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# Self Organizing Map Based Improved Color Image Segmentation

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***Abstract— Image segmentation has been and is likely to be an important component of the content-based image acquisition and retrieval systems. In this paper, we have proposed an image segmentation technique that uses self-organizing map (SOM) neural network for segmentation of color images. It has been observed that, SOM training if performed on the wavelet-transformed image, not only reduces the training time of the SOM but also make more compact segments. Our experiments have shown better results produced by our proposed technique than the previous approaches in practice.***

***Keywords— Color images segmentation, self-organizing map, neural networks, and wavelets.***

## I. Introduction

Image segmentation is the process of dividing an image into non-overlapping regions based on perceptual information. Applications of image segmentation include Content-Based Image Retrieval (CBIR), object recognition, matching of stereo pairs for 3-D reconstruction, navigation and artificial expert medical diagnosis. The Content-based image retrieval systems search the repository of images based on features of the digital images rather than labels. Major features include texture, color, object structure or any other selective information that can be extracted from the image itself.

Images are considered as one of the most important medium of conveying information. Understanding images and extracting the information from them such that the information can be used for other tasks is an important aspect of Machine learning. One of the first steps in direction of understanding images is to segment them and find out different objects in them. Thus image segmentation plays a vital role towards conveying information that is represented by an image and also assists in understanding the image. Image segmentation is the process of dividing the given image into regions homogenous with respect to certain features, and which hopefully correspond to real objects in the actual scene. Segmentation plays a vital role to extract information from an image to create homogenous regions by classifying pixels into groups thus forming regions of similarity. The homogenous regions formed as a result of segmentation indwell pixels having similarity in each region according to a particular selection criteria e.g. Intensity, color etc.

According to [1] applications of CBIR systems include, expert medical systems, art collections, photographic archives, retail catalogs, medical diagnosis, crime prevention, military use, intellectual property, architectural and engineering design, geographical information and remote sensing systems. The main bottleneck of CBIR systems is the inability to process high dimensional data. In a color image, where 8 bits for the representation of each color component (R, G, and B) are used, there are 16 million possible colors in that image. We need to decrease these dimensions in order to get meaningful results from the CBIR systems. Image segmentation is a method that helps decrease the number of colors required to represent an image by dividing an image into regions and by assigning each region with the same color. In the past, a number of classical methods e.g. edge-detection [2]-[4], region growing, histogram-based [5]-[7], and graph partitioning were used for image segmentation.

Segmentation plays an important role in image understanding, image analysis and image processing. Because of its simplicity and efficiency, clustering approaches were one of the first techniques used for the segmentation of (textured) natural images. After the selection and the extraction of the image features[usually based on color and or texture and computed on (possibly) overlapping small windows centered around the pixel to be classified],the feature samples, handled as vectors, are grouped together in compact but well-separated clusters corresponding to each class of the image. The set of connected pixels belonging to each estimated class thus defined the different regions of the scene. The method known as k -means [8] (or Lloyd's algorithm).The applications of Image segmentation are widely in many fields such as image compression, image retrieval, object detection, image enhancement etc.

The Human Visual System (HVS) has tremendous ability to segment and extract information from the images. This remarkable ability of the HVS is obviously a great motivation for anyone to apply Artificial Neural Networks in field of image segmentation. ANNs have many advantages over the other methods; such as, massive parallelism, fault-tolerance to missing, noisy or outlier attributes, better adaptability on different datasets and optimal or near optimal performance [9]. For image segmentation, mainly three types of ANNs are used: supervised, unsupervised, and a combination of the both. When segmenting color images, ANNs with unsupervised learning are preferred over the others. Because the former needs training samples for training and in some cases, training data might not be available at all.

Self-Organizing Map (SOM) Neural Network is a type of unsupervised ANN. It has two major characteristics, (i) it reduces the dimensions of data (ii) it groups together similar samples. These two characteristics of SOM help us in segmenting the regions of the image that has similar features, and it reduces the number of colors required to represent an image.

In the proposed method, a SOM is trained on approximation co-efficients of the wavelet transformed image.

The main contributions of the proposed method include:

- Works equally well for non-noisy as well as noisy images since approximation co-efficients of the image are used.
- Proposed technique is computationally less expensive than [11] technique, since training is performed using only approximation co-efficient.

## II. PROBLEM DEFINITION

Image segmentation is the problem of dividing an image into disjoint sets, such that the union of these sets makeup the complete image. An image when divided in K segments, each segment must satisfy 1. The value of K in unsupervised learning is determined at run-time or we can control K by implying maximum limit on K. (1) ,

$$I = \bigcap_{k=1}^{K} s_k \quad where \; s_i \bigcap s_j = \phi, \; for \; i \neq j \qquad \text{eq (1)}$$

A SOM is a two dimensional lattice of neurons. Each neuron has a weight vector associated with it. The weight vector is composed of three components, each representing Red, Green and Blue component of color. SOM can be used to reduce the representative colors of the image.It selects the dominant colors and replaces closely related colors by dominant colors. Fig. 2 is the histogram of the 'lena' image before segmentation and fig. 3 is the histogram after segmentation using SOM. From the comparison of the two histograms, we can easily infer that SOM has reduced the number of colors required to show the image without significant degradation in the quality of the image.

Nowadays, SOM is being widely used in image segmentation literature. In [11] authors propose a SOM-based technique to segment brain MRI images. They use wavelet-transformed images to train SOM. In [12], they use a two-stage SOM to segment medical images.

## III. RELATED WORK

Histogram thresholding is employed to phase the given image; there's bound pre-processing and post-processing techniques needed for threshold segmentation [14]. Major thresholding techniques planned by completely different researchers are Mean technique, P-tile technique, bar chart dependent technique, Edge Maximization technique, and visual technique. During this section, many new approaches from last 5 years concerning threshold based image segmentation are being mentioned.

Salem Saleh Al-amri [15] has applied Mean technique, Pile technique, HDT, and EMT technique on 3 satellite pictures so as to pick out the major effective segmental image from all on top of techniques. Experiments and comparative analysis of techniques have shown that HDT (Histogram Dependent Technique) and EMT (Edge Maximization Technique) are the most effective thresholding techniques that surpass all alternative thresholding techniques.

Kaiping Wei dynasty [16] have found that current image segmentation techniques are time intense and need heap of machine price so as to perform image segmentation. It’s an enormous drawback for real time applications. They planned a replacement threshold based segmentation technique exploitation Particle Swarm improvement (PSO) and 2-d Otsu algorithmic rule (TOPSO). TOPSO algorithmic rule used PSO technique to go looking associate best threshold for the segmentation method. They implement the planned hybrid technique on Matlab seven.0. Results shown that TOPSO algorithmic rule takes twenty five times less time as compare to ancient Otsu algorithmic rule. It’s sensible for real time applications.

### *A. Region based Image Segmentation*

Region based segmentation is easy as compare to alternative ways and additionally noise resilient. It divides a picture into completely different regions supported pre-defined criteria, i.e., color, intensity, or object. Region based segmentation ways are categorised into 3 main classes, i.e., region growing, region rending, and region merging [14].

### *B. Edge based Image Segmentation*

Edge detection may be a basic step for image segmentation method [18]. It divides a picture into object and its background. Edge detection divides the image by perceptive the modification in intensity or pixels of a picture. Grey bar chart and Gradient are 2 main ways for edge detection for image segmentation [19]. Many operators are employed by edge detection technique, i.e., Classical edge detectors, zero crossing, Laplacian of Guassian(LoG)[20].

Wesolkowsk [21] have used the Andrei Markov Random Fields for edge and region based hybrid color image segmentation. Firstly, line method is enforced exploitation edge detection algorithmic rule. Vector angle live is employed as a distance live between pixels so as to discover edges. The major drawback with their technique is that it's a component neighbor model and has identical drawbacks of region growing technique. A parameter estimation technique is employed to guage the MRF model.

### *C. Fuzzy Theory based Image Segmentation*

Fuzzy pure mathematics is employed so as to research pictures, and supply correct data from any image. Fuzzification operate will be accustomed take away noise from image also [22]. A gray-scale image will be simply remodeled into a fuzzy image by employing a fuzzification operates. Completely different morphological operations will be combined with fuzzy technique to induce higher results [23].

### *D. ANN based Image Segmentation*

Farhad Mohamad Kazemi [24] planned a quick C-means based coaching of Fuzzy Hopfield Neural network [25] so as to use it into image segmentation. Objective operate is employed supported 2-f Fuzzy HNN. This objective operates found the common distance between image pixels and cluster's centroids. per author,

Fuzzy HNN provides higher segmentation as compare to alternative ways. Firstly, they create clusters from given information, then perform normalisation, i.e. gray level pictures, calculate centroids, then figure distances, realize new centroids, and laptop new membership operate worth exploitation fuzzy C-means [26]. The results have shown that FHNN provides a quicker speed as compare to alternative techniques of ANN.

### *E. PDE based Image Segmentation*

PDE (Partial Differential Equations) equations or PDE models are used wide in image process, and specifically in image segmentation. They uses active contour model for segmentation purpose. Active Contour model or Snakes remodel the segmentation drawback into PDE. Some famed ways of PDE used for image segmentation are Snakes, Level-Set, and Mumford Shah technique [27]. during this section, many new approaches for image segmentation supported PDE are mentioned.

Feature extraction schemes in [28]-[29] are capable to handling geometrical quality, rate of modification, and orientation of image. New PDE based segmentation theme is additionally given that increase distinction criteria of texture data. PDEs are used for modelling the segmentation theme. Watershed technique [50] is extended by exploitation PDE models. They compare their planned theme with watershed segmentation technique, and it's found that coupling of textural data, and modelling exploitation PDEs leads the image segmentation to prime quality method and outperforms the watershed segmentation algorithmic rule.

## IV. IMAGE SEGMENTATION

The main idea of the image segmentation is to group pixels in homogeneous regions and the usual approach to do this is by 'common feature. Features can be represented by the space of colour, texture and gray levels, each exploring similarities between pixels of a region. Segmentation refers to the process of partitioning a digital image into multiple regions (sets of pixels). The goal of segmentation is to simplify and change the representation n of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. 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. Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture [13]. The segmentation is based on the measurements taken from the image and might be gray-level, colour, texture, depth or motion. Image segmentation techniques are categorized into three classes: Clustering, edge detection; region growing .Some popular clustering algorithms like k-means are often used in image segmentation adjacent regions are significantly different with respect to the same characteristic. Segmentation is mainly used in medical imaging, Face recognition, Fingerprint recognition, Traffic control systems, Brake light detection, and Machine vision.

## V. PROPOSED METHOD

### *A. SOM Initialization*

Mainly SOM has two types of Initializations. One is linear and the other is random. We have chosen random initialization for SOM because with random initialization our cluster (segment) centers have good chance of searching the maximum color segmentation space available. In Fig. 1 a randomly initialized SOM of size 16x16 is shown. Each color component is represented using 8-bits (24-bits per pixel).

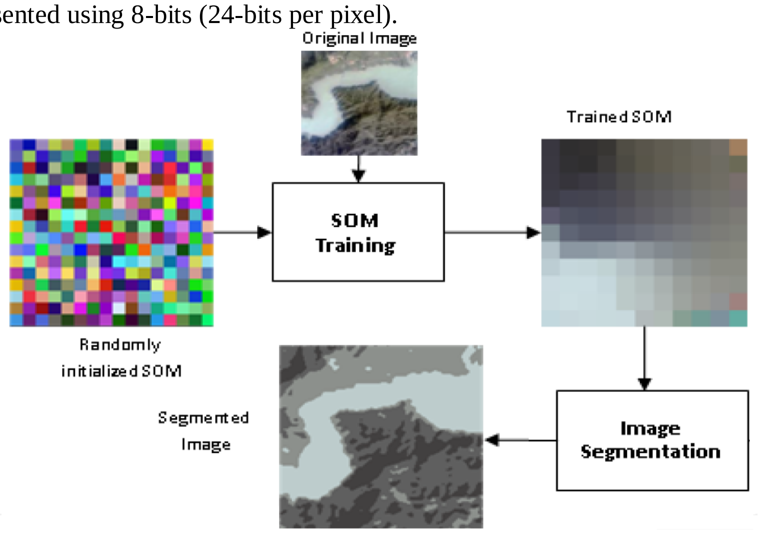



Fig. 1 Flow diagram of segmentation process using SOM

### *B. SOM K-Means Clustering*

SOM K-Means algorithm is the most popular partitioning based clustering technique. It is an unsupervised algorithm which is used in clustering. It chooses the centroid smartly and it compares centroid with the data points based on their intensity and characteristics and finds the distance, the data points which are similar to the centroid are assigned to the cluster having the centroid. New _k' centroids are calculated and thus k-clusters are formed by finding out the data points nearest to the clusters. Steps of the SOM K-Means algorithm can be outlined as mentioned below:

1. Choose k number of points randomly and make them initial centroids.
2. Select a data point from the collection, compare it with each centroid and if the data point is found to be similar with the centroid then assign it into the cluster of that centroid.
3. When each data point has been assigned to one of the clusters, re-calculate the value of the centroids for each k number of clusters.
4. Repeat steps 2 to 3 until no data point moves from its previous cluster to some other cluster until termination criterion has been satisfied.

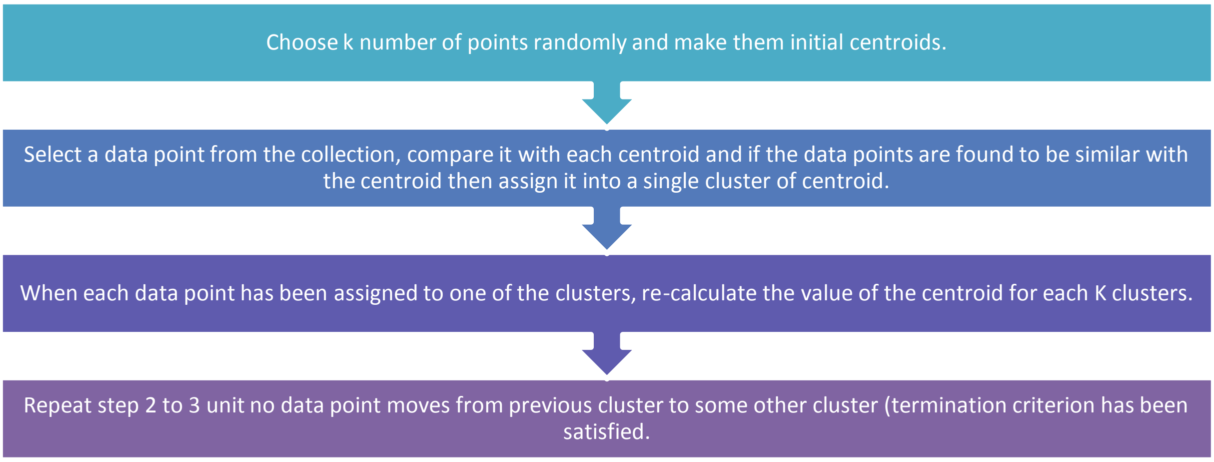



Fig. 2. SOM (K-Means) Clustering Algorithm in proposed work

### *C. SOM Training.*

For each pixel 'V' of the image, the Best Matching Unit (BMU) is selected in the SOM. BMU has the least dissimilarity with the input pixel from the rest of the SOM. The weight associated with this neuron is updated according to 2. New weight Wi of the neuron i at iteration t+1 is calculated. Here L0 is the initial learning rate, σ0is the initial neighbourhood size and η is a time constant. For each neuron within the neighbourhood of i, δi(t)is calculated. Then the weight vector of all neurons within the neighbourhood σ(t), at time t, is updated using (2). Neurons nearer to the BMU becomes more alike the BMU then those neurons farther but within the neighbourhood. After all the pixels of the image are presented to the SOM then t is incremented by 1. This process is repeated unless t reaches tmax. SOM after training on the 'lizard' image look like the fig. 4.

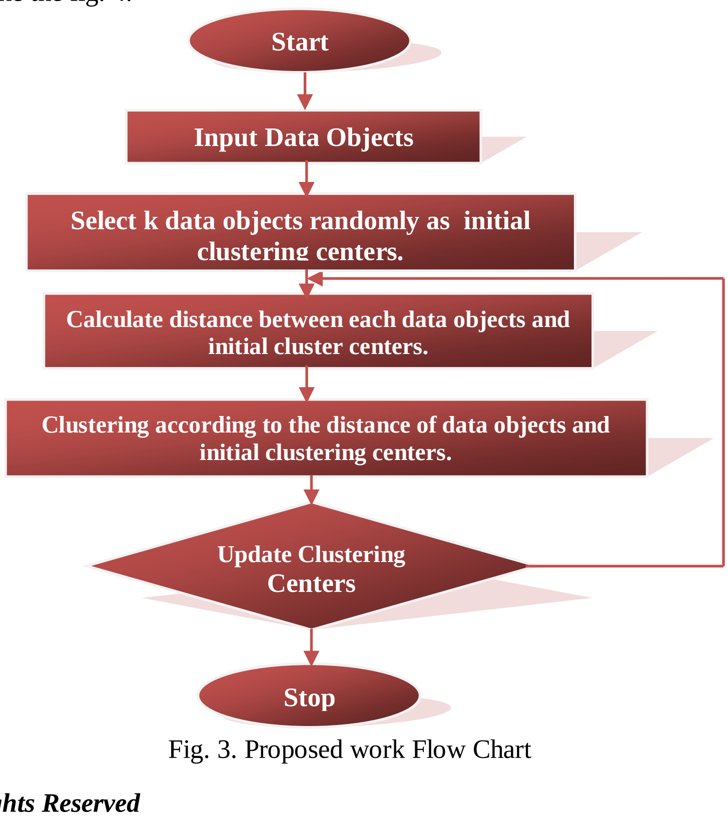



Fig. 3. Proposed work Flow Chart

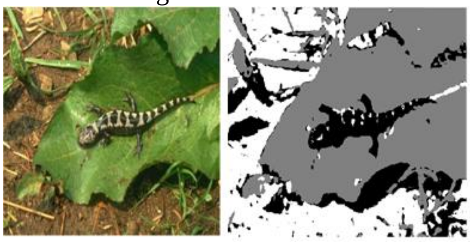
***D. Segmentation.***

After training the randomly initialized SOM using wavelet transformed image. For each pixel in the image, a BMU is found in the SOM. Then the value of the image pixel is replaced by the BMU from SOM. This results in the final segmented image. For SOM training, we use different sizes of lattices i.e.6x6, 8x8 and 16x16 SOM lattice. We train SOM for maximum 15 epochs. Initial learning rate was tested between 0.1 and 0.5, and initial radius started from 2,3 and 4 for 6, 8 and 16 lattice sizes respectively. The best results were obtained with 16x16 SOM with radius 4 and learning rate 0.5.

## VI. RESULTS

An image segmentation program using SOM clustering techniques has been developed using Matlab 7.0 in Pentium IV Dual Core PC for segmenting the colour images. Images of different size are chosen for comparing the results. For comparing the results the numbers of clusters chosen are also different.

The algorithm has been applied on a number of images. Experiments were carried out on a large number of different kinds of images. The present investigation was done by considering three feature of image red, green and blue value of a pixel. However, please not that in general we can take any number of features. From the results on some of the standard images of image processing, we can easily conclude that our method is better than previous attempts. Our approach has preserved the finer details of the image and correct segments are formed.



(A) (B)

Fig 4. (A) Original image (B) image labeled by its cluster index

Fig 5. Objects in cluster 1, Objects in cluster 2 and Objects in cluster 3.

Figure 4 (A) represents the original image ‘lizard.jpg’. Figure 4 (B) represents the image labeled by its cluster index and figure 5 shows the objects in cluster 1, 2 and 3 respectively. However image segmentation is a key step for understanding the image, which is a natural manner to obtain high level semantic. illustrate results of on images from the BSDS500.

Fig 6. Qualitative results with multiple labels. (Column 1) Images from the dataset; (Column 2) Ground truth segmentation (Column 3) result of proposed method.

## VII. CONCLUSION

We have successfully implemented k-means clustering algorithm. For smaller values of k the algorithms give good results. For larger values of k, the segmentation is very coarse; many clusters appear in the images at discrete places .This is because Euclidean distance is not a very good metric for segmentation processes. Different initial partitions can result in different final clusters. Hence it is necessary to re-run the code several number of times for same and different values of k in order to compare the quality of clusters obtained.

The result aims at developing an accurate and more reliable image which can be used in locating tumors, measure tissue volume, face recognition, finger print recognition and in locating an object clearly from a satellite image and in more. The advantage of K-Means algorithm is simple and quite efficient. It works well when clusters are not well separated from each other. This could be happen in web images. We proposed a framework of unsupervised clustering of images based on the colour feature of the image. It minimizes intra-cluster variance, but does not ensure that the result has a global minimum of variance.

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