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AUTOMATIC IDENTIFICATION METHOD OF BLURRED IMAGES

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Abstract. *Automatic identification method of the blur type is an important stage in automatic restoring and segmentation of partially blurred images. This article describes automatic identification method of blurred images that also allows to estimate the blur angle parameter. This method contains five steps: 1) applying modified Sobel operator to the input image; 2) image cutting on perimeter in order to eliminate the negative effects occurred at the previous step; 3) construction sequentially blurred image's versions from the step 2 with fixed radius; 4) similarity measure calculation of sequentially blurred image's versions along with original image; 5) estimation of the criterion value. Method has been tested and has shown correct result in more than 90% of input images, and the average angle's error does not exceed more than 8 degrees.*

Keywords: motion blur, image blurring, automatic identification

METODA AUTOMATYCZNEJ IDENTYFIKACJI TYPU OBRAZÓW ROZMYTYCH

Streszczenie*. Metoda automatycznej identyfikacji typu rozmycia jest ważnym etapem w zagadnieniach automatycznego przywracania i segmentacji obrazów częściowo zniekształconych. W artykule rozpatrzono metodę automatycznej identyfikacji obrazów rozmytych pozwalającą również określić kąt rozmycia. Metoda ta obejmuje pięć kroków: 1) zastosowanie do wejściowego obrazu zmodyfikowanego operatora Sobela; 2) cięcie obrazu na obwodzie w celu wyeliminowania negatywnych skutków występujących w poprzednim kroku; 3) budowa kolejno wersji obrazów rozmytych z kroku 2 zachowując zdefiniowany stały promień; 4) obliczenie miary podobieństwa wersji obrazów kolejno rozmytych z oryginalnym obrazem; 5) wyznaczenie wartości kryterium. Testowanie metody wykazało prawidłowy wynik w ponad 90% obrazów wejściowych, a średni błąd określenia kąta rozmycia nie przekracza 8 stopni.*

Słowa kluczowe: motion blur, rozmazanie obrazu, automatyczna identyfikacja

Introduction

Problems of automatic image restoration and segmentation of partially blurred images (images which are only partly blurred – motion blur or Gaussian blur) require determining the blur type. Based on the assumption that Gaussian blur and motion blur appears more often than other blur types (noise is not considered, because it has type of distortion that requires completely different mathematical tools), – an important issue is to identify automatically the blur type.

1. Related work

Method of automatic identification of the blur type is described in [4] and adopted to solve problems of partially blurred images segmentation. It is done by computing Local Autocorrelation Congruency metric, which is based on comparison of image and its spatially-shifted version, using the autocorrelation function.

Use of "Alpha Channel" method is described in articles [6] and [2]. It is used for blur type identification. In [6] method is used after computing partially-blurred images segmentation. Method's point lays in decomposition of the whole or specific part of the input image into two components (foreground and the background), which are combined with α-channel model and construction of α-motion blur constraint.

In [7] is considered the use of wavelet transformation to determine the type and degree of blurring. To achieve that, after computing wavelet transformation of the image, the number of different types of edges is counted for all scales: Dirac-Structure, Astep-Structur, Gstep-Structure, Roof-Structure. After that, correlation between the types of the edges is considered and distortion type and degree are determined.

There are described three approaches to determine the parameters of motion blur in [3]: method Cepstral, Steerable filters and Radon transformation.

Usage of neural networks and Fourier transformation to determine the type of blurring and its parameters are described in [1]. Structure, working method and using of the neural network are considered.

2. Automatic identification method of blurred images

Automated identification method of blurred images consists of the following five steps:

1. For the input image I applied a modified Sobel operator to highlight edges as shown in (1). As a result we achieve I'.

$$I' = \sqrt{\sum_{i=1}^{4} (H_i * I)^2} \quad (1)$$

where I' – matrix – result of usage of modified Sobel operator;
I – matrix – input image;
$*$ – convolution operator;
H_i – matrix – mask, which takes part in convolution. Masks H_1, H_2, H_3, H_4 are given in (2).

$$H_1 = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad H_2 = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$
$$H_3 = \begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix} \quad H_4 = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & -2 \end{bmatrix} \quad (2)$$

Result of work of the modified Sobel operator is given in the Fig. 1.

2. The second step is to cut I' on perimeter at the distance $R \geq 3$ from the image's edge to eliminate the negative edge effects, related with using of the modified Sobel operator. Due to inability to correct with modified Sobel operator pixels located at a distance less than 3 pixels from the border of the image. As a result we achieve I''.

3. Performed construction for I'' its alternately blurred versions with a fixed radius but different angle (within 0° to 180°). As follows, for some fixed $\Delta\alpha$, (e.g. $\Delta\alpha$ = 1°) and fixed radius of distortion R (experimentally determined recommended radius

$R = 9$) are created kernels of the blur operator $H_1, H_2, \ldots, H_N$, where $N = 180/\Delta\alpha$ and H_i – matrix, kernel of the blur operator with the radius R and the angle $\alpha = i \cdot \Delta\alpha$. Those kernels using convolution operation are applied to I'', i.e. $G_i = I'' * H_i, i = \overline{1, N}$.

4. Computed the similarity measure D_i of the obtained in the previous step G_i from I'', as it is shown in (3).

$$D_i = -\ln\left(\frac{1}{n \cdot m}\sum_{k=1}^{n}\sum_{l=1}^{m}(I'' - G_i)^2\right) \quad (3)$$

where n and m – image size of I''. In the Fig. 2 D_i are visualised Gausian blurred and motion blurred images.

5. The last step of the method lays in calculating the criterion value to identify the blur type, which is based on the values of the similarity measure $D_i, i = \overline{1, N}$ according to the formula (4).

$$Criterion = \left|\frac{(\max[D] - \tilde{D})}{(\tilde{D} - \min[D])}\right| \cdot Variance[D] \quad (4)$$

where *Criterion* – the criterion value;
max[D] – maximum value of sequence D_i;
min[D] – minimum value of sequence D_i;
$\tilde{D}$ – sequence median D_i;
Variance[D] – estimated variance of D_i.

If the value $Criterion > threshold$, where *threshold* is experimentally determined value and equals 0.25 for real photographs, then distorted image is blurred, and the angle of the blur is $\alpha = i_{\max} \cdot \Delta\alpha$, where i_{max} – index of the maximum element of the sequence D_i.

The described method is patented [5].

3. Implementation and testing of the automatic identification method of blurred images

Software for calculation and testing the blur criteria, namely the procedure of test images generation and running of calculations in the test data set was developed in numerical computing environment - Matlab. Matlab-function implementation is presented in Listing 1. It performs calculation of the automatic identification criterias of the blurred images.

Listing 1. The software code that implements the automatic identification function of the blurred images

```
function [y x metric] = CalculateMotionBlur-
rCurve(image)
image = ApplySobelOperator(image, true, true);
image = mat2gray(image);
[n, m] = size(image);
gropWidth = 5;
image = image(gropWidth:(n-gropWidth),
gropWidth:(m-gropWidth));
len = 9;
step = 1;
x = zeros(1, 180/step + 1);
y = zeros(1, 180/step + 1);
for i = 0:(180/step)
    degree = i * step;
    h = fspecial('motion', len, degree);
    conv2im = conv2(image, h, 'same');
    y(i + 1) = -log(mean2((image - conv2im).^2));
    x(i + 1) = degree;
end
t = median(y);
metric = abs((max(y) - t) / (t - min(y))) *
var(y);
end
```

a) b)

Fig. 1. Result of work of the modified Sobel operator: a) input image; b) output

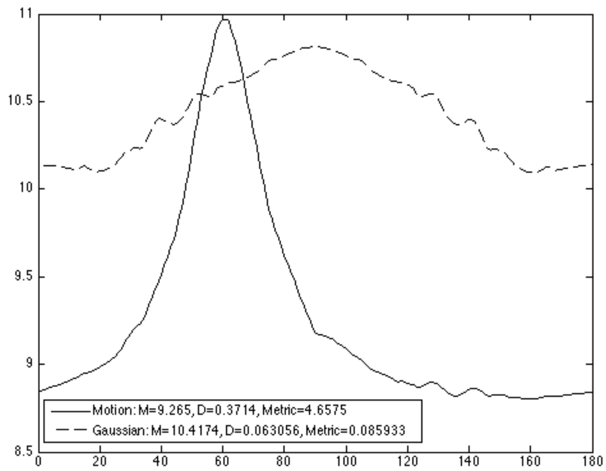

Fig. 2. Visualised D_i of the images with motion and Gaussian blur

To perform testing of the developed method were selected 84 clear photos (57 colour and 27 black and white) sized 512x512 pixels received from the Internet resource - “ImageProcessingPlace”. Based on selected clear pictures randomly were generated 756 blurred pictures, where 378 motion blurred images with different blurring radius and 378 Gaussian blurred images different radius and angle of blurring.

Developed method was tested using received generated set of test images. Namely, for each image in a set there were calculated the type of distortion and the angle of blur for the appropriate type of the distortion, according to the descried method. Then, the percentage of the correct results with relation to the total number of the images and the average error of the angle calculation. As a result of testing, the correct result was obtained for more than 90% of the test images, and the average absolute error of angle calculation of the blur is 8°. The method results of the sixteen selected images (Fig. 3) are presented in the table 1.

Table 1. Method results of the sixteen selected images

N	Criteria value	Rated type of distortion	Result	Rated angle of blur	Correct angle of blur
1	0.052	Gaussian Blur	Cor.	–	–
2	0.570	Motion Blur	Cor.	54°	54°
3	0.005	Gaussian Blur	Cor.	–	–
4	0.419	Motion Blur	Cor.	171°	159°
5	0.078	Gaussian Blur	Cor.	–	–
6	5.254	Motion Blur	Cor.	91°	97°
7	0.050	Gaussian Blur	Cor.	–	–
8	1.6621	Motion Blur	Cor.	162°	159°
9	0.108	Gaussian Blur	Cor.	–	–
10	1.541	Motion Blur	Cor.	167°	162°
11	0.165	Gaussian Blur	Cor.	–	–
12	0.698	Motion Blur	Cor.	44°	44°
13	0.066	Gaussian Blur	Cor.	–	–
14	0.347	Motion Blur	Cor.	32°	32°
15	0.045	Gaussian Blur	Cor.	–	–
16	0.147	Gaussian Blur	Incor.	–	149°

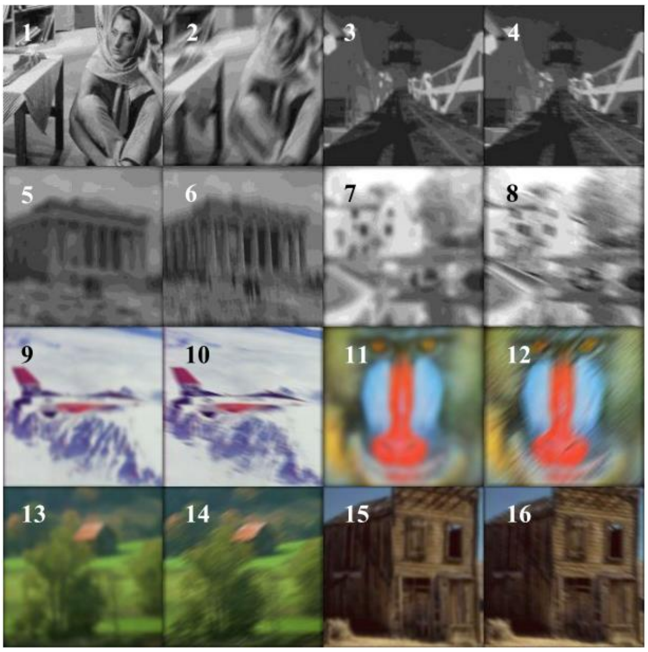

Fig. 3. Test images

4. Conclusion

The automatic identification method of blurred images, which also allows to determine the angle of the blur is presented in the article. During method testing were obtained reliable results of its work. The method can be used to determine the type of blur of segments after segmenting partially blurred images.

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