around the bacteria are removed and are labeled with the color of bacteria. This capability can also be observed for the figures (5,8,9,10).

4. Conclusion

The clusters are found based on a multilevel threshold approach could segment the color image. One of the advantages of this method is that it doesn't require a priori information about the color image. The use of derivative of histogram is a powerful method to find cluster s in the image.



(a)



(b)

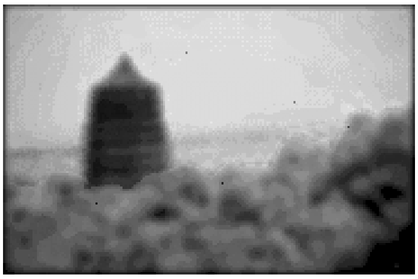
Fig.7 (a) original image, (b) Segmented image

(a)

(b)

Fig. 8 (a) Original image, (b) Segmented image

(a)



(b)

Fig. 9 (a) original image, (b) Segmented image

(a)

(b)

Fig. 10 (a) original image, (b) Segmented image

References

[1] Adams, R. and L. Bischof, *Seeded Region Growing.* IEEE Trans. Pattern Analysis and Machine Intelligence, 1994.16:p.641-647.

[2] Victor Boskovitz and Hugo Guterman, An Adaptive Neuro-fuzzy System for Automatic Image Segmentation and Edge Detection, IEEE Trans.Fuzzy Systems, vol.10, No.2, pp.247-262, April 2002.

[3] Chen, T.Q. and Y. Lu, *Color image Segmentation-An innovative approach*, pattern recognition, 2001.25:pages. 395-405

[4] Rafel C. Gonzalez and Richard E.Woods*, Digital* Image *Processing, Pearson* Education Pet. Ltd., New Delhi..

[5] Anil K. Jain*, Fundamentals of Digital Image Processing,* Prentic-Hall of India Pte.Ltd. New Delhi, 1995

[6] Suresh Kondabathula, A.V.Nandedkar, An adaptive neural network system for automatic image segmentation & edge detection, *M.E. dissertation, SGGSCE&T*, Nanded, India, 2003-2004

[7] P.Lambert1, H.Grecu2, A Quick And Coarse Color Image Segmentation, *International Conference on Image processing, ICIP2003*.

[8] Nevatia, Color Edge Detection And Its Use In Scene Segmentation. *IEEE Trans. System Man Cybernetics*, 1977.SMC-7 (11): pages 820-826

[9] Jacek M. Zurada, *Introduction to Artificial Neural Systems,* Jaico Publishing House, Mumbai, 2002

[10] Zhaqng, C. and P.Wang. A New Method Of Color Image Segmentation Based On Intensity and Hue Clustering. In *International Conference on Pattern Recognition (ICPR). 2000*:pages 613-616