Edge Detection Techniques for Image Segmentation

Priyanka A. Hajare
ME Student, Dept of CE, SIPNA's College of Engineering, Amravati (MS) INDIA
priyanka1hajare@gmail.com

Pritish A. Tijare
Assistant Professor, Dept of CSE, SIPNA's College of Engineering, Amravati (MS) INDIA
pritishtijare@rediffmail.co

ABSTRACT
The process of partitioning a digital image into multiple regions or sets of pixels is called image segmentation. Edge is a boundary between two homogeneous regions. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. In this paper, the main aim is to survey the theory of edge detection for image segmentation using soft computing approach based on the Fuzzy Min–Max Clustering, and Neural Network.

In this paper uses "Adaptive color image segmentation using fuzzy min-max clustering (ACISFMC)". ACISFMC uses a multilayer perceptron (MLP) like network which perform color image segmentation using multilevel thresholding. Threshold values used for finding clusters and their labels are found automatically using FMMN clustering technique. FMMN clustering technique uses a hyperbox fuzzy set concept. In the proposed work, Fuzzy entropy is used as a tool to decide number of clusters. ACISFMC uses saturation and intensity planes of HSV (hue, saturation, intensity) color space for segmentation. Here, neural network is used to find the number of objects automatically from an image. One of the good feature of this method is that, it does not require a priori knowledge to segment a color image.

Key words: Edge Detection, ACISFMC, FMMN

1 INTRODUCTION
Image Segmentation is the process of partitioning a digital image into multiple regions or sets of pixels. Actually, partitions are different objects in image which have the same texture or color. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. All of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics. Edge detection is one of the most frequently used techniques in digital image processing. The boundaries of object surfaces in a scene often lead to oriented localized changes in intensity of an image, called edges. Histogram thresholding is a popular technique that looks for the peaks and valleys in histogram. It assumes that images are composed of regions with different gray level ranges. The histogram of an image can be separated into a number of peaks (modes), each corresponds to one region, and there exists a threshold value corresponding to the valley between two adjacent peaks. The major advantage of this technique lies in its simple computation. However, this method lacks the spatial relationship information of the pixels. The neighborhood based approach usually uses the uniformity criteria to segment regions in the image. E.g. Region based techniques. These techniques consider that neighboring pixels within same region should have similar values (e.g. intensity, color, and texture). Here, we need to assume a set of seed points initially. However, the difficulty with this technique is the selection of initial seed points and the order in which pixels and regions are examined. Moreover, it is better than histogram thresholding techniques since it considers the spatial relationship between pixels.Clustering based approach generally uses a fuzzy logic to define membership of the pixels. Regions are formed by inspecting the membership values of pixels using partition method e.g. Fuzzy C-means (FCM) algorithm. For clustering based approach, fuzzy model of the image is a crucial factor for the successful implementation. Hybrid based techniques improve the segmentation result by combining all above methods for segmentation.

The proposed method is the application of FMMN clustering algorithm to find number of clusters of pixels with similar color. The clusters (segments) and their labels are automatically found out using FMMN clustering technique. Neural network is used to find multiple objects in the image. The network consists of three layers such as input layer, hidden layer and output layer. Each layer consists of fixed number of neurons equal to number of pixels in the image. The major advantage of this technique is that, it does not require a priori information of the image.

2 EDGE DETECTION FOR IMAGE SEGMENTATION
Edge detection techniques transform images to edge images benefiting from the changes of grey tones in the images. Edges are the sign of lack of continuity, and ending. As a result of this transformation, edge image is obtained without encountering any changes in physical qualities of the main image. Objects consist of numerous parts of different color levels. In an image with different grey levels, despite an obvious change in the grey levels of the object, the shape of the image can be distinguished in Figure 1.

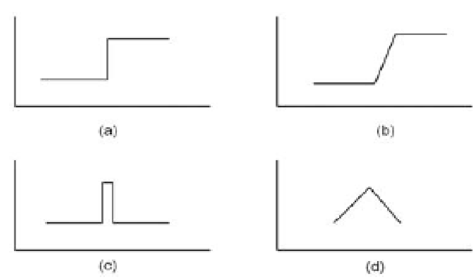


Fig. 1. Type of Edges (a) Step Edge (b) Ramp Edge (c) Line Edge (d) Roof Edge

An Edge in an image is a significant local change in the image intensity, usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity. Discontinuities in the image intensity can be either Step edge, where the image intensity abruptly changes from one value on one side of the discontinuity to a different value on the opposite side, or Line Edges, where the image intensity abruptly changes value but then returns to the starting value within some short distance. However, Step and Line edges are rare in real images. Because of low frequency components or the smoothing introduced by most sensing devices, sharp discontinuities rarely exist in real signals. Step edges become Ramp Edges and Line Edges become Roof edges, where intensity changes are not instantaneous but occur over a finite distance. Illustrations of these edge shapes are shown in Fig.1.

2.1 Steps in Edge Detection

Edge detection contain three steps namely Filtering, Enhancement and Detection. The overview of the steps in edge detection is as follows.

1) Filtering: Images are often corrupted by random variations in intensity values, called noise. Some common types of noise are salt and pepper noise, impulse noise and Gaussian noise. Salt and pepper noise contains random occurrences of both black and white intensity values. However, there is a trade-off between edge strength and noise reduction. More filtering to reduce noise results in a loss of edge strength.

2) Enhancement: Enhancement emphasizes pixels where there is a significant change in local intensity values and is usually performed by computing the gradient magnitude.

3) Detection: Many points in an image have a nonzero value for the gradient, and not all of these points are edges for a particular application. Therefore, some method should be used to determine which points are edge points. Frequently, thresholding provides the criterion used for detection.

3 FMMN CLUSTERING ALGORITHM

In this paper, we propose a system capable to perform adaptive multilevel color image segmentation based on thresholding and FMMN clustering technique. Clusters and their labels are automatically found out using FMMN clustering technique. The main advantage of this technique is that, it does not require a *priori* information to segment a color image.

The concept of fuzzy sets in which imprecise knowledge can be used to define an event. A fuzzy set A is represented as

$$A = \{\mu_A(x_i)/x_i, i = 1,2,......,n\} \qquad (1)$$

Where,

$\mu_A(x_i)$ gives the degree of belonging the element x_i in the set A.

A fuzzy set theory, that allows to deal with uncertainty and ambiguity has found considerable applications in image segmentation. The integration of fuzzy logic with neural network has emerged as a promising field of research in recent years. This has lead to the development of a new branch called neuro-fuzzy computing, such as FMMN clustering algorithm.

FMMN clustering technique uses a hyperbox fuzzy set concept. In FMMN , algorithm, hyperboxes are defined by a pair of min-max points and a membership function is defined with respect to these points. The membership function for each hyperbox fuzzy set must describe a degree to which the pattern fits within a hyperbox.

FMMN learning algorithm has three steps namely Expansion, Overlap test and Contraction of the hyperboxes respectively. The training set *D* consists of a set of *m* ordered pairs $\{x_h, d_h\}$ where $x_h = (x_{h1}, x_{h2}, ..., x_{hn}) \in I^n$ is the input pattern and $d_h \in \{1,2,3,......,m\}$ is one of the *m* classes.

When a training sample is presented to network, the algorithm tries to search a hyperbox for the same class which can expand to include the input. If no suitable hyperbox is found to accommodate the applied training sample, a new hyperbox is formed and added to the neural network. After expansion, overlap test find out the overlap between expanded hyperbox with all other class hyperboxes. When the overlap occurs between hyperboxes representing the same class, the overlap is not removed. But when the overlap occurs between hyperboxes that represents the different classes, the overlap is eliminated using contraction process. The contraction process only eliminates the overlap between those portions of the hyperboxes from separate classes that are having full membership. The membership function for the hyperbox is as follows (2).

$$b_j(A_h) = \frac{1}{2n}\sum_{i=1}^{n}\left[\begin{array}{l}\max(0, 1 - \max(0, \gamma \min(1, a_{hi} - w_{ji})))\\ + \max(0, 1 - \max(0, \gamma \min(1, v_{ji} - a_{hi})))\end{array}\right] \qquad (2)$$

Where,

$A_h = (a_{h1}, a_{h2}, ..., a_{hn}) \in I^n$ is the h^{th} input pattern

$V_j = (v_{j1}, v_{j2}, ..., v_{jn})$ is the min point for B_j

$\gamma =$ Sensitivity parameter.

4 ADAPTIVE COLOR IMAGE SEGMENTATION USING FUZZY MIN-MAX CLUSTERING

4.1 ACISFMC architecture overview

The proposed block diagram of “Adaptive Color Image Segmentation Using Fuzzy Min-Max Clustering (ACISFMC)” is as depicted in Fig. 1. ACISFMC uses HSV color space for the color image segmentation. HSV color representation is compatible with vision psychology of human eyes and its three components such as hue (H), saturation (S), and intensity (V) are relatively independent [5]. It is better than RGB transformation since there exists a high correlation among three color components such as red (R), green (G), and blue (B) which makes these three components dependent upon each other and associate strongly with intensity. Hence, RGB color space is very difficult to discriminate highlights, shadows and shading in color images. HSV color space can solve this problem. HSV color model is having following advantages.

1. Hue is an invariant to certain types of highlights, shading, and shadows.

2. HSV color model decouples the intensity component from color information (hue and saturation) in a color image.

ACISFMC system consists of a multilayer neural network which performs adaptive, multilevel thresholding of the color image. Clusters and their labels are automatically found out by applying FMMN clustering algorithm on image histogram in saturation and intensity plane respectively. ACISFMC uses saturation and intensity planes for color image segmentation since these are the two quantities that may vary and hue value remains same also, non-removable singularity is one of hue’s drawbacks this may create discontinuities and spurious modes in the representation of colors.

Fuzzy entropy is used as a tool to measure the error of the system. Given an input image, system is forced towards a minimum fuzzy entropy state in order to obtain segmentation. Segmentation is carried out independently in each plane respectively. The final segmentation is achieved by combining the results of these planes.

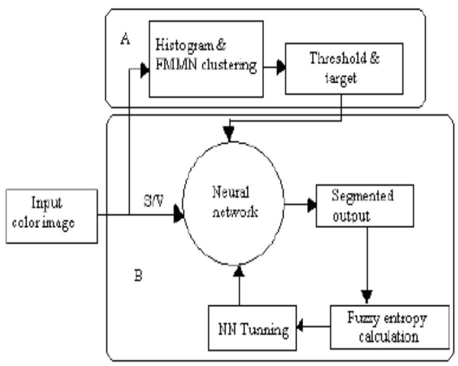


Fig1.Block diagram of ACISFMC.

4.2 System flowchart

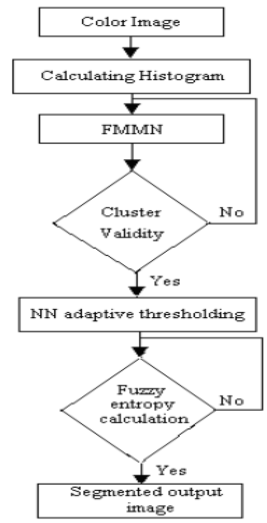
A general flowchart of the proposed algorithm is depicted in Fig. 2. First, clusters and their labels are automatically found out by applying FMMN clustering algorithm on image histogram in respective plane respectively. ACISFMC is a histogram multithresholding technique hence it is necessary to find different thresholds and target to segment objects in the image. Once the clusters are found out, average of two cluster center in respective planes is taken as a threshold value. After detecting thresholds, labels for the objects are decided. The information about labels is used to construct network's activation function. Neuron uses a multilevel sigmoid function as an activation function. This activation function takes care of thresholding and labeling the pixels during training process. The details are given in section C.

Viewed as a system, ACISFMC consists of two major processing blocks as shown in Fig. 1.

• Adaptive threshold selection block (A)

• Neural network segmentation block (B)

Adaptive threshold selection block is responsible to determine clusters and compute a multilevel sigmoid function of neurons. Neural network segmentation block does the actual segmentation based on the number of objects found out by adaptive threshold selection block.



\

Fig2. System Flowchart.

4.2.1 ADAPTIVE THRESHOLD SELECTION BLOCK (A)

Adaptive threshold selection block consists of adaptive thresholding system itself. The purpose of this block is to find out number of clusters and computation of multi-level sigmoid function for neurons. With the aim of keeping the system totally adaptive, there is a need of an automatic way to determine number of clusters. In the proposed work, this was done by using a FMMN clustering technique. The main aspire here is to locate the number of clusters without a priori knowledge of the image. To accomplish this, first the histogram of given color image for saturation and intensity planes are found out. Clusters and their labels for the objects are found out by applying a FMMN clustering algorithm to image histogram in respective planes. Threshold and target values are obtained from the clusters. Cluster centers are considered as a target while the average of two targets is considered as a threshold. The average value as a threshold helps to segment the objects with a color appropriate to its original color. Hence in ACISFMC system, objects are colored with their mean color i.e. system tries to maintain the color property of the object even after segmentation. This can be helpful in image post-processing. Once threshold and target values are calculated, a neural network activation function is constructed.

4.2.2 NEURAL NETWORK SEGMENTATION BLOCK (B)

Neural network segmentation block consists of fuzzy entropy calculation block and NN tunning/training block.

The proposed ACISFMC system consists of two independent neural networks one each used for saturation and intensity planes respectively. In Fig. 3, we depict the three layered proposed network architecture. The layer where the inputs are presented is known as the input layer. On the other hand the output producing layer is called as output layer. Besides, the input and output layer, there exists a third layer called as a hidden layer. Each layer is having a fixed number of neurons equal to the size (M x N) of image. Each neuron in a layer represents a single pixel. The input to a neuron in the input layer is normalized between [0-1]. The output value of each neuron is between [0-1]. All neurons are having primary connection weight as 1. Each neuron in a layer is connected to the corresponding neuron in the previous layer and to its neighbors over N^d neighborhood. So for N^1 neighborhood connection scheme, a neuron has five links, representing "1" as depicted in Fig. 4. Whereas for N^2 neighborhood connection scheme, there are nine links associated with every neuron representing "1" and "2" and so on. Neurons in the same layer do not have connection among themselves. The output of the nodes in one layer is transmitted to the nodes in another layer via links that amplify or inhibit such outputs through weighting factors. Except for the input layer nodes, the total input to each node is the sum of weighted outputs of the nodes in the previous layer. Each node is activated in accordance with the input to the node and the activation function (3) of the node.

4.3 Fuzzy entropy

Fuzzy set plays an important role in various distributed systems because of their ability to model non statistical ambiguity. Consequently, characterization and quantification of fuzziness are important issues that affect the management of uncertainty in many system models and designs. The entropy of a fuzzy set is a measure of fuzziness of that fuzzy set. The first fuzzy entropy formula without reference to probabilities was proposed in 1972 in the work of Luca and Termini , who defined entropy using Shannon's functional form.

There have been numerous applications of fuzzy entropy in image segmentation. Cheng presented a thresholding approach by performing fuzzy partition on a two-dimensional histogram based on fuzzy relation and maximum fuzzy entropy principle. Zhao presented an entropy function by using fuzzy partition (FP) and the probability partition (PP) which was used to measure the compatibility between FP and the PP.

In the proposed work, fuzzy entropy is used to calculate the error of the system. The partition entropy (PE) is calculated. Here, the aim of network is to reduce the degree of fuzziness of the input color image.

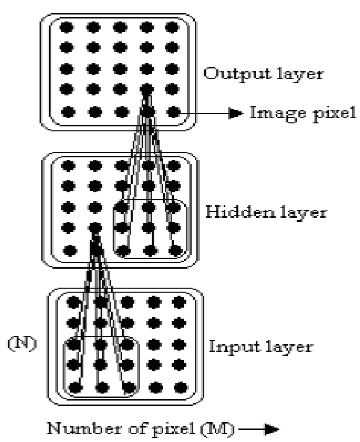


Fig3. Neural network architecture.

4.4 Neural Network (NN) Tunning

The purpose of NN tunning block is to update the connection weight by taking into consideration the output error in network. A back propagation algorithm is employed for training. At every training epoch, error is computed by getting a difference between the actual output and the desired output of neuron. After the weights have been adjusted properly, the output of the neurons in the output layer is fed back to the corresponding neurons in the input layer. The second pass is then continued with this as an input. The iteration (updating of weights) is continued until the network stabilizes; i.e. the error value (measure of fuzziness) becomes minimum in order to obtain segmentation. As discussed before, the intention of network is to reduce the error in order to obtain segmentation.

As the training progresses, a pixel gets the color depending upon its surrounding pixel colors. From the output image shown in Fig. 4(b), it can be observed that network tries to label a cluster with an even color spread. The segmentation using multiple thresholds is explained with an example in the next section.

Consider Fig. 4(a) to understand the segmentation process. As a first step, thresholds in saturation (S) and intensity (V) planes are found out. Fig. 4(c) shows the histogram of the image. Clusters are automatically found out by applying a FMMN clustering algorithm to image histogram in respective planes. Thresholds and target values are obtained from the clusters. Cluster centers are considered as a target whereas average of two target values is considered as a threshold value. By using threshold and target values, the neuron's activation function is constructed. Fig. 4(b) shows the segmented output using proposed method. The main advantage of this technique is that, it does not require a priori knowledge to segment regions. Following Figure 5(c) are for the saturation plane. Similar Figures are for the intensity plane.

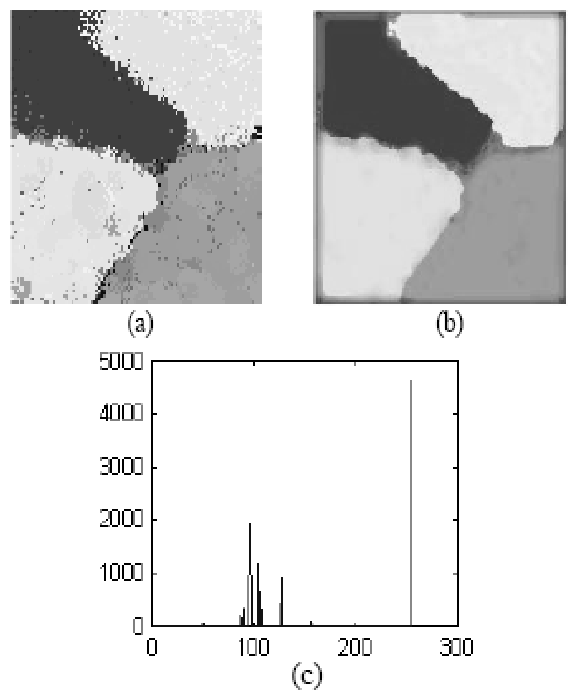


Fig4. (a) Original image (b) Segmented output using proposed method (c) Histogram of the image.

5 CONCLUSION

This paper mainly focuses on the study of soft computing approach to edge detection for image segmentation. The soft computing approaches namely, fuzzy based approach, and Neural network based and the results show the efficiency of image segmentation.

A novel segmentation technique for color images is presented. The segments in images are found automatically based on adaptive multilevel threshold approach and FMMN clustering algorithm. The neural network function tries to label the objects with its original color even after segmentation. One of the good features of the proposed system is that it does not require *a priori* information about number of objects in the image. ACISFMC system is tested on several images of different types. The algorithm has been implemented on a set of noisy images. Results show that the system performance is robust to different types of noisy images also.

6 REFERENCES

[26] Orlando J. Tobias and Rui Seara,"Image Segmentation by Histogram Thresholding Using Fuzzy Sets", *IEEE Transactions on Image Processing*, Vol.11, No.12, pp. 1457-1465.

[27] Dinesh K. Sharma, Loveleen Gaur and Daniel Okunbor, "Image Compression and Feature Extraction with Neural Network", *Proceedings of the Academy of Information and Management Sciences*, Vol.11, No.1, 2007, pp. 33-38.

[28] M. Abdulghafour, "Image segmentation using Fuzzy logic and genetic algorithms", *Journal of WSCG*, vol. 11, no.1, 2003.

[29] Lei Jiang and Wenhui Yang, "A Modified Fuzzy C-Means Algorithm for Segmentation of Magnetic Resonance Images", *Proc. VIIth Digital Image Computing: Techniques and Applications*, vol. 10-12, 2003.

[30] N. R. Pal, S.K. Pal, "A review on image segmentation techniques," *Pattern Recognition*, vol. 26, 1993, pp. 1277-1291.

[31] Rosenfeld and Kak, *Digital Picture Processing.* 2, Academic Press, New York, 1982.

[32] R. C. Gonzalez and R.E. Woods, *Digital Image Processing.* Pearson Education Pet. Ltd. New Delhi.

[33] G.A. Hance, S.E. Umbaugh, R.H. Moss and W.V. Stoecher, "Unsupervised color image segmentation with application to skin tumor borders," *IEEE Eng. Med. Biol*. vol. 15, 1996, pp. 104–110.

[34] X. Lin, S. Chen, "Color image segmentation using modified HSI system for road following," *Proceedings of the IEEE Conference.*

[35] P.K. Sahoo, S. Soltani, A. K C. Wong, and Y.C. Chen, "A survey on thresholding techniques," *Computer Vision Graphics Image Processing*, vol. 41**,** 1988, pp. 233-260

Author Biographies

Ms. Priyanka A. Hajare is a student of Sipna College of Engineering and Technology, Computer Engg.[M.E.] Amravati, Sant Gadge baba Amravati University. She has presented 2 papers in National Conferences. Her area of interest is network security and image processing.

Prof. Pritish A. Tijare is working as a Associate Prof. in Computer Science and engineering department of Sipna College of Engg. And technology, Amravati. He is having 7 years of experience in teaching field. He has published various state, national and international conference and journals. He has guided BE , ME students. His interest of research is in Image processing and Computer Architecture.

.