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STUDY OF THE IMPACT OF THE REJECTION OF CERTAIN STAGES OF SEGMENTATION METHOD, APPLYING LAW'S CHARACTERISTICS ON ITS RESULTS

The paper offers for consideration the method of images segmentation, based on the usage of Law's energy – characteristics, the analysis of the impact of the rejection of its certain stages on segmentation results is carried out. Applying such method the possibility of qualitative determination of image segments, for their further usage in the process of image processing, emerges.

Key words: *image, segmentation, Law's energy characteristics, model, sample of test images.*

Introduction

As a result of spreading of large volume of information in the form of digital images, problems of recognition of certain objects on the image and their contours allocation become actual. These problems are solved by means of segmentation, that enables to determine necessary objects on the image.

As a rule, segmentation is one of the key stages of image processing. Proceeding from the variety of images and problems, different methods of segmentation are used, for instance, correlation, threshold methods, color analysis methods etc. The aim of the given paper is improvement of segmentation quality by means of usage Law's energy characteristics application, that enable to describe various types of textures with high accuracy. The research also contains the analysis of the impact of the rejection of certain stages of the suggested segmentation method on its result. As the method itself is rather cumbersome, that influences its complexity and fast acting, the assumption is made regarding the fact whether all its stages are really necessary for efficient operation of the method.

The aim of the research is to improve images segmentation quality, that is determined by the ratio of the area of correctly identified image segments to their real area.

The notion of the texture could be defined by two basic approaches. In accordance with structural approach texture is the set of texels, located in certain regular order or in a repeated order. There exists also statistic approach, it consists in calculation of numerical characteristics of textures. In this case, texture is a quantitative characteristic of intensity values distribution in the image area [1 - 3].

In accordance with the above – mentioned approaches two categories of methods applied for texture image description can be distinguished: statistic (calculation of coincidence matrices, Law's energy characteristics [4, 5]) and structural (construction of Voronoi mosaic).

If we perform the analysis of modern state of art of texture images segmentation problem, then we could note that at present this problem is solved only for partial tasks at determined limitations on the type of images, availability of geometric distortions and brightness distortions, etc. Further study in the sphere of the development of texture images segmentation methods is vital and necessary problem.

Segmentation method, based on Law's energy characteristics application

Mathematical model of images segmentation problem using Law's characteristics has the form

$$D \to \{D_1, ..., D_S\}, \tag{1}$$

where the area $D = U_{r=1}^{S} D_r$;

$$D_r = \{(i,j) \mid \rho(\overline{E}(x_r, y_r), \overline{E}(i,j)) < \delta\}, r = \overline{1,S},$$
$$\rho(\overline{E}(x_r, y_r), \overline{E}(i,j)) < \delta, \qquad (2)$$

where $\rho(\overline{E}(x_r, y_r), \overline{E}(i,j)) < \delta$ – criterion, determined as a measure of similarity, that can be calculated applying one of the known methods; δ – certain threshold value; $\overline{E}(x_r, y_r)$ - vector $\overline{E}(x_r, y_r) = (E_1(x_r, y_r),..., E_9(x_r, y_r))$ of energy cards of reference class r; (x_r, y_r) – reference point of textures class r, (i, j) – point, membership of which to textures class r is determined at the present moment.

Formulas and method of energy cards calculation are described in the source [4]. Methods of point-wise and fragment segmentation were developed on the base of model (1).

In case of point-wise segmentation energy cards for the whole image are built, as a result each pixel $(i, j) \in D$ is characterized by the vector $\overline{E}(i, j)$ of 9 values, used as signs of image segmentation.

For decision – making regarding the point membership (i, j) to one class of textures r criterion (2), is used in the suggested method, where similarity measure is calculated by the formula:

$$\rho_{ij} = \frac{\sum_{k=1}^{9} \left| E_k(i,j) - E_k(x_r, y_r) \right|}{9}, \qquad (3)$$

where $\left| E_k(i,j), E_k(x_r, y_r) \right|$ – values of pixels $(i, j), (x_r, y_r)$ on the current and, correspondingly, reference k –th energy card; $(i, j), (x_r, y_r) \in \frac{D}{D_{r-1}}$.

Now let us consider how fragment segmentation is realized. Image is divided into fragments of 15×15 pixels of size. For all the fragments vectors of the characteristics $\overline{E}(i_f, j_f)$ are built, where i_f i j_f – ordinal numbers of the fragment vertically and horizontally vectors. Vectors $\overline{E}(i_f, j_f)$ for the fragments are obtained by means of averaging of energy characteristics values for each fragmented pixel.

The obtained vectors of texture signs of the fragments are applied for calculation of similarity degree between them. Thus, in the formula (3) the coordinates (i, j) and (x_r, y_r) are the coordinates of the fragment, being determined and reference fragment, correspondingly. Algorithm of images segmentation, using the described Law's characteristics, is shown in Fig. 1.

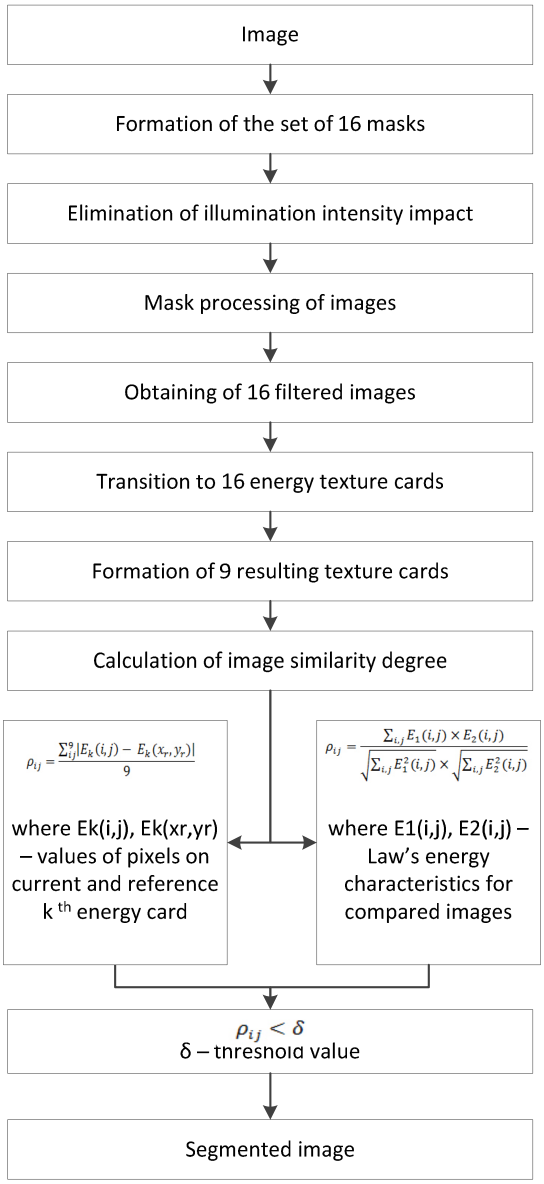


Fig. 1. Segmentation algorithm, using Law's energy characteristics

The developed algorithm is expected to be used in further research as an integral part of the complex method of images compression, that will be based on the already existing compression methods [6, 7].

In order to verify the expediency of Law's characteristics application for graphic information segmentation it was proposed to use correlation method of images similarity assessment as it possesses high accuracy. Images similarity was assessed, applying two methods:

1) calculation of similarity degree between images themselves by the expression:

$$\rho(i,j) = \frac{E_{i,j} B_1(i,j) \times B_2(i,j)}{\sqrt{E_{i,j} B_1^2(i,j)} \times \sqrt{E_{i,j} B_2^2(i,j)}}, (i,j) \in D, \quad (4)$$

where B_1, B_2 – the compared images;

2) another method is calculation of similarity degree of energy cards of these images. For this purpose, brightness values in the formula (4) are replaced by Law's energy characteristics

$$\rho(i,j)=\frac{E_{i,j}E_1(i,j)\times E_2(i,j)}{\sqrt{E_{i,j}E_1^2(i,j)}\times\sqrt{E_{i,j}E_2^2(i,j)}},(i,j)\in D\cdot \tag{5}$$

The sample of test images was formed, it contained texture images, given in Fig. 2.

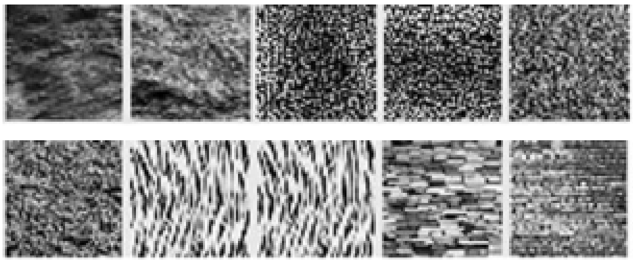


Fig. 2. Test images

Fig. 3 shows the results of similarity degree (4) calculation for the given images

	A	B	C	D	E	F	G	H	I	J
1	1	0,847	0,784	0,777	0,843	0,843	0,856	0,856	0,843	0,855
2	0,847	1	0,781	0,781	0,847	0,848	0,849	0,849	0,844	0,848
3	0,784	0,781	1	0,710	0,769	0,765	0,779	0,779	0,765	0,773
4	0,777	0,781	0,710	1	0,769	0,769	0,782	0,782	0,763	0,773
5	0,843	0,847	0,769	0,769	1	0,829	0,837	0,837	0,826	0,837
6	0,843	0,848	0,765	0,769	0,829	1	0,839	0,839	0,828	0,837
7	0,856	0,849	0,779	0,782	0,837	0,839	1	1	0,839	0,851
8	0,856	0,849	0,779	0,782	0,837	0,839	1	1	0,839	0,851
9	0,843	0,844	0,765	0,763	0,826	0,828	0,839	0,839	1	0,843
10	0,855	0,848	0,773	0,773	0,837	0,837	0,851	0,851	0,843	1

Fig. 3. Correlation coefficients for test images from Fig. 3.

Symmetric matrix 10×10 was built, where at the intersection of the i –[th] row and j –[th] column the value of correlation coefficient for i –[th] and j –[th] images is located. Only in two out of ten experiments the textures, containing visually similar images turned out to be the most similar .

In the first row the texture of water by its coefficient is the most similar to the texture of tiger's skin but not to the other texture of water as it was expected.

Now we will analyze the results of calculations according to energy cards of the images (Fig. 2). They are presented in Fig. 4.

A	B	C	D	E	F	G	H	I	J
0,7736	0,7993	0,7828	0,8665	0,8573	0,9366	0,8583	0,8583	0,9915	1
0,9716	0,9855	0,9779	0,9733	0,9767	0,9164	0,9815	0,9815	1	0,9915
0,9819	0,9824	0,9882	0,9908	0,9874	0,9400	1	1	0,9815	0,8583
0,9819	0,9824	0,9882	0,9908	0,9874	0,9400	1	1	0,9815	0,8583
0,8751	0,9014	0,9124	0,9591	0,9938	1	0,9400	0,9400	0,9164	0,9366
0,9793	0,9811	0,9872	0,9911	1	0,9938	0,9874	0,9874	0,9767	0,8573
0,9598	0,9682	0,9853	1	0,9911	0,9591	0,9908	0,9908	0,9733	0,8665
0,9833	0,9843	1	0,9853	0,9872	0,9124	0,9882	0,9882	0,9779	0,7828
0,9875	1	0,9843	0,9682	0,9811	0,9014	0,9824	0,9824	0,9855	0,7993
1	0,9875	0,9833	0,9598	0,9793	0,8751	0,9819	0,9819	0,9716	0,7736

Fig. 4. Correlation coefficients, calculated by energy cards

Matrix analogous to the previous one, was constructed, where it is shown that in each of the ten experiments maximum coefficient (5) was found between the most visually similar images.

Hence, the analysis of the results obtained (Fig. 3, 4) shows that for visually similar texture images the transition to energy cards considerably increases the correlation coefficient and underlines texture peculiarities of images.

Coefficient of texture images segmentation quality was calculated, applying the suggested method. Coefficient was calculated as the ratio of correctly segmented sections area to their real area. For point-wise segmentation averaged quality coefficient was 0,78. Hence, the analysis of the results showed the expediency of applying Law's characteristics for the solution of numerous practical tasks in the sphere of image processing.

Analysis of the impact of certain stages of the method rejection on segmentation result

Segmentation method, based on Law’s energy characteristics is rather bulk, that influence its operation rate. Main stages of its operation are: obtaining of energy characteristics (elimination of intensity impact, image processing by masks, calculation of energy cards) and division of the image into sections with similar energy characteristics (by the criterion (2)). In order to increase operation rate of the algorithm the assumption was put forward, that not all the stages of the method are really necessary. That is, to reduce operation time we can neglect one or even several stages. The impact of the stages on final result of segmentation was assessed. The results of the experiments, carried out, are shown in Fig. 5.

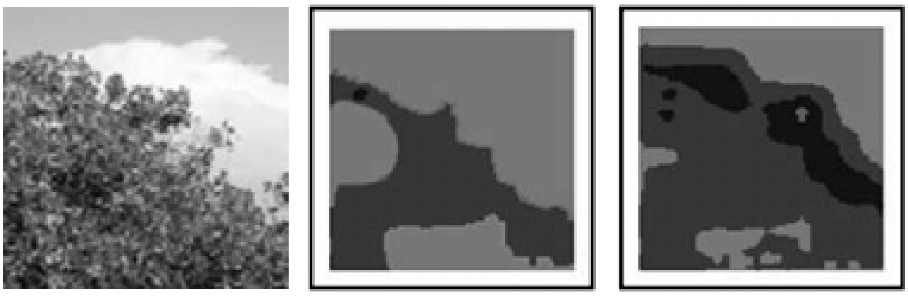
a b c

d e f

Fig. 5. Results of the point-wise segmentation a, d – output image; b, e – segmentation without elimination of light intensity impact, threshold δ=80; c, f – segmentation with elimination of light intensity impact, threshold δ=80

Thus, the first step of algorithms, built on the base of Law’s energy characteristics is -- elimination of light intensity impact. A number of research was carried out with program model, where energy cards of test images were calculated using the first step and without it. Having analyzed the results obtained visually, it can be seen that elimination of light intensity impact at the first stage of image processing by means of energy characteristics method is really necessary, as illumination change of visually similar textures greatly influences the value of Law’s characteristics and this results in referring textures to different classes. Thus, the given step enables to equal all the compared images, leaving for further study information regarding the textures.

Studies, regarding the necessity of the transition from filtered images to energy cards, that are averaging of the results of image processing by masks, were carried out. The following experiments were performed: segmentation of testing images was realized on the base of the image, processed by masks and on the base of energy cards. The result of the segmentation of one of the images is shown in Fig. 6.



a b c

Fig. 6. Results of the point-wise segmentation a – output image; b – segmentation on the base of the image, processed by masks, threshold δ=80; c – segmentation on the base of energy cards usage, threshold δ=80

The studies, carried out, show, that the transition from filtered images to energy cards, enables to take into account texture features of images, as filtered values of its circumference points influence the value of each point of energy cards.

As it is seen, the stage of transition form filtered images to energy cards and the stage of light intensity impact elimination is necessary for the construction of image texture description and usage of such description for segmentation problem solution.

Conclusions

Method of texture segmentation, based on the usage of Law's energy characteristics is developed. They underline characteristic feature of texture images and could be used for the solution of various problems, dealing with images processing, in particular, segmentation problems. Using the given method, it is much more easy and efficient to allocate separate classes of textures as compared with application of other approaches. In order to increase the speed of the method, the impact its certain stages rejection on the result of segmentation is analyzed.

Testing of the method showed that for visually similar texture images the transition to energy cards substantially increases the correlation coefficient and enables to reveal the textures similarity with high degree of accuracy. It is also shown, that neglecting of certain stages of the method is not expedient, as they influence the quality of the resulting segmented image.

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