Quantization of Images based on Color Levels in Histogram

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Abstract

In this paper, developed an algorithm of image quantization based on histogram distribution. Aim of study presented an algorithm that working on separating regions of images depending on real brightness ranges of colors in the histogram representation and color intensity distribution. The new way of image quantization represented lead to avoiding overlap of regions and reducing calculation’s complexities for image segmentation that followed image quantization stage, where it’s acts main steps in Image analysis and preprocessing. The proposed algorithm providing high accuracy of image quantization comparing with the methods of quantization presented recently.

Keywords

Image Processing, Histogram Distribution, Image Quantization, Local minima.

Introduction

Image segmentation (Kaur et al., 2015) process needs high requirements of hardware resources for getting separation of image regions in limited time and high accuracy. Therefore quantization of images (Inampudi, 1999) as preprocessing stage having an important role in preparing these images by eliminating unimportant details, and noise from quantized homogenous areas that by results, reducing forward required resources and calculation's time of segmentation. Decreasing of processing resources will inflect for reduction of costs of technique's manufacturing used for image processing applications that already having a wide use in many fields like data analysis (Borodkin et al., 2006), medicine (Rincon-Montes, 2013), Drones and applications of ERS images (Dey et al., 2010). Additionally, in this study, presented efficiency of suggested algorithm in increasing accuracy of image segmentation results and stability of regions and segmentation, other words the number of segments. At the same time, in many tasks, including edge detection (Yekeen, & Ibiyemi, 2018), objects detection tasks (Hammed et al., 2021) and image compression (Esakkirajan, 2008), a reduction in segmentation accuracy is permissible, that's means loss of parts having a size less than specified, to increase its speed and reduce memory requirements.

The aim of the work is to evaluate the effectiveness of the algorithms of image quantization, which discussed. Separation of regions is implemented depending on gray-color ranges in histogram by choosing peaks in local minima ranges that acts the highest points for color repeated in these ranges of intensity. This way is with speed time of processing, as far as of calculation complexities.

Related Work

For image quantization methods presented (Halder, & Pramanik, 2012) many algorithms (Delon et al., 2007) that lacking for accuracy in rebuilding of image after quantization process, also almost of these algorithms using histogram representation of image as base for calculations of homogenous regions (Daniel, & Neelima, 2012). Where incorrect event for this step acts the homogenous region's calculation that depends on restriction values of pixels in processed region. Limitation range associated with the highest repeated pixels in this region considered in suggested algorithms that got by histogram distribution, other quantization algorithms (Wider et al., 2011) used two thresholds values for restriction pixel's values of regions or one constant threshold (T), that represent range of brightness for each region (example T-value<=5). Also presented in literature algorithm that using local minima and local maxima distribution depending on histogram of image (Taylor, & Woodard, 2017) that not effective with various of high resolution images especially ERS images (Puzicha et al., 2000).

Mentioned recent algorithms (Krstinic et al., 2011) having disadvantages, can be refer by decreasing the stability of region's areas, for quantized imaged by comparing it with input image that considers as the main factor (parameter) for measuring efficiency of the quantization algorithms. Also, difference the number of segments of processed image that leading to losing in details of quantized image.

Algorithm Image Quantization based on Histogram Distribution

The proposed algorithm of image quantization working on based of histogram distribution (Lezoray, & Cardot, 2002) for color brightness in the image, where determining the highest point of repeated color value in the ranges of local minima (Ibraheem, & Khan, 2013), showing in Fig. 1, then through quantization of image, rebuilding the regions of the image by giving the highest peak value for the colors values in this range, that will result an quantized images with homogenous regions, what a distinguish of this algorithm that is more accurate than automatic quantization of images (Schroff et al., 2006) that causes overlap in edges of regions. Used in this way a Modified-standard code of Matlab library for getting of histogram representation (Carey et al., 1999).

Algorithm's implementation depends on tow mainly steps, start with Finding the values of peaks points for the highest repetition (repeated) pixels in each region of the input image by generating an automatic histogram (distribution) of the image, Fig. 1. Second step rebuilding new regions of homogeneous areas of image, and process the overlapping of borders between regions.

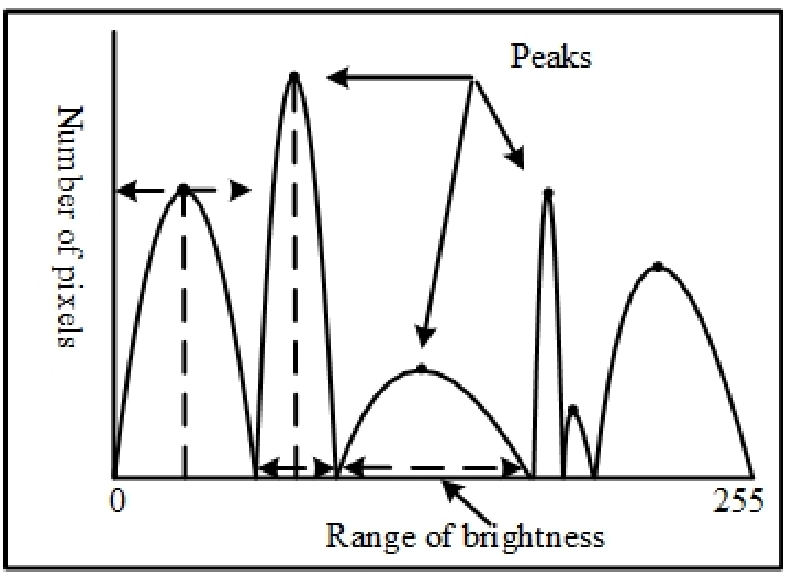

Fig. 1 Histogram of the input image - choosing of local minima

The process of proposed algorithm of quantization implemented by steps below, Fig. 2:

1. Initialization of the probability vector of pixel brightness values (histograms) of the original image. To each element $g(q)$ there are $G = \|g(q)\|_{(q=\overline{0,Q-1})}$ probability vector of pixel brightness values of the original image $I = \|i(y,x)\|_{(y=\overline{0,Y-1},x=\overline{0,X-1})}$

assigned a value 0 ($g(q) \leftarrow 0$ for $q = \overline{0, Q-1}$), where Q – number of quantization levels; Y, X – image dimensions vertical and horizontal.

2. Initialization of the values of thresholds for localization of histogram maxima. Set the value of the brightness thresholds Δ_E and probabilities of pixel brightness values Δ_G. These values determine the number and area of segments allocated as a result of wave region grown.
3. Histogram Formation. Elements of the probability vector G of pixel brightness values of the input image I, that are changing in accordance with the expression:

$$g(i(y,x)) \leftarrow g(i(y,x)) + 1 \quad (1)$$

For $y = \overline{0, Y-1}$, $x = \overline{0, X-1}$.

4. Allocation of local histogram maxima.

4.1 Initialization of the values G_{MAX} and coordinates E_{MAX} of the current local maximum using expressions $G_{MAX} \leftarrow g(0)$, $E_{MAX} \leftarrow 0$.

4.2 Initialization of the vector $E_G = \|e_G(k)\|_{(k=\overline{0,Q-1})}$ coordinates of the current local maximums of histogram using expression $e_G(k) \leftarrow 0$, for $k = \overline{0, Q-1}$.

4.3 Initialization of the value q, cycle counter and k local maximums of histogram using expression $q \leftarrow 1$, $k \leftarrow 0$.

4.4 Start the cycle of searching for local maxima of the histogram. Checking the conditions for fixing the value of the current local maximum of the histogram

$$(q - E_{MAX} \geq \Delta_E) \vee (g(q) - G_{MAX} \geq \Delta_G) \Rightarrow$$

$$\Rightarrow (e_G(k) \leftarrow E_{MAX}), (G_{MAX} \leftarrow g(q)), (k \leftarrow k+1), (E_{MAX} \leftarrow q), (\text{go to step 4.6}).$$

4.5 Checking the overriding condition for the value of the current local maximum of the histogram

$$(g(q) > G_{MAX}) \Rightarrow (G_{MAX} \leftarrow g(q)), (E_{MAX} \leftarrow q). \quad (2)$$

4.6 The increment of the q-value of the loop counter using the expression $q \leftarrow q+1$

4.7 Checking the end condition of the cycle. If the condition $q < Q$ is satisfied, then go to step (4.4). If this condition is not satisfied, the loop is exited and the completion of step (4) allocating local histogram maxima.

5. Fixing the number of local maxima of the histogram. The number K of local maxima of the histogram is determined by the current value of the counter k by using the expression of vector length of local maxima of the histogram.
6. Localization of local maxima of the histogram of pixel brightness in the image.

6.1 Initialization of zero matrices $E_L = \left\| e_L(y,x) \right\|_{\left(y=\overline{0,Y-1}, x=\overline{0,X-1}\right)}$ and vectors $Y_L = \left\| y_L(p) \right\|_{\left(p=\overline{0,YX-1}\right)}$, $X_L = \left\| x_L(p) \right\|_{\left(p=\overline{0,YX-1}\right)}$ the coordinates of the initial growth points of areas in the image, whose their elements are determined using expression:

$$e_L(y,x) \leftarrow 0,\ y_L(p) \leftarrow 0,\ x_L(p) \leftarrow 0 \qquad (3)$$

Where $y = \overline{0,Y-1}$, $x = \overline{0,X-1}$ $p = \overline{0,YX-1}$.

6.2 Initialization of counter value p of growth points of areas: $p \leftarrow 0$.

6.3 Values of matrix elements E_L and vectors Y_L, X_L the coordinates of the initial growth points of areas in the image redefined using expression:

$$\exists k \left(k \in [0, K-1]\right)\left(i(y,x) = e_G(k)\right) \Rightarrow$$
$$\Rightarrow \left(e_L(y,x) \leftarrow 1\right), \left(y_L(p) \leftarrow y\right), \left(x_L(p) \leftarrow x\right), \left(p \leftarrow p+1\right). \qquad (4)$$

Where $y = \overline{0,Y-1}$, $x = \overline{0,X-1}$.

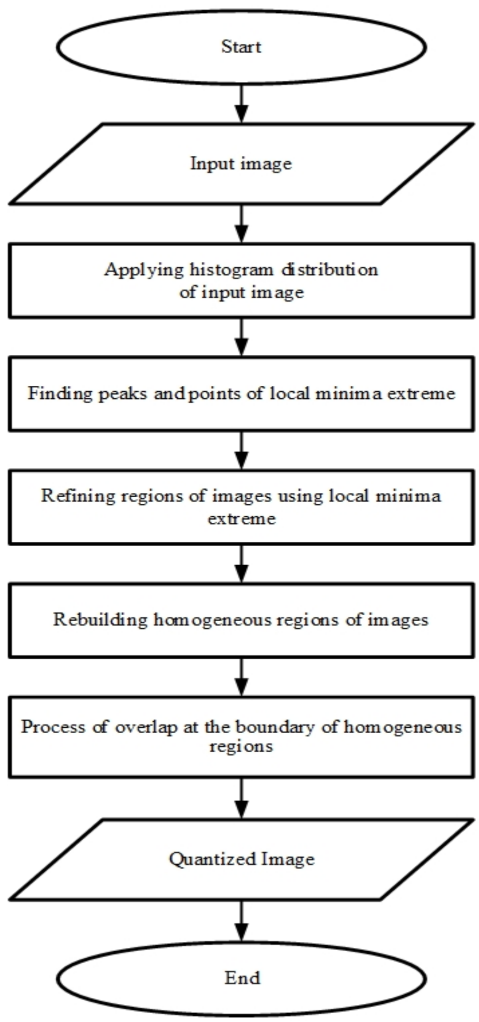

Fig. 2 Algorithm of Image Quantization based on Color Levels Distribution

Results (Evaluation the Effectiveness of the Algorithm)

For evaluation of suggested algorithm used a group of gray scale images that includes standard test-images and ERS-images with various of surfaces, shown in Fig (3). As parameters for measuring the efficiency of presented algorithm evaluated the stability of regions for quantized images after quantization by comparing with two-threshold method, and the time's calculations for image quantization and segmentation.

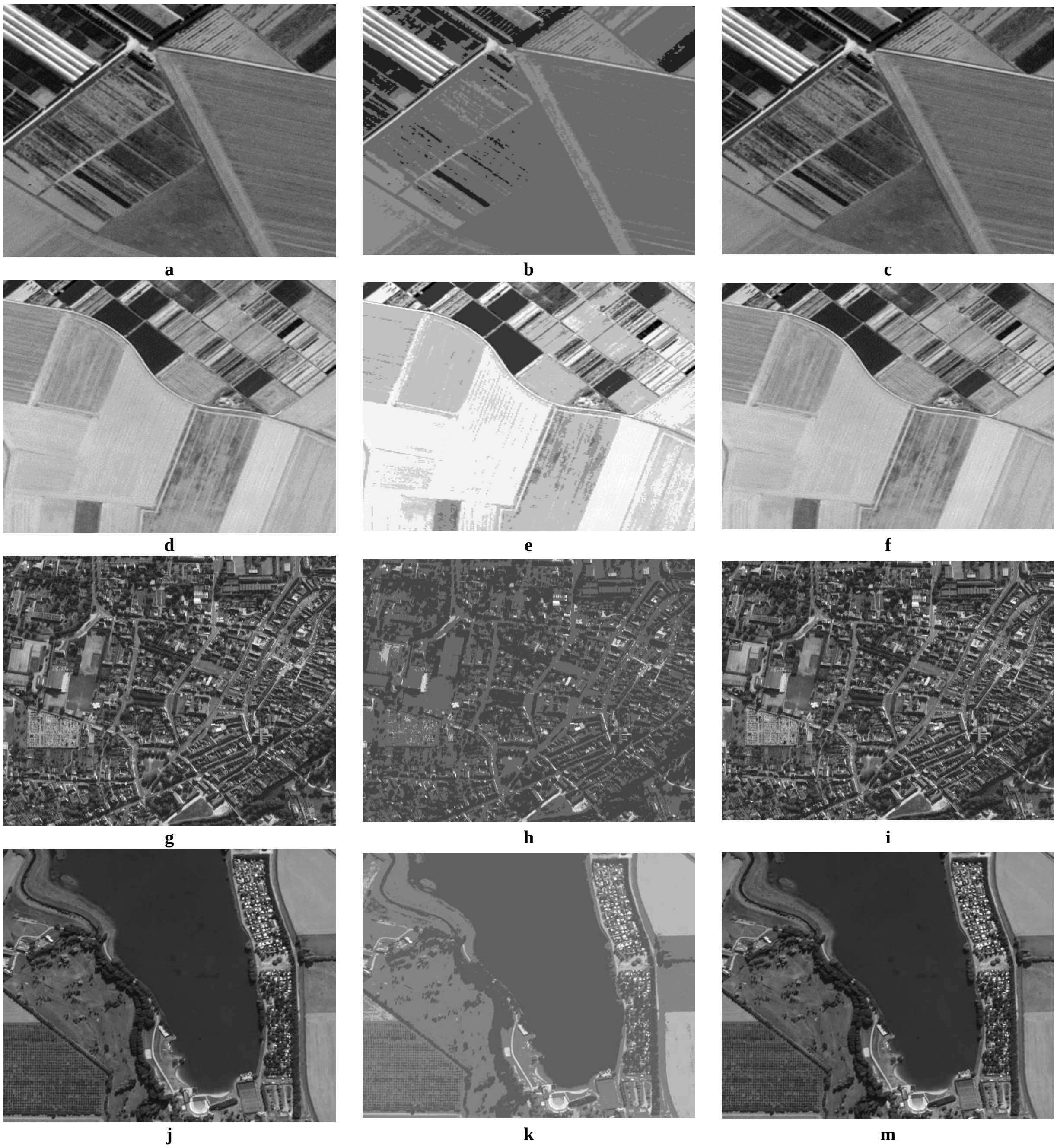

Fig. 3 (a, d, g, j) Test images, (b, e, h, k) Images after Two-thresholds quantization, (c, f, i, m) Results of proposed algorithm of image quantization.

Stability of Regions for Quantized Image

Presented in table.1 below results of image quantization of test images with different resolution, the parameter of stability in areas of segments is measured by overall ratio, percent of the quantized image that showed that proposed algorithm gives a high percent of stability of regions over 10 times than other algorithm presented in literature used in comparison. The stability of regions allowing kept the essential distribution of processed image after the process of quantization, which considered the main advantage of suggested algorithm.

Table 1 Stability the number of segments

Test images	No. of segments	
	Suggested algorithm	Two- thresholds algorithm
france-256*256	25051	2436
France2-256*256	37277	4503
City-512*512	155223	6466
France3-1024*1024	315698	22928
France4-1024*1024	446389	8877

In Fig. 4 below presented Structural scheme for evaluating the effectiveness of image quantization and segmentation for suggested algorithms.

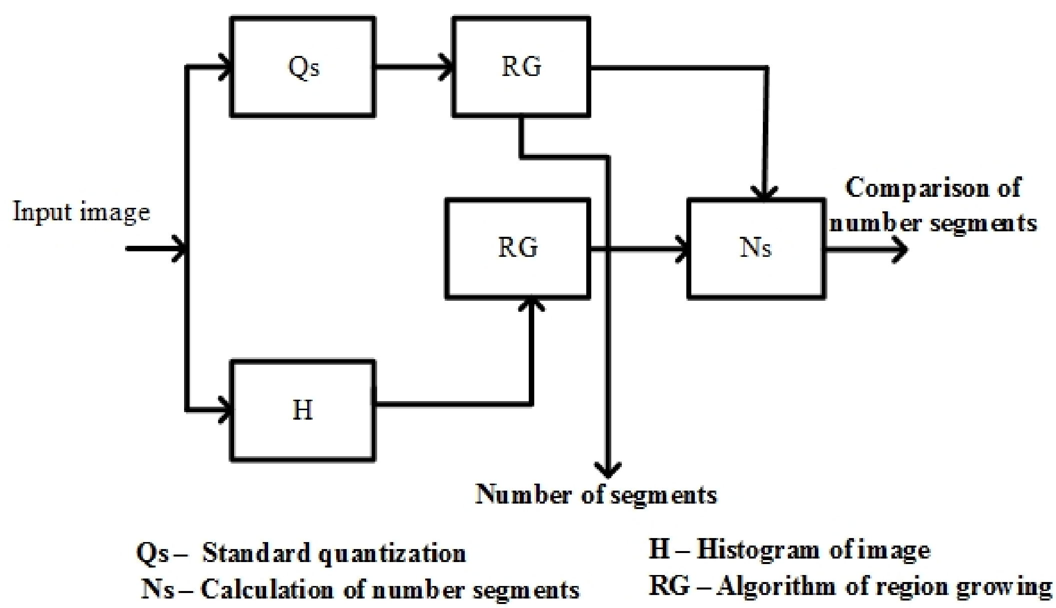

Fig. 4 Structural scheme for evaluating the effectiveness of quantization algorithms

Time Calculation for Process of Image Quantization

Below presented results implementation of quantization algorithms on tested images, table.2. Tested on computer with specifications (Windows 10 O.S, Processor Intel core i5, Ram 4 G). The analysis showed that process of compared two-algorithms spending nearest values of time, while proposed algorithm providing a high accuracy of image quantization.

Table 2 Time processing for test images

Test images, Different sizes	Time of process (seconds)	
	Proposed algorithm	Standard Quantization (Two-Thresholds)
france-256*256	0.46	0.41
France2-256*256	0.51	0.41
City-512*512	2.04	1.48
France3-1024*1024	5.81	5.38
France4-1024*1024	7.65	5.56

Conclusion

The proposed algorithm providing high accuracy of image quantization comparing with the methods of quantization presented recently. Calculated results showing that the images after quantization using proposed algorithm gives number of segmented regions above ten times more than using standard methods of quantization. In addition, experiments shows that implementation of new algorithm required a similar time or nearest above average of calculations, cause of high details of quantized images. Which meaning increasing of execution's time required, on other side there are better determining in the number, location and evaluate sizes of the objects of interest in the analyzing of images.

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