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DETECTION OF DIGITAL IMAGE BLURRING TRACES

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In this paper we develop and implement a method to separate digital image that was subjected to blurring operation from not processed one. Digital image blurring traces indicate the possible digital image falsification.

Keywords: image falsification, digital image blurring

Introduction

The considerable increase of unauthorized changes of digital images (DI) by software tools (Adobe Photoshop, Adobe Illustrator, CorelDRAW, etc.) causes an extraordinarily actual problem of such falsifications recognition. As we know from practice and relative papers blurring is often used while DI tampering. Sometimes it can be concluded that the presence of digital image blurring (IB) traces indicates the possible DI falsification. In accordance with [1-3], singular values (SV) and singular vectors of DI matrix determine the informative system. Accordance between energy and singular spectrums of signal matrix is determined in [1, 4, 5]. By this accordance while using of IB singular values diminish as follows: SV, that correspond to the high-frequency constituent of DI signal (the least and the middle ones), are subjected to the largest changes. Speed of their increase will be near to zero (thus, the more radius of IB, the less difference of increase speed from zero), unlike increase speed of the least SV of not blurred image (Fig. 1, see SV 6-12).

We will use this feature of singular spectrums for separation of original DI from blurred one.

We'll also automatize this process. To reach our aim it is necessary to decide following *problems*:

- To choose the way of small and middle (most informative in this task) SV presentation for valuation of their conduct;
- To get the threshold values for separation of blurred DI from not blurred one.

Determination of threshold values for image blurring detection

To present small and middle SV of DI matrix we will use the polynomial of degree 1 as approximating function. It is necessary to valuate increase speed of the least SV of DI matrix. So we can receive numerical parameters and threshold values for separation of blurred DI (BDI) from not blurred DI (NBDI).The computing experiment with more than 400 different DI produced by modern photo cameras in the jpeg-format was carried out. DI were blurred by filter of Adobe Photoshop "Blurring on Gauss". This filter is chosen because of its high-usage in different aims, including the concealment of DI falsification tracks. We'll examine case when blurring radius is equal to 1. This is the most difficultly "caught" situation. The blurring radius increase leads to differences increase between BDI and NBDI.

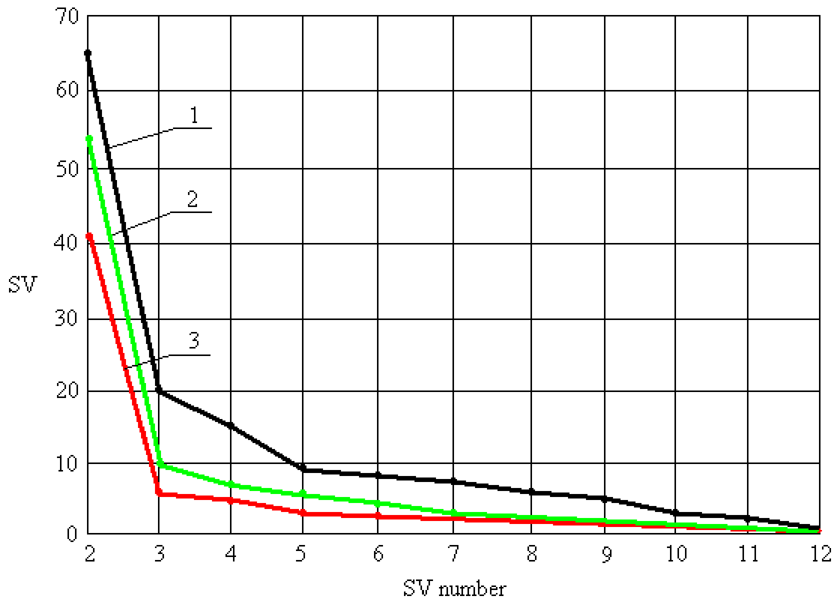


Fig. 1. Interpolating spline powers of one for SV set of testing DI; 1 – origin DI; 2 – blurred DI (radius 1); 3 – blurred DI (radius 2)

Proof of DI authenticity is the important task in many areas of human activity and in particular in judicial trials. DI can be used as a material proof. Its quality must be acceptable. This means that artifacts presence on an image is impermissible. Besides, image's bad quality causes a doubt in authenticity not allows to examine it as a material proof. One can save DI in jpeg-format using different values of "quality" Q (Q takes on values 0, 1,.., 12 at Adobe Photoshop). It was determined by the subjective ranging, that DI artifacts are noticeable to a greater or less extent at $Q \in \{0,1,...,7\}$. Good visual perception is arrived at $Q=9, Q=10$. Therefore further researches are carried out for $Q \in \{8,9,10\}$. Obviously increase speed of small and middle SV for BDI differs from analogical description for NBDI, when an original image is saved in the best quality ($Q=10$). Really, NBDI contours will be the clearest in this case; the signal high-frequency constituent will be the most considerable. Increase speed of the least SV of DI matrix will be the greatest in comparison with $Q=8, Q=9$. There by the effect of the least SV and their increase speed diminishing will be most noticeable under blurring. Most "complications" will arise up at $Q=8$, because high-frequency constituent of signal is quite small in itself in this case.

Let F is testable DI $n \times m$ matrix. We break up this matrix into 8×8 blocks standard character [6]. The total amount (B) of blocks will be equal

$$B = \left[\frac{n}{8}\right] \cdot \left[\frac{m}{8}\right] = \underline{O}(mn), \qquad (1)$$

where $[\bullet]$ is argument's integer part. For each block we calculate the set of SV. We build a linear approximating function for five the least SV of every 8×8 block. The angular coefficient of the approximating function is the approximate value of SV increase speed. We put the $\left[\frac{n}{8}\right] \times \left[\frac{m}{8}\right]$ matrix in accordance to testable DI. Every $\left[\frac{n}{8}\right] \times \left[\frac{m}{8}\right]$ matrix element corresponds to a 8×8 block with the same indexes and is equal to increase speed of the least five SV of block. We'll call this matrix "matrix of increase speed" (MIS). MIS differ qualitatively for NBDI and BDI. To automatize the process of recognition we create the vector of mean values (VMV). VMV is the result of MIS values column-wise (row-wise) averaging. Graphic VMV presentations and VMV approximating linear functions are given in Fig. 3 for DI "MASHA" (Fig. 2). To watch the range of values for basic part of MIS elements before and after IB we enter two parameters: maximal ($VMV_{\max}$) and mean (VMV_c) values of VMV. It is necessary for these parameters to find the threshold value separating BDI from NBDI. As experiment shows the threshold value is equal to 1. So, if

$$VMV_{\max} > 1 \quad \wedge \quad VMV_c > 1,$$

then the image is not blurred; if

$$VMV_{\max} < 1 \quad \wedge \quad VMV_c < 1,$$

then the image is blurred or does not contain contours. However, by virtue of the examined task specific, probability of analysis an image without contours is extraordinarily small. A variant is possible in practice, when

$$VMV_{\max} > 1 \quad \wedge \quad VMV_c < 1. \qquad (2)$$

Fig. 2. Testing digital image "MASHA"

This may happened when an image produced in the mode "macro survey" or when $Q = 8$ (and less than). Additional researches are required in this case. For greater visualization of results distinctions the aggregate of graphics (further – resulting aggregate (RA)) is put in accordance to MIS. Each graphic corresponds to MIS column and reflects dependence between a column element number in and its value [2]. RA for image "MASHA" is presented in Fig. 6, where every RA graphic has an individual color. Apparently, range of values (RV) for most "density" of RA for NBDI much wider than analogical description for BDI; iterated blurring does not change a qualitative picture practically, as compared with primary blurring (Figs. 4(b), 4(c)).An analogical situation is observed for VMV (Figs. 3(b), 3(c)). This feature enables to improve conclusion about blurring of testable DI.

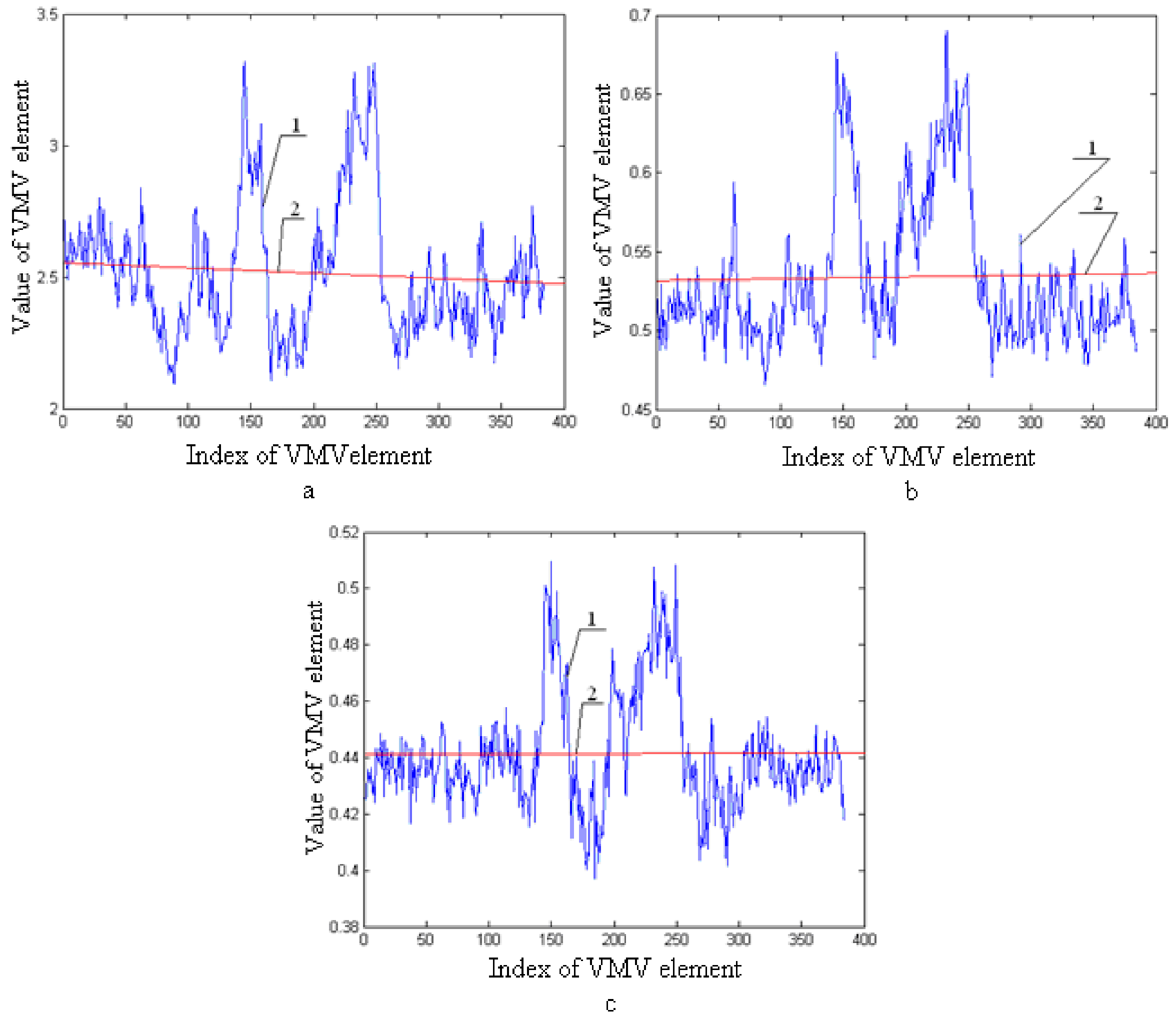


Fig. 3. 1 – graphic presentations of VMV for test DI “MASHA”, 2 – linear approximation of VMV: a – before blurring; b – after blurring (radius – 1 pixel); c – after iterated blurring (radius – 1 pixel)

Additional researches

One of possible reasons for origin (2) situation is a production of DI in the mode “macro survey”, when the image means a sharp object (objects) on a blurred (unintentionally) little informative background.

Degree of background blurring can be different at a macro survey. This depends from parameters of photo camera, and also from distance to the object. In this case it is necessary to resort to additional verification:

Step 1. Intentionally blur out a testable image. Use a minimum blurring radius.

Step 2. Build resulting aggregate and VMV for received DI.

Step 3 (analysis). Compare RA and VMV before blurring and after one. If the image was already blurred, then undertaken blurring will change neither basic part of RA fundamentally, nor VMV (Figs. 3(b, c), 4(b, c)). This will smooth out some largest values only. If testable DI was not blurred out originally, then undertaken IB will be the first for the image. This will reflects in RA and VMV (Figs. 3(a, b), 4(a, b)). Blurring is considered primary if after IB implementation the range of RA values and is diminished in more than 2 times.

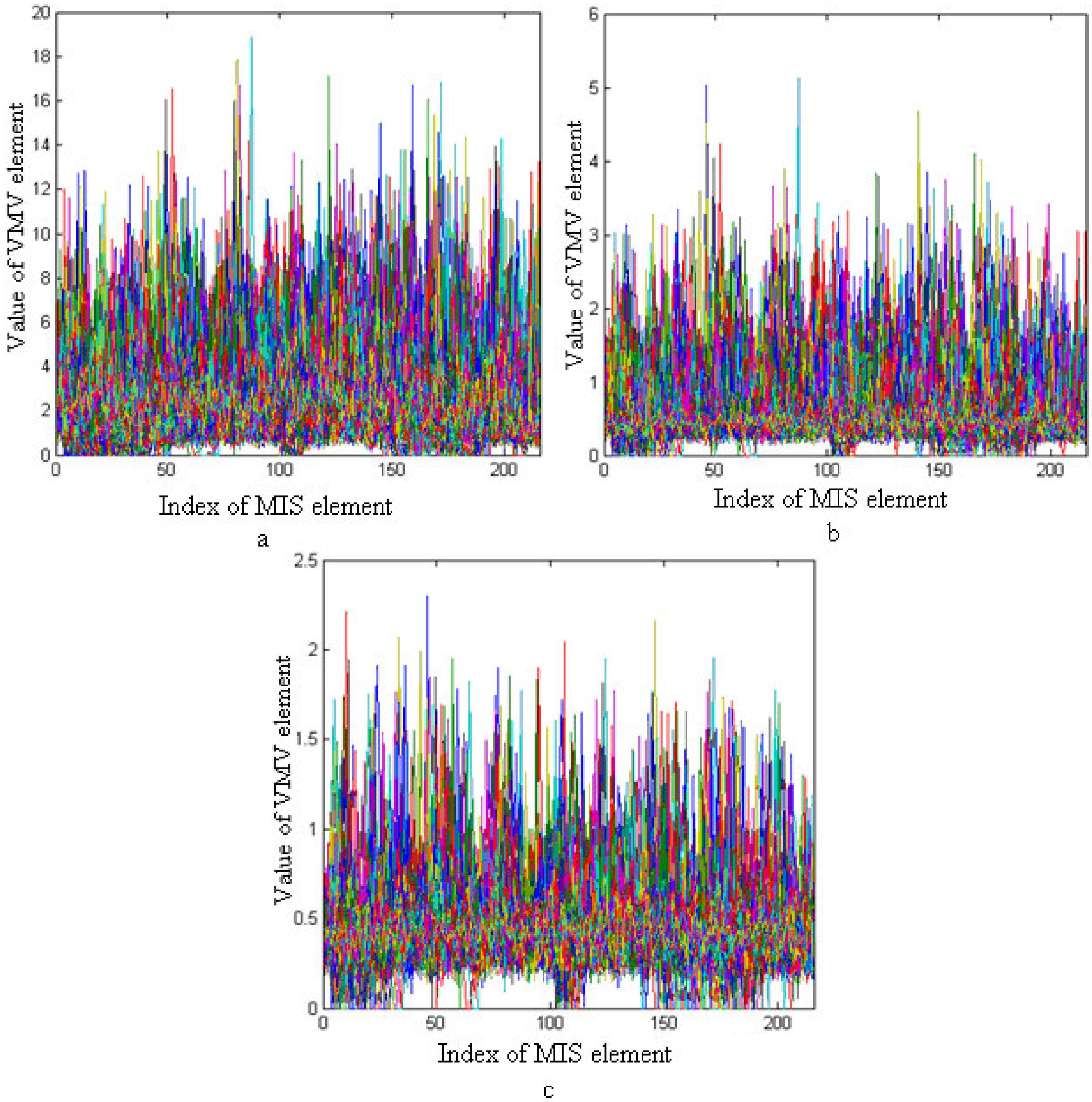


Fig. 4. RA for DI "MASHA": a – before blurring; b – after blurring (a radius is a 1 pixel); c – after repeated blurring (a radius is a 1 pixel)

To illustrate an efficiency of an additional verification we consider an example. Let's analyze DI (Fig. 5), produced in the mode "macro survey" and not exposed to intentional blurring. The program, realizing the developed algorithm, reaches a conclusion (2). RA and VMV for this image are presented in Figs. 7(a), 6(a). RA and VMV acquired the form, presented in Figs. 7(b), 6(b) accordingly after intentional "suspicious" DI blurring. It is obvious from comparison of Figs. 6(a) and 6(b) that diminished in more than 3 times after blurring. Comparison of Figs. 7(a) and 7(b) shows diminishing for range of RA values in 3 times. It allows making conclusion that an image was not blurred originally.

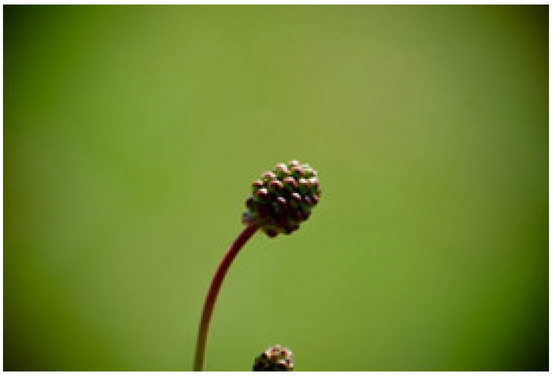
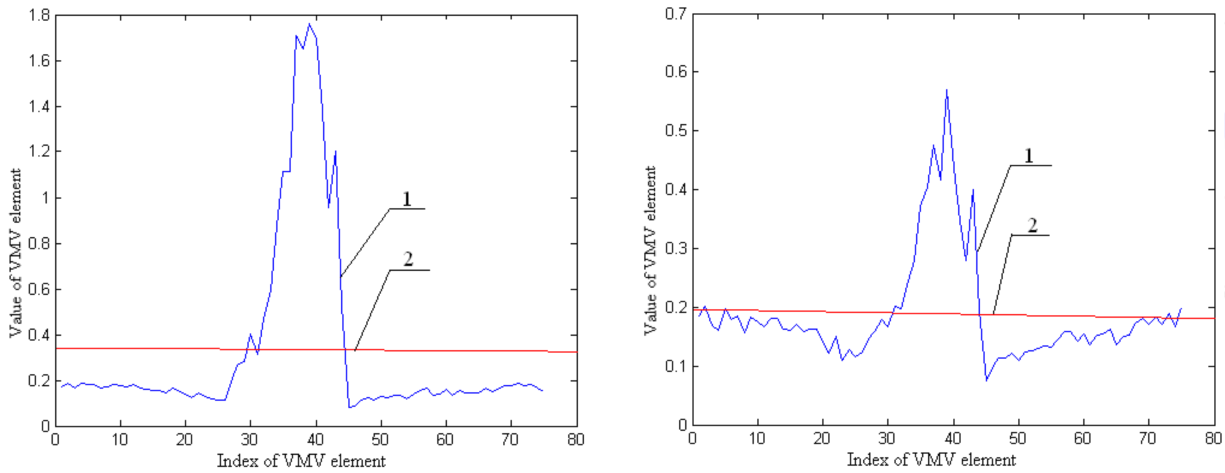
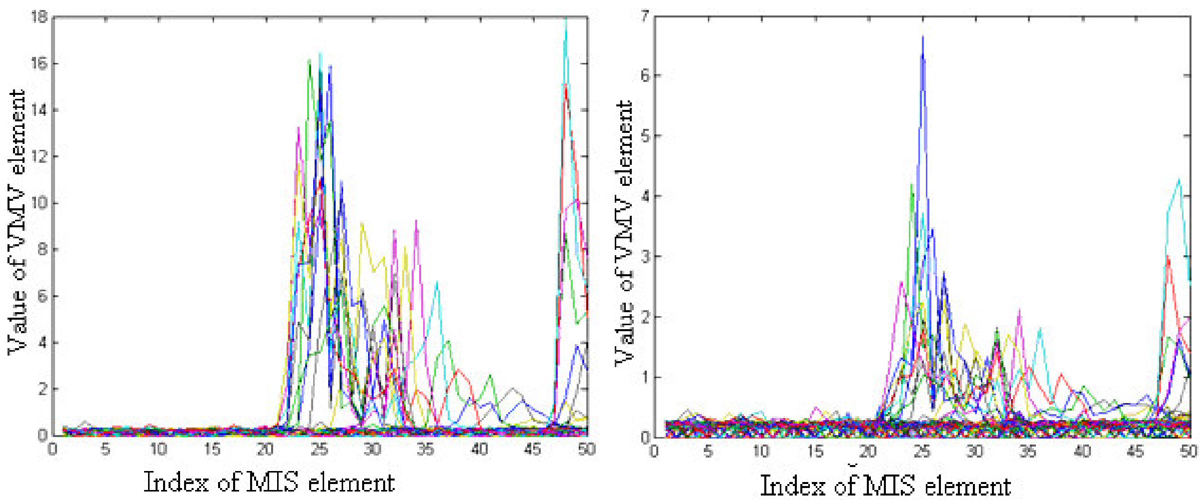


Fig. 5. DI in mode of "macro survey"



a **b**

Fig. 6. 1 – graphic presentations of VMV for test DI, removed in the mode "macro survey", 2 – linear approximation of VMV: a – before blurring, b – after blurring



a **b**

Fig. 7. RA for DI removed in the mode "macro survey": a – before blurring, b – after blurring

Computing experiment results

A computing experiment was conducted using MATLAB with more than 400 different DI in the jpeg-format with a different “quality”. Images were produced by modern photo cameras. DI was exposed to the operation IB in the Adobe Photoshop. Original and tampered images were tested through intermediary of the developed and implemented method. Experiment results confirm high efficiency of developed method. These are given in Table 1.

Table 1.

Efficiency of developed method

	$Q = 10$	$Q = 8$
Amount of right answers (%)	90-95	80-86
Amount of right answers at additional verification (%)	99	95

Conclusion

The effective method of separation BDI from NBDI is developed. Its computing complication is determined by the amount of blocks which the matrix of investigated DI is broken up on. The offered method is maximally effective in the case when an image was blurred as a whole. If IB was conducted only to pieces of DI, then it will be considerably more difficult to detect blurring. In this case it is necessary:

1) To extract “suspicious” area of testable DI, that defiant doubts in authenticity;

2) To expose to the analysis containing a “suspicious” area part of image using the developed algorithm.

At the moment authors are working on creation complex method of images falsification detection. The offered method will be used as component in the complex method.

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ВИЯВЛЕННЯ НАСЛІДКІВ РОЗМИТТЯ ЦИФРОВОГО ЗОБРАЖЕННЯ

У даній статті розроблено та реалізовано програмно метод, що дозволяє відділити навмисно розмите цифрове зображення від нерозмитого. Навмисне розмиття цифрового зображення може вказувати на його фальсифікацію.

Ключові слова: фальсифікація зображення, розмиття цифрового зображення

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ВЫЯВЛЕНИЕ ПОСЛЕДСТВИЙ РАЗМЫТИЯ ЦИФРОВОГО ИЗОБРАЖЕНИЯ

В данной статье разработан и программно реализован метод, позволяющий отделить цифровое изображение, подвергнутое операции размытия, от неразмытого. Намеренное размытие цифрового изображения может указывать на его фальсификацию.

Ключевые слова: фальсификация изображения, размытие цифрового изображения