A Survey on Color Image Segmentation Techniques for Melanoma Diagnosis

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Abstract

Image segmentation is an important process in Melanoma diagnosis. It divides the image into segments which provides a better path for extracting features and classifying them accordingly and so far many literatures have explained how the segmentation has been carried out for gray scale images. Though most algorithms have been written for gray scale images it is not necessary that we must stick on only to that instead we can also use color images directly for segmentation process. On doing so, variation in color can be used as an important feature for melanoma diagnosis. Color is a unique feature which can be used to provide a distinct differentiation between Melanoma and Benign. Hence on applying this color image segmentation, earlier detection can be done easily. This literature presents a survey on existing techniques for color image segmentation. Color images when segmented directly, yields better differentiation between the lesions.

Keywords: Benign, Color Image Segmentation, Gray Scale Images, Melanoma, Segmentation

1. Introduction

Many algorithms exist for Color image segmentation. Many color spaces are available in image processing in which color image segmentation is carried out. The color spaces available for segmentation described by¹ are:

- RGB
- HSI
- CIE
- MUNSEL

Colors are to be made which are independent of changes in intensity of lights while performing color image segmentation. Intensity variations are to be captured by an efficient method across the distribution of spectral. Normalized RGB color space is expressed as:

\[ r = R/(R + G + B) \]
\[ g = G/(R + G + B) \]
\[ b = B/(R + G + B) \]

The third component is found when two components are known because \( r + g + b = 1 \). Distribution sensitivity to the color variability is reduced by normalization. Illumination change does not affect it. If the colors that are normalized fall below low intensities they appear to be very noisy because of a nonlinear transformation to normalized RGB space from RGB space. HSI system is also one among the usually employed color space in image processing. Some categories of HSI system are:

- HSB
- HSL
- HSV

Separation of image’s color data from its intensity data is done by HSI system. Saturation and hue values denote the color information and brightness of the image is described by the intensity. Basic colors are represented by hue which is found by dominant wavelength present in the light wavelength’s spectral distribution. The saturation signifies the quantity of white light combined with hue and it is a purity measure of the color. The coordinates of HSI can be converted from RGB space. The equations are:

\[ \text{Hue} = \arctan \left( \frac{\sqrt{3}(G - B)}{(R - G) + (R - B)} \right) \]
The intensity of an image can be calculated as:

\[ \text{Intensity} = \frac{R + G + B}{3} \]  

(5)

The saturation can be defined as:

\[ \text{Saturation} = 1 - \frac{\min(R, G, B)}{I} \]  

(6)

The two prominent CIE color spaces are:

- \( L^* a^* b^* \)
- \( L' u' v' \)

\( L^* a^* b^* \) is denoted as

\[ L^* = 116 \left( \frac{Y}{Y_o} \right) - 16 \]  

(7)

\[ a^* = 500 \left( \frac{X}{X_o} \right) - \left( \frac{116 Y}{Y_o} \right) \]  

(8)

\[ b^* = 200 \left( \frac{Y}{Y_o} \right) - \left( \frac{116 Z}{Z_o} \right) \]  

(9)

\( L' u' v' \) is denoted as

\[ L' = 116 \left( \frac{Y}{Y_o} \right) - 16 \]  

(10)

\[ u' = 13L'(u' - u_0) \]  

(11)

\[ v' = 13L'(v' - v_0) \]  

(12)

The mathematical equations for hue, intensity and saturation are:

For \( L^* a^* b^* \)

\[ \text{Hue} = \arctan \left( \frac{a^*}{b^*} \right) \]  

(13)

\[ \text{Intensity} = L^* \]  

(14)

\[ \text{Saturation} = \sqrt{((a^*)^2 + (b^*)^2)} \]  

(15)

For \( L' u' v' \)

\[ \text{Hue} = \arctan \left( \frac{u'}{v'} \right) \]  

(16)

\[ \text{Intensity} = L' \]  

(17)

\[ \text{Saturation} = \sqrt{((u')^2 + (v')^2)} \]  

(18)

Cylindrical coordinate system having H, C and V can be used for representing the Munsel Color space which is analogous to HSI space. Munsel color system cannot be converted to CIE system by any formulas. Therefore for mapping the real color signals into Munsel space a method is required.

The design of the paper follows the pattern as described below. Section II contains the study of color image segmentation techniques which describes about the algorithms used for color image segmentation. Section III contains the results describing the need for color image segmentation. Section IV gives the conclusion.

2. Study of Color Image Segmentation Techniques

In hill-climbing segmentation technique is used. Hill climbing algorithm is used to detect the region of interest in CIE’s color channels \( L^* a^* b^* \). Count of histogram bins and the image are taken as input arguments by HCA for every dimension. HCA returns a label which denotes a color cluster. 3D color histogram is computed for input image. With this algorithm, most appropriate peaks are found in uphill move. The given image is generally divided into 2 regions by this method as lesion and background skin. Peaks are detected globally by hill climbing algorithm in 3D color histogram. It is a search window algorithm which runs over the n dimensional space of the histogram for finding biggest bin in that window. It is a non parametric simple and fast algorithm. In K-means clustering technique is used. On the basis of certain characteristics, K mean clustering method tries to identify groups of similar respondents. The required number of segments or clusters is specified by the analyst. The distance between the centre of the cluster and the respondent is calculated. The process is repeated continuously till the maximum distance between the centers of the cluster is achieved. Respondents are allocated to the cluster which has the nearest center. Segmentation takes place in two stages. For enhancing the medical images through color separation, decorrelation stretching is used. The second step is grouping of regions into two classes. High level of differentiation can be achieved with this method. This technique is implemented to overcome segmentation process of low level images. It is fast, straightforward technique. It is based on heuristic partitioning and unsupervised iterative method. In Radial Search algorithm is used for segmentation. Border of a lesion can be detected more accurately with the help of this algorithm. Intensity lesion image is formed by converting the image's
pixels. The initial point is considered as the center of the intensity lesion image. N radial lines are emerging from the center equally at an angle of \((360/N)\) degrees. The border points are found by radial search technique in an independent way, for tracing the border based on the border point of the nearest neighbor. Along each radial line the border point are searched by the algorithm. Radial search expressions are:

\[ h(x_l, y_l) = \forall m: \arg \min\{h(x_l, y_l)\} \]  
\[ x_l = x_0 + r_l \cos(\theta_m) \]  
\[ y_l = y_0 + r_l \sin(\theta_m) \]  
\[ r_l = 0 \ldots M \]  
\[ \theta_m = 0 \ldots 2\pi - \Delta\theta \]

When candidate points are not found for specific radius then failure occurs. The boundaries on the inner side are found using this algorithm. Computation time is reduced when this method is used.

In\(^{15-17}\) graph theoretic color image segmentation technique is used. He presented this method to improve the performance of normalized cut segmentation method. This technique uses a weighted directionless graph with an image. The regions are represented by the nodes. Neighboring region's intensity match is represented by the weights present between the two nodes. Over segmentation problem was solved by this method. Graph theory produces some tools to solve the problems in the spatially discrete space. The image's low variability features are preserved by this technique. In\(^{18-22}\) Markov Random fields segmentation technique is used. Edge detection algorithm is used to implement the line process. Edges are detected with the help of vector angle measure. MRF model is evaluated by parameter estimation method. MRF is a theoretical process which specifies the image's local characteristics and true image is reconstructed when it is combined with the data given. Pre specified feature set of scan points are used by MRF. More time and computing power are required. In\(^{23-27}\) Fuzzy Color image segmentation method is used. This algorithm is based on fuzzy dissimilarity and fuzzy divergence. Eigen vectors of sub images are extracted using watershed algorithm. Clusters are created and FCM is applied on each cluster. It is a twofold process. The effect of noise is compensated by integrating local image feature's spatial information with membership function and similarity measure. Without smoothing the image more accurate segmentation is obtained by introducing an anisotropic neighbourhood which is based on features of phase congruency. For both real and synthetic images segmentation results are obtained. This method is more immune to noise. Fuzzy C means is the most analytic approach for clustering. This method does not work well with local irregularities which generally occur on real time images. This is a supervised learning technique. In\(^{28}\) an improved Fuzzy C means algorithm is proposed. This algorithm introduces a kernel metric and trade-off weighted fuzzy factor. Based on neighboring pixel's space distance and their difference on gray-level, the trade-off weighted fuzzy factor value arrives. This factor is used to estimate the neighboring pixel's damping extent. Kernel distance measure is introduced to the objective function to enhance robustness for outliers and noise. Fast bandwidth selection rule is used to determine the parameter of the kernel based on variance of distance of all data points present in the collection. In\(^{29-32}\) FLANN technique is used for segmentation. The color distribution disparity is reduced by using an averaging filter of order 3*3. HSV conversions are used to convert the pixels to RGBSV space. To give the result of the cluster, Fast Learning Artificial Neural Network clustering is done. Separation is done for the pixels which are of same color. Each segmented image is assigned a number. More accurate results are obtained using this method. This is generally a clustering method which produces the result as cluster of original image. The same colored pixels are separated. This is generally used to find the matches between the most closest neighbour with high accuracy. In\(^{33-36}\) Mean Shift Algorithm is used for segmentation. It searches for typical estimation of centers of color clusters. A non parametric model is used for characterizing the segments developed by Mean Shift Algorithm. The result is a cluster, where the data of the image is portrayed into a feature space. This technique is very simple and needs only less computational power. This is an unsupervised learning technique. In\(^{37}\) the Mean Shift Algorithm is modified and a new method is proposed. The method is of three steps. The images are mapped to the feature space taking into consideration both local homogeneity and global color information. The peaks are obtained by applying this method. The pixels are assigned to each cluster after post processing. In\(^{38-40}\) multiregion model is used for segmentation of regions. Exclusion and inclusion of geometric constraints are enforced in the regions which paves the path for correct segmentation even in the presence of identical intensity
distribution. The segmented results are not dependent on initialization since this method rely on global optimization technique. This technique is generally used when there is a huge amount of data. In\textsuperscript{[1-4]} JSEG algorithm is used for segmenting color images. J-images matches to local image's measurements in homogeneities at various scales. The peaks in the image correspond to the boundary locations and valleys correspond to homogeneous regions. In order to obtain segmentation, regions are grown from the j-image's valleys by spatial segmentation algorithm. The colors present in the image are quantized without degrading the quality of color. The desire is to derive certain representing colors which are used to discriminate neighbouring regions. Good quantization of color is more important in the process of segmentation. At each scale value of \( j \) decreases. This is due to over segmentation of the image. This over segmentation problem may occur due to error in selection of seed. This aims at mapping the image to a structure and a class label is assigned to every pixel. This segments only images which have homogeneity.

### 3. Results

Various color image segmentation techniques which are used in the diagnosis process of Melanoma are stated in this study. These techniques gives more accurate results on giving color image as an input rather than converting it to gray scale form and makes the process simpler and easier, which paves the way for earlier detection of melanoma. Reliability is attained for the image segmentation process using color images rather than gray scale images. In various applications, using the hue feature gives successful results. When intensities are low it must be applied with care. Color acts as a key distinguishing feature for differentiating Benign and Melanoma. Hence when color image segmentation is used melanoma can be identified easily.

According to the survey, K means clustering, Markov fields and Fuzzy C means, Mean shift algorithm and JSEG algorithm are most widely and frequently used algorithms for color image segmentation. More accurate results are obtained when these methods are implemented in segmentation step.

### 4. Conclusion

In this paper, various methods are discussed for Melanoma diagnosis using color image segmentation. Color image segmentation is more useful than gray image segmentation since color is a unique feature which differentiates benign from melanoma easily. Hence it can be concluded that color images when segmented directly give more accurate and clear result when compared to gray scale images. K means clustering, Markov fields and Fuzzy C

### Table 1. Color image segmentation techniques

| Methods                        | References                                                                 |
|--------------------------------|-----------------------------------------------------------------------------|
| Hill-climbing segmentation     | Fondon et al.\textsuperscript{2}, Ding et al.\textsuperscript{3}, Goyal\textsuperscript{4}, Ohashi et al.\textsuperscript{5}. |
| K-means clustering technique   | Salunke\textsuperscript{6}, Bhuian et al.\textsuperscript{7}, Muthukannan.K et al.\textsuperscript{8}, Dubey et al.\textsuperscript{9}, Burney S.M. et al.\textsuperscript{10}. |
| Radial Search algorithm        | Nandini et al.\textsuperscript{11}, Lacerda et al.\textsuperscript{12}, Shaikh et al.\textsuperscript{13}, Swamy M.S.\textsuperscript{14}. |
| Graph theoretic color image segmentation | Cigla et al.\textsuperscript{15}, Peng et al.\textsuperscript{16}, Basava Prasad B\textsuperscript{17}. |
| Markov Random fields segmentation | Wesolkowski et al.\textsuperscript{18}, Sharif et al.\textsuperscript{19}, Held et al.\textsuperscript{20}, Anguelov et al.\textsuperscript{21}, Sziranyi et al.\textsuperscript{22}. (2000) |
| Fuzzy Color image segmentation | Yaju et al.\textsuperscript{23}, Despotović\textsuperscript{24}, Chaabane S et al.\textsuperscript{25}, Capitaine et al.\textsuperscript{26}, Borji A et al.\textsuperscript{27}, Gong et al.\textsuperscript{28}. |
| FLANN technique               | Zhang et al.\textsuperscript{29}, Khan\textsuperscript{30}, Kim et al.\textsuperscript{31}, Farooque et al.\textsuperscript{32}. |
| Mean Shift Algorithm          | Comaniciu et al.\textsuperscript{33}, Sudhamani M.V et al.\textsuperscript{34}, Ozden et al.\textsuperscript{35}, LeBourgeois et al.\textsuperscript{36}, Wang et al.\textsuperscript{37}. |
| Multiregion model for segmentation | Ulen et al.\textsuperscript{38}, Manipoonchelvi et al.\textsuperscript{39}, Ugarriza et al.\textsuperscript{40}. |
| JSEG algorithm                | Vartak et al.\textsuperscript{41}, Deng et al.\textsuperscript{42}, Geng et al.\textsuperscript{43}, Ilea E et al.\textsuperscript{44}, Kumar V et al.\textsuperscript{45}. |

![Figure 1. Comparison chart for Color image segmentation techniques.](image-url)
means, Mean shift algorithm and JSEG algorithm are most widely algorithms in color image segmentation. Accuracy is high when these algorithms are applied.

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