An Approach for Segmentation of Colored Images with Seeded Spatial Enhancement

Jagmeet Singh
Lecturer
Deptt. of CSE
RIET,Abohar
jagmeetsingh.730@gmail.com

Lovnish Bansal
A.P
Deptt. of CSE
B.M.S.C.E, Sri Muktsar Sahib
lovnish_bansal@yahoomail.com

Abstract:-In the image analysis, image segmentation is the operation that divides image into set of different segments. The work deals about common color image segmentation techniques and methods. Image enhancement is done using four connected approach for seed selection of the image. An algorithm is implemented on the basis of manual seed selection. It select a seed point in an image an then check for its four neighbor pixels connected to that particular seed point. And segment that image in foreground and background framing. At the end, the evaluation criterion will be introduced and applied on the algorithms results. Five most used image segmentation algorithms, namely, efficient graph based, K means, Mean shift, Expectation maximization and hybrid method are compared with implemented algorithm.

Keywords: *- Segmentation, Enhancement, Framing, Seed Point.*

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1. INTORDUCTION

In recent years color constancy - the ability to understand of objects in the real world without light up effects - made a major concern in the research community of image science and technology. It seems to human that object surfaces in a scene instead of shading and highlight effects. This paper offers an algorithm for color image section which is invariant to shading and highlight effects. The Dichromatic Reflection Model [1] is a useful tool for modeling light reflection, which causes essential illumination effects, and will be used as the theoretical foundation of this paper.

Common approaches for color image segmentation are clustering algorithms such as k-means [2] or Mixture of Principal Components [3], however these algorithms do not take spatial information into account. Furthermore, clustering algorithms require prior information regarding number of clusters, which is a difficult or ambiguous task, requiring the assertion of some criterion on the very nature of the clusters being formed. Some progress has been made on this issue, however much experimentation still needs to be done [4].

An alternative set of algorithms exist which uses color similarity and a region-growing approach to spatial information [5].Region growing is based on
the following principles. The algorithm starts with a seed pixel, examines local pixels around it, determines the most similar one, which is then included in the region if it meets certain criteria. This process is continued until no more pixels are added. The explanation of similarity can be set in any number of various ways.

Region growing algorithms have been used mostly in the gist of grayscale images; however, some significant work has been completed in the color realm by Tremeau et al. [6]. They discuss the segmentation of RGB color regions which are same in kind in color (i.e., no illumination effects are considered) thus restricting the application domain. They use the different thresholds when calculating whether a color pixel is part of a region or not, and the Euclidean distance is used as the measure of similarity between two color vectors. In [7], the authors describe a method where pixels are aggregated together when the distances between the candidate pixel and an adjacent pixel belonging to the region, and between the candidate pixel and the region prototype are both less than some experimentally set thresholds. The region prototype is determined by computing the vector mean of the pixels within the region. The similarity is assessed as in [6] using the Euclidean distance; however, the XYZ space together with normalized uv planes is used (for a total of 5 color planes). However, it is well established [8] that the human perception of color similarity is poorly modeled by the Euclidean distance.

2. COLOR THEORY

The Dichromatic Reflection Model (DRM) was introduced by Shafer [9,10]. The basic premise behind this model is that light is reflected in two different components: one is specular reflection and another is diffuse reflection .The main focus in this paper will be on homogenous dielectric materials for instance plastics. The presentation of the DRM follows closely that given in [4]. Light reflected from an object surface (called the color signal) is described as a function of pixel location x and wave length λ:

$C^0(\lambda,x)$ = body reflection + interface reflection (2.1)

$$C^0(\lambda,x)=\alpha(x)S^0(\lambda)\,E(\lambda)+\beta(x)\,E(\lambda) \quad (2.2)$$

where E(λ) is the spectral power distribution of a light source, $S^0(\lambda)$ is the spectral-surface reflectance of object o, α(x) is the shading factor and β(x) is a scalar factor for the specular reflection term. Sensor responses can be represented with

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \int C^o(\lambda, x) \begin{bmatrix} R_R(\lambda) \\ R_G(\lambda) \\ R_B(\lambda) \end{bmatrix} d\lambda \quad (2.3)$$

where $R_i(\lambda)$ (i=R,G,B) are the camera's spectral sensitivity functions in the visible spectrum. Substituting (2.1,2.2) into (2.3),

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \alpha(x)\int S^o(\lambda)E(\lambda) \begin{bmatrix} R_R(\lambda) \\ R_G(\lambda) \\ R_B(\lambda) \end{bmatrix} d\lambda + \beta(x)\int E(\lambda) \begin{bmatrix} R_R(\lambda) \\ R_G(\lambda) \\ R_B(\lambda) \end{bmatrix} d\lambda = \alpha(x)\vec{c}_b + \beta(x)\vec{c}_i \quad (2.4)$$

where $\vec{c}_b$ and $\vec{c}_i$ are the body and the illumination color vectors (are normalized to unit vector length). If the sensor outputs R, G, and B are balanced for a white surface, then the illumination is considered to be white light. This is satisfied as long as the spectral sensitivity functions have the same areas. Otherwise a white balancing procedure needs to be carried out [4,10].

In [4], the authors demonstrate how highlight invariance is obtained by applying the following transformation

R' = R - AVG
G' = G - AVG
B' = B - AVG

Since the algorithm described in this paper also uses the vector angle to discriminate between colors, the method is also said to be shading invariant. This has been demonstrated previously [4].

3. MAGE SEGMENTATION

Image segmentation is a subset of an expensive field of computer version which deals with the analysis of spatial context of image."Segmentation" refers to the process of dividing a digital image into multiple segments such as a set of pixels, also known as super pixels (Chad and Hayit ,2002). The main objective of segmentation is to simplify and/or change the representation of an image into meaningful image that is more appropriate and easier to analyze. Segmentation is basically a collection of methods that allowing spatially partitioning close parts of the image as objects.

"Image segmentation" is an important aspect of digital image processing. Image segmentation may be defined as a process of assigning pixels to homogenous and disjoint regions which form a partition of the image that share certain visual characteristics (Fan, Zeng and Hacid,2005). Image segmentation is used to locate and find objects and boundaries (lines, curves, etc.) in images. It basically aims at dividing an image into subparts based on certain feature. Features could be based on certain boundaries, contour, color, intensity or texture pattern, geometric shape or any other pattern (Pichel, Singh and Rivera, 2006). It provides an easier way to analyze and represent an image.

All image processing operations generally aim at a better recognition of objects of interest, i. e., at finding suitable local features that can be distinguished from other objects and from the background. Te second step is to check every one pixel to see whether it belongs to an object of interest or not. This step produces a binary image and it is called segmentation. If one pixel belongs to the one object then one pixel is equal value one. Segmentation is the operation at the threshold between low-level image processing and image analysis. Whenever this process is completed then it is possible to infer that which pixel belongs to which object. The image is parted into regions and we know the discontinuities as the boundaries between the regions.

3.1 Image Segmentation Techniques

Image segmentation methods are categorized on the basis of two properties discontinuity and similarity. Methods based on discontinuities are called as boundary based methods and methods based on similarity are called Region based methods Segmentation is a process that divides an image into its regions or objects that have similar features or characteristics.

Mathematically complete segmentation of an image R is a finite set of regions R1…Rs, [14].

$$R = \bigcup_{i=1}^{s} Ri \qquad Ri \cap Rj = \emptyset \qquad i \neq j \quad (3.1)$$

Image segmentation methods can be categorized as below-

3.1.1 Region Based Techniques

Region based methods are based on continuity. These techniques divide the entire image into sub regions depending on some rules like all the pixels in one region must have the same gray level. Region-based techniques rely on common patterns in intensity values within a cluster of neighboring pixels. The cluster is referred to as the region, and the goal of the segmentation algorithm is to group the regions according to their anatomical or functional roles.

3.1.2 Clustering Technique

Given an image this methods splits them into K groups or clusters. The mean of each cluster is taken and then each point p is added to the cluster where the difference between the point and the mean is smallest. Since clustering works on hue estimates it is usually used in dividing a scene into different objects. The performance of clustering algorithm for image segmentation is highly sensitive to features used and types of objects in the image and hence generalization of this technique is difficult. Ali, Karmarkar and Dooley [15] presented a new shape-based image segmentation algorithm called fuzzy clustering for image segmentation using generic shape information (FCGS) which integrates generic shape information into the Gustafson-Kessel (GK) clustering framework. Hence using the algorithm presented in[15] can be used for many different object shapes and hence one framework can be used for different applications like medical imaging, security systems and any image processing application where arbitrary shaped object segmentation is required. But some clustering algorithms like K-means clustering doesn't guarantee continuous areas in the image, even if it does edges of these areas tend to be uneven, this is the major drawback which is overcome by split and merge technique.

3.1.3 Split and Merge Technique

There are two parts to this technique first the image is split depending on some criterion and then it is merged. The whole image is initially taken as a single region then some measure of internal similarity is computed using standard deviation. If too much variety occurs then the image is split into regions using thresholding. This is repeated until no more splits are further possible. Quad tree is a common data structure used for splitting. Then comes the merging phase, where two regions are merged if they are adjacent and similar. Similarity can be measured by comparing the mean gray level or using statistical tests. Two regions R1 and R2 are merged into R3 if,

$$H(R_1 \cup R_2) = TRUE$$
$$|m1-m2| < T$$

Where, m1 and m2 are the mean gray-level values in the regions R1 and R2, and T is some appropriate threshold [14].

Merging is repeated until no more further merging is possible. The major advantage of this technique is guaranteed connected regions. Quad trees are widely used in Geographic information system. Kelkar D. and Gupta, S[16] have introduced an improved Quad tree method (IQM) for split and merge .In this improved method they have used three steps first splitting the image, second initializing neighbors list and the third step is merging splitted regions. They have divided the third step into two phases, in-house and final merge and have shown that this decomposition reduces problems involved in handling lengthy neighbor list during merging phase. The drawbacks of the split and merge technique are, the results depend on the position and orientation of the image, leads to blocky final segmentation and regular division leads to over segmentation (more regions) by splitting. This drawback can be overcome by reducing number of regions by using Normalized cuts method.

3.1.4 Normalized Cuts

This technique is proposed by Jianbo Shi and Jitendra Malik[22] is mostly used in segmentation of medical images. This method is based on graph theory. Normalized cuts aim at splitting so that the division is optimal. Each pixel is a vertex in a graph, edges link adjacent pixels. Weights on the edge are assigned according to similarity between two corresponding pixels.

The criterion for similarity is different in different applications. Similarity can be defined the distance, color, gray level, textures and so on.

The advantage of this technique is that it removes the need to merge regions after splitting. It gives better definition around the edges Shi and Jitendra Malik [22], in their paper Normalized cuts and image segmentation shows how normalized cut is an unbiased measure of disassociation between subgroups of a graph and it has the nice property that minimizing normalized cut leads directly to maximizing the normalized association, which is an unbiased measure for total association within the subgroups.

Wenchao Cai, JueWu, Albert C. S. Chung [17] improved the performance of the normalized cut by introducing the shape information. This method can correctly segment the object, even though a part of the boundary is missing or many noisy regions accompany the object. Thus there are various advantages of this method like it presents a new optimality criterion for partitioning a graph into clusters, different image features like intensity, color texture, contour continuity are treated in one uniform network.

But there are certain disadvantages like lot of computational complexity involved especially for full-scale images.

The performance and stability of the partitioning highly depends on the choice of the parameters.

3.1.5 Region Growing

Region growing is the very famous method. This method starts with a pixel and will go on adding the pixels based on similarity, to the region. When the growth of a region stops another seed pixel which does not belong to any other region is chosen, and again the process is started. The whole process is repeated until all pixels belong to some region.

The advantage of this technique is, connected regions are guaranteed.
Matei Mancas, Bernard Gosselin and Benoit Macq [18] have used in their research a method which only needs one seed inside the region of interest (ROI). They have applied it for spinal cord segmentation but have found that it also shows results for parotid glands or even tumors. There are various applications where region growing techniques is mostly used like, to segment the parts of human body during treatment planning process e.g. segmentation of prostrate, bladder and rectum from contrast CT data.
There are certain advantages of this technique like multiple criterions can be selected at the same time, gives very good results with less noisy images.
But the various disadvantages of this technique are, if seeded region growing method is used then noise in the image can cause the seeds to be poorly placed, over segmentation may take place when the image is noisy or has intensity variations, cannot distinguish the shading of the real images, this method is power and time consuming.

3.1.6 Thresholding

This is the simplest way of segmentation. Using thresholding technique regions can be classified on the basis range values, which is applied to the intensity values of the image pixels. Thresholding is the transformation of an input image f to an output (segmented) binary image g as follows [14].

$$g(i, j) = 1 \text{ for } f(i,j) \geq T$$
$$= 0 \text{ for } f(i, j) < T$$

Where T is the threshold, g (i,j)=1 for image elements of objects and g(i,j)=0 for image elements of the background(or vice versa)
Thresholding is computationally inexpensive and fast, it is the oldest segmentation method and is still widely used in simple applications. Using range values or threshold values, pixels are classified using either of the thresholding techniques like global and local thresholding. Global thresholding method selects only one threshold value for the entire image. Local thresholding selects different threshold values for different regions. To segment complex images multilevel thresholding is required.

3.1.7 Edge Based Techniques

Segmentation Methods based on Discontinuity find for abrupt changes in the intensity value. These methods are called as Edge or Boundary based methods.
Edge detection is the problem of fundamental importance in image analysis. Edge detection techniques are generally used for finding discontinuities in gray level images. Edge detection is the most common approach for detecting meaningful discontinuities in the gray level. Image segmentation methods for detecting discontinuities are boundary based methods

Edge detection can be done using either of the following methods

Edges are local changes in the image intensity. Edges typically occur on the boundary between two regions. Important features can be extracted from the edges of an image (e.g., corners, lines, curves).Edge detection is an important feature for image analysis. These features are used by higher-level computer vision algorithms (e.g., recognition). Edge detection is used for object detection which serves various applications like medical image processing, biometrics etc. Edge detection is an active area of research as it facilitates higher level image analysis. There are three different types of discontinuities in the grey level like point, line and edges. Spatial masks can be used to detect all the three types of discontinuities in an image.
The various reasons that cause intensity changes are

- **Geometric events**
  - object boundary (discontinuity in depth and/or surface color and texture)
  - surface boundary (discontinuity in surface orientation and/or surface color and texture)
- **Non-Geometric events**
  - Specularity (direct reflection of light, such as a mirror)
  - shadows (from other objects or from the same object)
  - inter-reflections

3.2 Ideal edges in an image

- **Step edge:** the image intensity abruptly changes from one value to one side of the discontinuity to a different value on the opposite side.
- **Ramp edge:** a step edge where the intensity change is not instantaneous but occur over a finite distance.

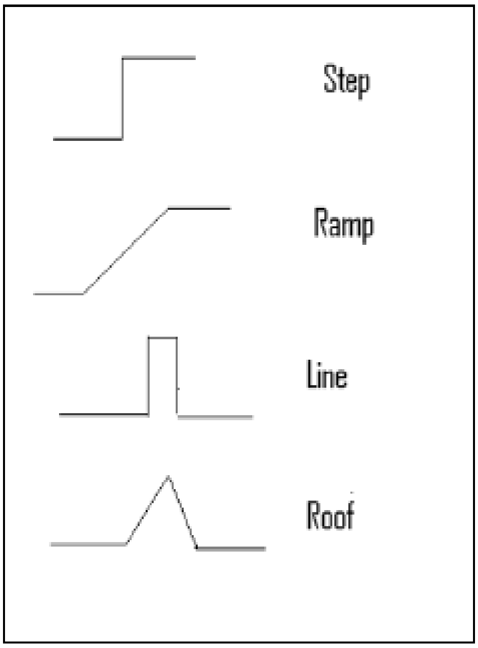

Figure 3.1: Various ideal edges in an Image

- **Line edge:** the image intensity abruptly changes value but then returns to the starting value within some short distance (generated usually by lines).
- **Roof edge:** a ridge edge where the intensity change is not instantaneous but occur over a finite distance (generated usually by the intersection of surfaces).

In typical images, edges are characterized as object boundaries and are therefore useful for segmentation, registration and identification of object in the scene.

An edge is a vector variable with two components magnitude and orientation, where

- Edge magnitude – gives the amount of the difference between pixels in the neighborhood (the strength of the edge).
- Edge orientation gives the direction of the greatest change, which presumably is the direction across the edge

Edge detection, segments the object while filtering the noise while preserving the structural properties of the image. Edge detection becomes difficult in case of noisy images as noise is also a high frequency content According to John canny the following three criterions should be well taken care of while edge detection [19]

1. High probability of marking the real edge point and low probability of marking non edge points
2. The points marked as edge points should be as close as possible to the center of the true edge
3. There should be only one response to a single edge i.e. double line for edges should not be detected

4. REGION BASED METHODS

The region based segmentation means to divide image into same areas of connected pixels through the application of homogeneity/similarity criteria among candidate sets of pixels. Each of the pixels in a region is similar with respect to some characteristics or computed property such as color, intensity and/or texture.

Failure to adjust the homogeneity/similarity criteria accordingly will produce undesirable results. The following are some of them:

- The segmented region might be smaller or larger than the actual
- Over or under-segmentation of the image (arising of pseudo objects or missing objects)
- Fragmentation

Region growing is a simple region-based image segmentation method. It is also classified as a pixel-based image segmentation method since it involves the selection of initial seed points. This approach to segmentation examines neighboring pixels of initial “seed points” and determines whether the pixel neighbors should be added to the region [20]. The process is iterated on, in the same manner as general data clustering algorithms. The fundamental drawback of histogram-based region detection is that histograms provide no spatial information (only the distribution of gray levels).

Region-growing approaches exploit the important fact that pixels which are close together have similar gray values**.**

Region growing approach is the opposite of the split and merges approach.

- An initial set of small areas are iteratively merged according to similarity constraints.
- Start by choosing an arbitrary seed pixel and compare it with neighboring pixels.
- Region is grown from the seed pixel by adding in neighboring pixels that are similar, increasing the size of the region.
- When the growth of one region stops we simply choose another seed pixel which does not yet belong to any region and start again.
- This whole process is continued until all pixels belong to some region.

Region growing methods often give very good segmentations that correspond well to the observed edges

5. REGION-BASED SEGMENTATION

The head purpose of segmentation is to divide an image into regions. Some segmentation methods such as "Thresholding" achieve this goal by looking for the boundaries between regions based on discontinuities in gray levels or color properties. Region-based segmentation is a technique for determining the region directly.

Basic concept of seed points:

The first step in region growing is to select a set of seed points. Seed point selection is based on some user criterion (for example, pixels in a certain gray-level range, pixels evenly spaced on a grid, etc.). The initial region begins as the exact location of these seeds.

The regions are then grown from these seed points to adjacent points depending on a region membership criterion. The criterion could be, for example, pixel intensity, gray level texture, or color.

Since the regions are grown on the basis of the criterion, the image information itself is important. For example, if the criterion were a pixel intensity threshold value, knowledge of the histogram of the image would be of use, as one could use it to determine a suitable threshold value for the region membership criterion.

Some important issues:

Then we can conclude several important issues about region growing are:

1. The suitable selection of seed points is important.
2. More information of the image is better.
3. The value, “minimum area threshold”.
4. The value, “Similarity threshold value“.

Merits and Demerits of Region Growing

We have some pros and corns of region growing.

Merits

1. Due to Region growing methods we can correctly separate in a accurate method.
2. It can provide the original images which have clear edges the good segmentation results.
3. This is very easy theory. to represent the property we need a small numbers of seed point.
4. We can decide the seed point and the criteria we want to make.
5. At a time we can multiple criteria.
6. It performs well with respect to noise.

Demerits

1. It is time and power consuming process.
2. Noise or variation of intensity may result in holes or over segmentation.
3. We can not change the real shades of image

We can conquer the noise problem easily by using some mask to filter the holes or outlier. So that, the problem of noise actually does not exist.

6. PROPOSED ALGORITHM

Step 1. Input a color image.
Step 2. Select seed point manually from image.
Step 3. Add seed point to the temporary buffer.
Step 4. Evaluate step 5to 7 for each color index.
Step 5. For specific color index evaluate the four neighbors and add them to foreground or background on the basis of following condition

If (gray (p_c) – gray(s))/gray(s) ≤ 0.5
  Add gray (p_c) to foreground;
Else
  Add gray (p_c) to background;

Where gray (p_c) is the color of current point and gray(s) is the color of seed point selected in step 2.

Step 6. Repeat step 5 till all the pixels of image are processed once.
Step 7. Alter the gray values in proportion to mean gray of foreground to make it more brighten.
Step 8. Display all the segmented partitions individually and foreground background framing and image.

7. EVALUATION CRITERION

With the increase in the number of developed algorithms for image segmentation, evaluation criterion for studying of segmentation is required. The criterion used for comparing image segmentation algorithms presented in this article, is based on computing precision, recall and F1. These three parameters determine the algorithms efficiency by comparing boundaries their segments. Each of the algorithms is compared with segmentation by a human. Based on this comparison, precision, recall and F1 are computed. The definition of precision, recall and F1 is given by [21]:

$$P= C / C+ F * 100 \% \quad (7.1)$$
$$R= C/ C+M *100 \% \quad (7.2)$$

Where C is the number of correct detected pixels that belongs to boundary, F is the number of false detected pixels and M is the number of not detected pixels. F1 is combined measure from precision and recall. It is in high values if both precision and recall have high values and on the other hand, if one of them has low value, the value of the F1 is going down. The definition of F1 is given by:

$$F1 = 2PR / P+R * 100 \% \quad (7.3)$$

8. RESULTS AND COMPARISONS

8.1 Results

In this work I have implemented my algorithm on three different images using manual seed slelection. The the average results of all images is compaired

ISSN: 2321-8169
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with the results of other algorithms.

Fig. 8.1 Input Image

Fig. 8.2 Input Image

Fig.8.3 Input Image

8.2 Comparisons

Fig. 8.1 Average Results of Image Segmentation Algorithms

Avg Results	EGA (%)	KMA (%)	MSA (%)	EMA (%)	HA (%)	RGES (%)
P	30.2	22.1	20.4	12	14.2	40.68
R	16.1	10.7	12.5	9.9	11	53.19
F1	20.9	14.4	15.4	10.8	12.4	45.04

Table 8.1 Average Comparison of various segmentation algorithms

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