Image Segmentation Using 2-D Histogram in RGB Color Space in Digital Libraries

El Asnaoui Khalid, Aksasse Brahim, Ouanan Mohammed

***Abstract*—**This paper presents an unsupervised color image segmentation method. It is based on a hierarchical analysis of 2-D histogram in RGB color space. This histogram minimizes storage space of images and thus facilitates the operations between them. The improved segmentation approach shows a better identification of objects in a color image and, at the same time, the system is fast.

***Keywords*—**Image segmentation, hierarchical analysis, 2-D histogram, Classification.

I. Introduction

IMAGE segmentation is a task in image processing aiming at partitioning a digital image into multiple objects which share some common properties [1]. Images segmentation are now used in many different areas. Among its practical applications are content based image retrieval, storage and management, robotics, localization and mapping, medical imaging, traffic control systems, and machine vision, etc. Recently, a number of image segmentation algorithms have been developed [2]. These algorithms have proven to be successful in many applications, but none of them is generally applicable to all images, and different algorithms are usually not equally suitable for a particular application [3].

The good performance of recognition algorithms depends on the quality of the segmented image. Despite the full of algorithms which have been developed up to now, it is difficult to find a segmentation method that can bring perfect results for all images and as well as the human visual system, because the shape of objects and image quality greatly influences the segmentation result.

The present work describes an improved method for color image segmentation. The subsequent sections are arranged as follow: A review of previous related work is presented in Section II. The relation between image segmentation and digital libraries is discussed in Section III. In Section IV, we study the image segmentation by hierarchical analysis of 2-D histogram. We conclude this paper by giving some results and conclusions.

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II. Related Work

Image segmentation is an active area of research in image analysis and computer vision for more than 30 years. In this section, we will briefly outline some of the already developed methods as described in the literature.

Clément et al. [4] presented an unsupervised algorithm for the segmentation of scenes containing vegetation and soil. It is based on a hierarchical analysis of 2-D dimensional color histograms. The classification algorithm based on hierarchical analysis of RG-histogram has proved to be a suitable tool for the segmentation of scenes containing vegetation and soil. It gives results about identical to those obtained with a neural network classifier, with the advantage that it is unsupervised, and needs no learning phase. Operating here to classify RGB images, it can be used in the frame of other colorimetric spaces, and can be extended to the case of multi-spectral data.

The technique given by [5] proposes to use a method for unsupervised segmentation of color images. It is based on a hierarchical analysis of compact color histograms. Each mode of the histogram is a core class, where the number of corresponding pixels is greater than or equal to an arbitrary threshold. Generalized to n dimensions, using the nD histogram compact without data loss can significantly reduce the memory space occupied. Consequently, segmentation can be performed without requantization of colors in the color space considered in the classification phase. It is shown that, for color images using the 3D histogram compact leads to better segmentation than those of 1-D or 2-D histograms.

Masmoudi et al. [6] developed an approach of color image segmentation, which is based on the analysis of 2-D histogram using HSV space. The method was applied to various synthetic and real images to prove the performance of segmentation algorithm. Additionally, the method was applied to a particular agricultural application to separate the vegetation and soil. The obtained results have been compared to the methods of others, and shown to be more satisfactory than those obtained either by 1-D histogram using HSV or by 2-D histogram using RGB space.

Image segmentation has grown in recent years and rapidly became color-oriented, since most of the images are colors.

III. Relevance of Image Segmentation for Digital Libraries

In this section, we present briefly the relation between digital libraries, image segmentation, and Content-Based Image Retrieval.

The problem that digital libraries encounter is close to the problem faced by the search engines. Indeed, the problem is not to retrieve information because the communication means allow quick and reliable access, but to find it among millions of potential candidates. Generally, what is proposed is a catalog access to scanned images; access made possible through the establishment of research tools functioning by keywords. The establishment and access to these digital libraries allow introducing two important concepts that are images indexing and the concept of aid to navigation. These two concepts are complementary.

The concept of aid to navigation touches the accessibility problem of information sought in a mass consequent size data.

Indexing is to find a way to associate to the images relevant information (metadata about the book, word index, illustrations index...). The indexing phase is intended to extract a large amount of information that must be analyzed and structured, eventually allowing access to what user search. There are two ways of apprehending indexing. The main question is how to extract information from images of scanned texts? Some digital libraries have chosen to manually index their images while others use solutions including automatic indexing. In the first case, digital libraries take an approach of writing visual content in a text form (using keywords). These keywords serve as an index to access to the associated visual data. The advantage of this approach is that it provides access to databases by using standard query languages, such as SQL. However, this method requires a large amount of manual processing. Furthermore, the reliability of descriptive data is not provided: they are subjective and may not accurately describe the contents of the image. To solve these problems, Content-Based Image Retrieval (CBIR) systems are introduced. The aim of CBIRs systems is to represent images using only digital visual content of the image (color, shape, and texture). But this approach is not simple to implement. Indeed, the scanned documents are often in poor condition, badly scanned and / or an alphabet that does not allow to easily find the text in images.

Many systems use segmentation to calculate image features to construct (CBIR) systems [7]- [9]. In fact, the segmentation step is obligatory to extract information from images. Indeed, how is it possible to get an object in an image without first extracting its own regions? Several kinds of segmented region may be extracted according to the homogeneity criteria used such as color, shapes. Many approaches are recently developed and many of them propose an adapted, new, and optimized version of some well-known classical algorithms.

Even if a segmentation step is required in a feature extraction process, the expected results from this low level process still have to be discussed. Of course, if the segmentation succeeded to extract semantic regions, the discussion will be close. If we consider the semantic extraction impossible, we must first estimate the robustness of this segmentation step to select the appropriate settings when really function extraction. Nevertheless, at this point of research in image retrieval by content, the question of using or not using segmentation may be requested. And, in this case, which method or approach may be used. Whatever these interrogations are often inquired, few objective studies permit to answer it.

Our goal in this paper is to use color image segmentation and is not to set up a new algorithm but this paper must be considered firstly as an amelioration step to overcome some drawbacks encountered in [4]-[6] and shortly we will use this segmentation algorithm to index digital libraries [10], [11].

IV. Improved Image Segmentation

A. Construction of 2-D Histogram

A 2-D histogram of a color image A is a map of value $p(x_1, x_2)$. Each value is the number of pixels in A image presenting the colorimetric components (x_1, x_2). Since each colorimetric axis of image A is quantified on 256 levels, the 2-D histogram p_n can be represented by an image B whose spatial resolution is equal to 256 x 256. The value p_n (x_1, x_2) of the pixel of coordinates (x_1, x_2) in B is obtained by a linear dynamic contraction of the histogram between 1 and M=min (pmax, 255) [4]:

$$p_n(x_1, x_2) = round \times \left[\frac{(M-1) * p(x_1, x_2) - M * p_{\min} + p_{\max}}{p_{\max} - p_{\min}} \right] \quad (1)$$

where p_{min} and p_{max} are the minimum and maximum values of p. Using this representation, the 2-D histogram analysis can be performed using the tools developed for grayscale images. Prior to normalize the histogram to be the B image, a filter is necessary to smooth the image by deleting the small local extrema. A two-dimensional Gaussian filter is used:

$$G(x, y) = \frac{1}{\sqrt{2\pi\sigma}} e^{\left(-\frac{x^2+y^2}{2\sigma^2}\right)} \quad (2)$$

The size of the convolution mask is [2K +1, 2K +1], 99.9% of area under the gauss curve will be taken into account by taking:

$$\sigma = \frac{2K+1}{6} \quad (3)$$

However, this mask cannot be only considered as Gaussian for sufficiently high values of K.

B. Classification by Hierarchical Analysis of 2-D Histograms

Classification methods by analyzing of 2-D histograms have the advantage of producing segmentation without a priori knowledge of the images. In particular, the classification by hierarchical analysis of 2-D histogram has an interest compared to other classification methods [4]. Indeed, it requires no color re-quantization of the images. Furthermore, it is tolerant on the values of its parameters and shows some noise resistance [12]. The algorithm is composed of two steps: the first step involves learning and the second concerns the decision step [4].

a. Learning Step

Learning step consists in a hierarchical decomposition of the gray levels in the B image. For each gray level P_n on the B image, the peaks are identified with a connected component labeling whose peak values are greater than or equal to P_n. Each peak is then decomposed iteratively into finest peaks with gray level between 0 and 255. A peak is labeled as significant if it represents a population greater than or equal to a threshold S. This threshold is expressed as a percentage of the total population in the B image.

V. Experimental Results

In this section, we apply the segmentation algorithm to RGB color image based on hierarchical analysis of the 2-D histogram [13].

A. Segmentation Results

We consider a synthetic color image used in [14] and [15] in order to evaluate the segmentation on one hand, and on the other hand to test the validity of the programming step. Fig. 1 (a) shows a synthetic image of 280x281, which contains four forms (circular, square, or random form) with different colors. The circular region includes two forms, which differ only by the variation of the saturation component. The image then contains six classes if background is considered.

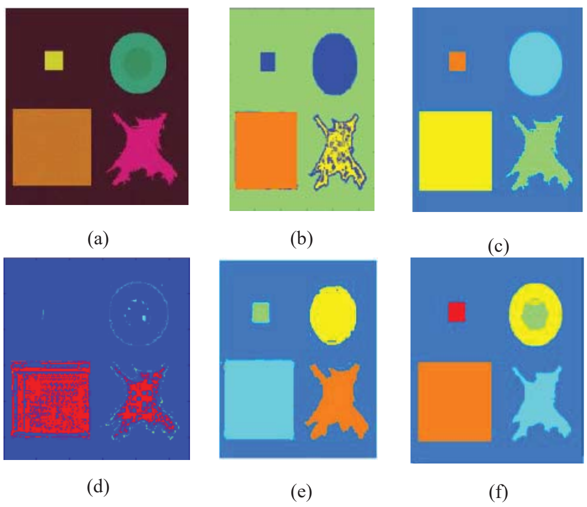

Fig. 1 Segmentation results: (a) Original image, (b) RB-histogram method, (c) RG-histogram method [4] (d) GB-histogram method (e) Sural's method (f) The improved method

We compared the improved method with the Sural's one [16] and hierarchical segmentation by 2-D histogram analysis in RGB space [13]. Two regions that differ in the variation of the saturation pose problem to the segmentation methods. Often two distinct colors are merged. The method of segmentation by classification based on 2-D histogram in RGB space fails to separate the two circular shapes (Fig. 1 (b)-(d)) [6]. The same problem arises when we applied the 1-D histogram method in the HSV space.

B. Implementation

The implementation of the improved technique is done in MATLAB 2009a using computer with Processor: Intel(R) Core (TM) 2 CPU T5200 @ 1.60 GHz, 1.60 GHz, 2Go RAM running on a Microsoft Windows 7 Professional (32-bit). In this section, we report the response time. The results obtained are given in Table I.

TABLE I
Comparison according to Elapsed Time in Seconds

Image / Method	Square [6]	Mandrill image [6]	Synthetic image (Fig. 1)	Real image [6]
Masmoudi 's method [6]	*7.365*	*105.085*	*11.107*	*95.649*
The improved method	*1.328*	*19.18*	*2.564*	*7.282*

C. Comments

Fig. 1 presents experimental results. The improved approach (Fig. 1 (f)) provides a better image segmentation and the problem of two circular forms is resolved. We recall that [6] and [5] showed that the Clément et al.'s method [4] fails in segmenting the two circular regions. Furthermore, we demonstrate that our method is faster than Masmoudi et al.'s method [6] according to the elapsed time (Table I).

D. Segmentation's Evaluation

In order to evaluate the segmentation algorithm, we use the Q function [17], [18].

$$Q(I_s) = \frac{1}{10000\ \mathrm{N}} \sqrt{R} \times \sum_{i=1}^{R} \left(\frac{e_i^2}{1 + \log N_i} + \frac{R(N_i)^2}{N_i^2} \right) \quad (4)$$

I_s is the segmented image, N is the image size, R is the number of regions of the segmented image, N_i is the area of the ith region, R (N_i) is the number of regions having an area equal to Ni, and e_i is the average color error of the ith region, which is defined as the sum of the Euclidean distances between the RGB color vectors of the pixels of the ith region and the color vector attributed to the ith region in the segmented image. The smaller the Q value, the better the image segmentation method.

TABLE II
Values of Evaluation Function 'Q' for Various Images

	Square [6]	Mandrill image [6]	Synthetic image (Fig. 1)	Real Image [6]
Clément's method [4]	35 ,506	52128	8080,9	8765,8
Masmoudi's method [6]	33 ,065	17367	721,7661	6466,8
The improved method	31,764	17050	700,367	6401,246

Finally, to evaluate the improved method, we have used the 'Q' evaluation function equation (4). From Table II, it can be seen that the improved method performs better than the analysis of 2-D histogram using RGB space [4] and Masmoudi's method [6].

VI. Conclusion

In this paper, we have developed an improved approach of color image segmentation, which is based on the analysis of 2-D histogram in RGB color space. The method has been applied to various synthetic and real images to demonstrate the performance of the algorithm for image segmentation. The results are compared with other methods, and shown to be more satisfactory than those obtained either by Sural's method or by 2-D histogram using HSV space [6] or [4].

The results obtained indicate that the improved approach might be considered as a solution for the development of color image segmentation.

In future, the performance may be improved using more kind of images, and other colorimetric distances and shortly we will use this segmentation algorithm to index digital libraries [10], [11].

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