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MANUFACTURING AUTOMATION

КОМП'ЮТЕРНІ Й ІНФОРМАЦІЙНІ МЕРЕЖІ І СИСТЕМИ. АВТОМАТИЗАЦІЯ ВИРОБНИЦТВА

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ACCURACY IMPROVEMENT OF CLONING AREA DETECTION

О.Ю. Лебедева, А.А. Кобозева, В.В. Зоріло. Підвищення ефективності визначення області клонування. В роботі проведена модифікація методу виявлення і локалізації областей порушення цілісності в цифровому зображенні, отриманого в результаті клонування. **Мета:** Метою роботи є підвищення точності визначення областей порушення цілісності цифрового зображення шляхом розробки модифікації методу виявлення і локалізації областей клонування, заснованого на блоково-орієнтованому підході, за рахунок одночасного використання при експертизі зображення квадратних, трикутних, круглих блоків і блоків складної форми. **Матеріали і методи:** Представлено подальший розвиток блоково-орієнтованого підходу до вирішення завдання виявлення результатів клонування в цифровому зображенні. Запропоновано модифікація методу виявлення і локалізації областей клонування, заснованого на врахуванні близькості блоків матриці, яка кількісно оцінюється за допомогою різних варіантів завдання метрики. **Результати:** Розроблено методика одночасного використання квадратних, трикутних, круглих блоків і блоків складної форми для експертизи цифрових зображень. Шляхом обчислювального експерименту встановлено підвищення точності визначення областей порушення цілісності цифрового зображення при використанні запропонованої модифікації методу виявлення і локалізації областей клонування при одночасному використанні при експертизі блоків різних видів розбиття: відносна величина площі виявленої області від реальної області клону збільшується в 1,6 рази, в порівнянні з результатами роботи алгоритмічної реалізації методу, взятого за основу.

Ключові слова: точність виявлення, фальсифікація зображення, виявлення фальсифікації, клонування.

Ye.Yu. Lebedeva, A.A. Kobozeva, V.V. Zorilo. Accuracy improvement of cloning area detection. In the work the modification of a method of detection and localization of regions of the integrity violation in the digital image obtained as a result of cloning is developed. **Aim:** The aim of the work is to increase the accuracy of detection of integrity violation regions of the digital image by development of modification of a method of detection and localization of cloning regions based on the block oriented approach due to simultaneous use in case of expertise of the image with square, triangular, round blocks and of irregular shape blocks. **Materials and Methods:** Further development of the block oriented approach to the solution of problem of cloning results detection in digital image is provided. Modification of the method of detection and localization of the cloning regions developed by authors earlier, based on the accounting of closeness of the matrix blocks which is quantitatively evaluated by means of different variants of the metrics assignment is offered. **Results:** The technique of simultaneous use of square, triangular, round blocks and blocks of irregular shape in case of the expertise of the image based on the block oriented approach is developed. Providing the computational experiment the accuracy increase of determination of integrity violation regions of the digital image when using of the offered modification of the method of detection and localization of fields of cloning in case of simultaneous use in case of expertise of different partitioning types blocks is set: the relative value of the area of the revealed region from real region of a clone increases by 1.6 times in comparison with results of operation of algorithmic implementation of the method taken as a basis.

Keywords: detection accuracy, falsification of image, falsification detection, cloning.

Introduction. Digital images (DI) of different storage formats and different quality are currently being falsified. In addition, both large falsified parts of the image and small falsified parts that do not

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attract attention at first glance. Especially relevant are the falsification of small details of the image: codes, numbers and other information in the image, obscuring the details on the faces (moles, wrinkles, scratches), etc. The most widely used and simple instrument of falsification is the cloning of parts of the image of any form. The cloning process replaces part (parts) of DI by part (parts) of the same DI. As a result, modified regions are called cloned (clone) of original images, and the original regions that have been the basis of the clones are called as their prototype image. Currently existing methods of cloning detection are able to quickly and efficiently detect large falsified region, but they are often powerless in the case of small regions and regions of unusual shape. In addition, at the detection of large cloning regions, there might be situations requiring the maximum precision of the cloning region detection (boundaries). Such situations may arise when it is important not only to determine whether the digital image is violated, but also to obtain maximum of reliable information of the available digital image. Therefore, extremely urgent there is a question of development new and modifications of the existing methods of effective detection and localization of the cloning regions allowing to increase the detection accuracy provided today.

We will understand the integrity violation of DI happening by cloning as falsification of the digital image.

Today the most popular graphics editors are Adobe Photoshop and GIMP. Their tools are used for creation of falsification in the image. Such tools are the Rectangular marquee, Elliptical marquee, Lasso, Polygonal lasso, the Magnetic lasso, the Stamp, the Eraser, etc. Use of these tools allows to create falsifications of arbitrary (not rectangular) form (Fig. 1) that makes impossible to find precisely the cloned region using blocks of square shape which are standard in methods of detection of falsifications in the images.

In [1] the method was developed used for detection and localization of cloning regions which on the first step partitions the image into a set of the crossed blocks of the standard form. As experimental results showed, use of standard blocks doesn't allow to receive the exact sizes and to precisely detect a location (form) of the found falsifications regions.

In [2...4] the method of detection and localization of cloning regions for use of blocks of triangular, irregular shape and round blocks was modified. These types of blocks are well proved themselves in the detection and localization of cloned regions of any shape.

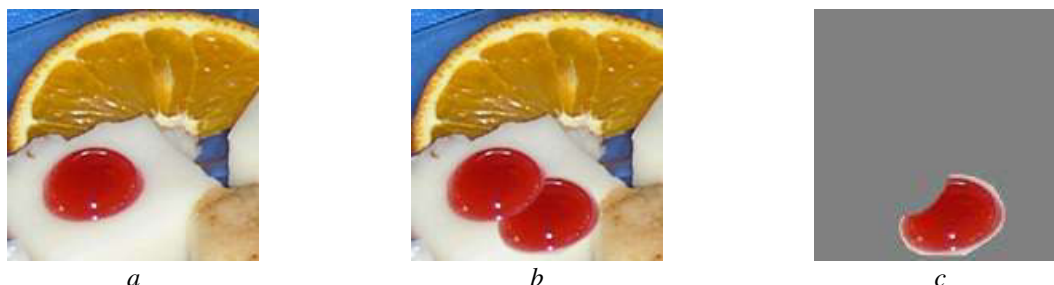


Fig. 1. The difference between falsified and original images: original (a); falsified (b); the falsified region (c)

The aim of the work is to increase the accuracy of detection of integrity violation regions of the digital image by development of modification of a method of detection and localization of cloning regions based on the block oriented approach due to simultaneous use in case of expertise of the image with square, triangular, round blocks and of irregular shape blocks.

Accuracy of detection will be evaluated by the relative value of the area of the revealed cloning region to the actual area of the cloning region defined as a percentage. We will define the real area of cloning region as a difference between the original and falsificated images. Value of the area is measured in pixels.

To achieve the goal, it is necessary to solve the following problems:

– to research feasibility, taking into account the aim of the work, of simultaneous use of blocks of different (non-standard) shape for detection of falsification regions in DI;

– to develop a technique of simultaneous use of square, triangular, round blocks and blocks of irregular shape.

– to modify the existing method of detection and localization of cloning regions by simultaneous use of square, triangular, round blocks and blocks of irregular shape for expertise of DI.

Materials and Methods.

Technique of simultaneous use of blocks of irregular shape. In [2...4] the procedure of obtaining of triangular blocks, blocks of irregular shape and round blocks is explained. During the experiments the best block partitions of different shape from the point of view of detection accuracy, provided in Fig. 2, were revealed. So the triangular blocks providing the highest accuracy of cloning region detection in comparison with remaining triangular partitions, are provided on Fig. 2, *a*, blocks of irregular shape – on Fig. 2, *b*, sector blocks in Fig. 2, *c*.

All blocks considered in this work are results of partitioning reference square blocks. They can be used as means of specification when square blocks do not provide the required accuracy of detection of cloning region.

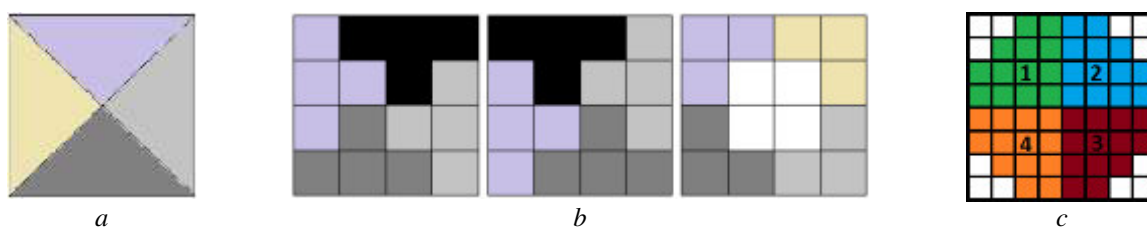


Fig. 2. Blocks of a DI matrix which give the best accuracy of cloning region detection: triangular shape (*a*); irregular shape (*b*); round form (*c*)

Thus, first of all it is necessary to use splitting of its matrix into square blocks at simultaneous use of square, triangular, round blocks and blocks of irregular shape in process of detection of falsification regions in DI. Criterion of detection of the cloned region is equality of correlation coefficient to unit between pair of blocks. If in the developed method of detection and localization of cloning regions the square partitioning doesn't give the value of correlation coefficient equal to unit, then it is necessary to use triangular blocks, blocks of irregular shape and sector blocks for detection of the cloned region.

In modification of the method of detection and localization of cloning regions the following steps have to be considered:

1. To obtain pair of blocks of square shape;
2. To check whether pair of square blocks are clone and a prototype, if yes then go to step 4;
3. Parallel execution of the following steps:
 - 3.1. To obtain the triangular blocks. To check whether triangular blocks are cloned;
 - 3.2. To obtain the irregular shape blocks. To check whether irregular shape blocks are cloned;
 - 3.3. To obtain the sector blocks. To check whether sector blocks are cloned;
4. Go to the next pair of blocks.

According to the given technique of simultaneous use of square, triangular, round blocks and blocks of irregular shape, we modify the method of detection and localization of cloning regions. To accelerate the checking process of different types of blocks, we will apply them only in regions, suspicious on falsification. The area is suspicious on falsification if value of correlation coefficient is more than set threshold. We will partition regions, suspicious on falsification, into blocks of different types and the basic method of detection of the cloned regions [3] is applicable to each type of blocks.

The main steps of modification of the method of detection and localization of cloning regions for simultaneous use of square, triangular, round blocks and blocks of irregular shape looks as follows:

1. To initialize the area to be identified $res = \emptyset$ and to split brightness matrix Y of DI for crossed

blocks $C = \{c_1, c_2, \dots, c_s\}$, $\bigcup_{i=1}^s c_i = Y$, with sizes $p \times p$ (here each subsequent block c_i differs from previous c_{i-1} in shift on 1 pixel to the right, to the left, down or up);

2. Each block c_i , $i=1, \dots, s$, is considered together with all c_j , $j=i+1, \dots, s$, accordingly. For each pair;
 3. To calculate a proximity measure $\delta = \text{Metrica}(c_i, c_j)$;
 4. To test accessory of pair of blocks c_i, c_j to regions of clone and its prototype by the analysis of measure of proximity value δ ;
 5. If the pair of blocks c_i, c_j are the areas of clone and its prototype, then $res = res \cup c_i \cup c_j$, else to test the pair of blocks on suspiciousness by analysis of measure of proximity value δ ;
 6. If the pair of blocks c_i, c_j are suspicious ones, then execute steps 6.1...6.3 simultaneously:
 - 6.1. To obtain triangular blocks c_{nt}^i and c_{mt}^j of blocks c_i, c_j :
 - 6.1.1. To calculate a proximity measure $\delta_t^{ij} = \text{Metrica}(c_{nt}^i, c_{mt}^j)$;
 - 6.1.2. By analysis of measure of proximity value δ_t^{ij} determine to reveal accessory of blocks c_{nt}^i and c_{mt}^j to regions of clone and its prototype;
 - 6.1.3. If the pair of blocks c_{nt}^i and c_{mt}^j , are the regions of clone and its prototype, then $res = res \cup c_{nt}^i \cup c_{mt}^j$;
 - 6.2. To obtain irregular shape blocks c_{nc}^i and c_{mc}^j :
 - 6.2.1. To calculate a proximity measure $\delta_c^{ij} = \text{Metrica}(c_{nc}^i, c_{mc}^j)$;
 - 6.2.2. By analysis of measure of proximity value δ_c^{ij} to reveal accessory of blocks c_{nc}^i and c_{mc}^j to regions of clone and its prototype;
 - 6.2.3. If the pair of blocks c_{nc}^i and c_{mc}^j , are the regions of clone and its prototype, then $res = res \cup c_{nc}^i \cup c_{mc}^j$;
 - 6.3. To obtain sector blocks c_{ns}^i and c_{ms}^j :
 - 6.3.1. To calculate a proximity measure $\delta_s^{ij} = \text{Metrica}(c_{ns}^i, c_{ms}^j)$;
 - 6.3.2. By analysis of measure of proximity value δ_s^{ij} to reveal accessory of blocks to regions of clone and its prototype;
 - 6.3.3. If the pair of blocks c_{ns}^i and c_{ms}^j , are the regions of clone and its prototype, then $res = res \cup c_{ns}^i \cup c_{ms}^j$;
 7. To output the obtained region res .

The example of work of the modified method of detection and localization of cloning regions by simultaneous use of square, triangular, round blocks and blocks of irregular shape is presented in Fig. 3.

The efficiency analysis of the developed modification. During the computational experiment, which aim was to carry out the efficiency analysis of the modified method from the point of view of the accuracy of detection of the cloned regions, the size of the cloned region was chosen randomly depending on the specific image and didn't depend on the size of blocks of the partitioning used in experiments.

All of DI have various sharpness depth of the represented space and were exposed to falsification and post-processing using the Adobe Photoshop and GIMP graphic editors. Original DI had various compression ratios corresponding to quality factor Q from 4 to 10 in the Adobe Photoshop graphic editor. After cloning process finished, the obtained falsified DI were saved in a lossless graphic format (BMP). When falsified DI are saved in a graphic format with losses (JPEG), falsifications can be detected by method of identification of double quantization effect in DI [5]. The contour of the cloned region was exposed to blurring.

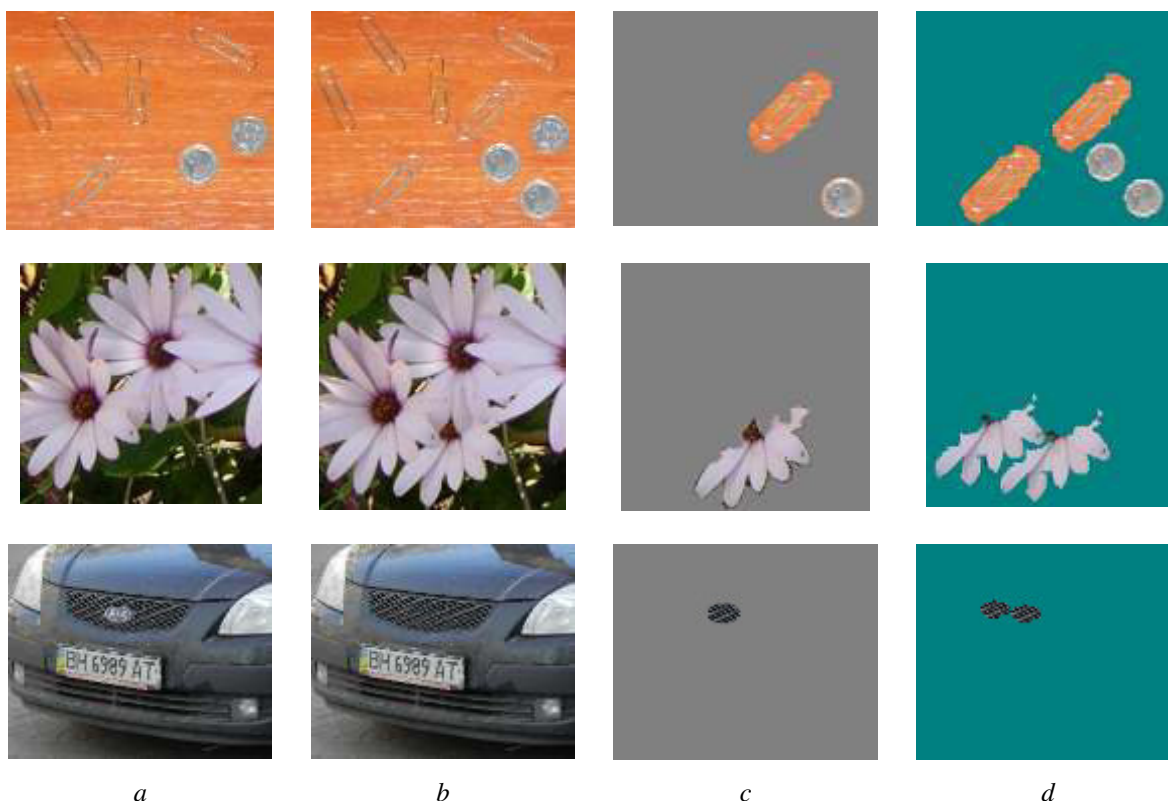


Fig. 3. Result of work of the modified method of detection and localization of cloning regions by simultaneous use of square, triangular, round blocks and blocks of irregular shape: original image (a); falsified image (b); falsified region (c); detected cloning region (d)

As a result of an experiment it has been received:

- the digital images containing the revealed cloning region with use of square blocks (Fig. 4, d);
- the digital images containing the revealed cloning region with use of triangular blocks (Fig. 4, e);
- the digital images containing the revealed cloning region with use of irregular shape blocks (Fig. 4, f);
- the digital images containing the revealed cloning region with use of sector blocks (Fig. 4, g);
- the digital images containing the revealed cloning region with use of triangular blocks, irregular shape blocks and sector blocks (Fig. 4, h);
- the relative size of the area of the revealed cloning region to the actual area of cloning region for different types of blocks and the modified method (Table 1).

Let's consider results of detection accuracy of cloning region for the images provided in this paper with use only of square blocks, only triangular blocks, only blocks of irregular shape, only sector blocks and at simultaneous use of all listed types of partitioning (Table 1).

By results from Table 1 it is possible to draw a conclusion on the higher accuracy of detection of cloning region with simultaneous use of square blocks, triangular blocks, blocks of irregular shape and sector blocks. When using in a method of detection and localization of cloning region of the blocks of different types of partitioning the relative size of the area of the revealed region will increase by 1.6 times from real area of the clone in comparison with use of standard partitioning and in case of blurring of a contour of the cloned region.

Conclusions. The possibility of simultaneous use of square, triangular, round blocks and blocks of irregular shape at identification of falsification regions in DI is investigated.

The technique of their simultaneous application in the process of detection and localization of the cloned region is offered.

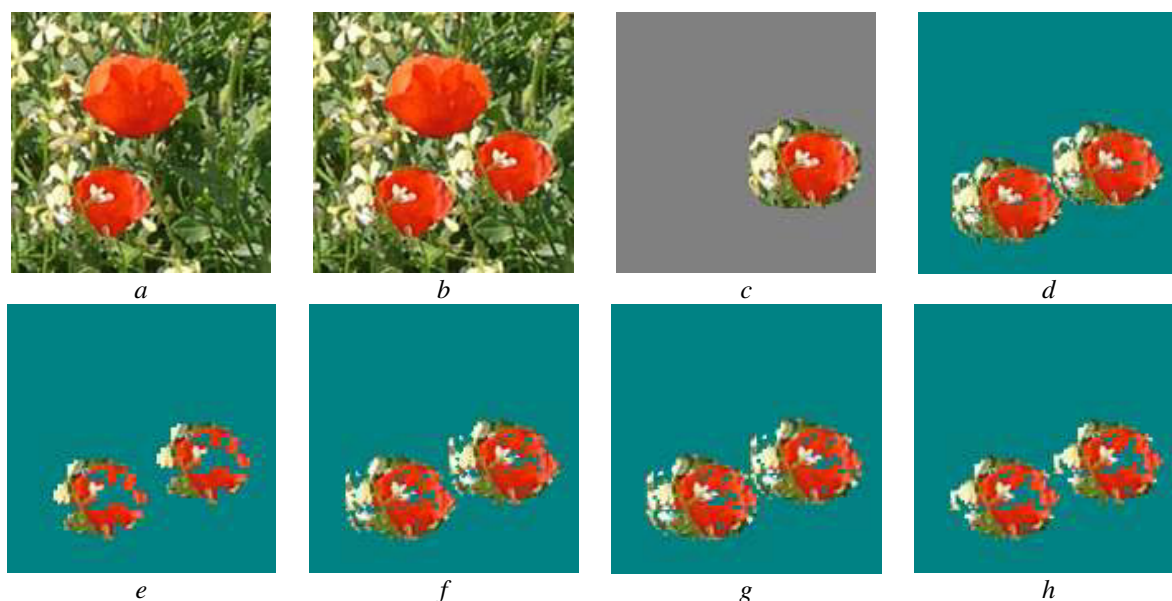


Fig. 4. Result of work of the modified method of cloning regions detection by simultaneous use of square, triangular, round blocks and blocks of irregular shape: original image (a); falsified image (b); cloning region (c); result of work of the modified method (d); use of square blocks 8×8 (e); use of triangular blocks 8×8 (f); use of sector blocks 8×8 (g); use of irregular shape blocks 8×8 (h)

Table 1

Results of detection accuracy of cloning region which contours have been subjected to blurring, using blocks of different types of partitioning

Images	The relative size of the revealed region from real cloning region (%)				
	Square blocks	Triangular blocks	Irregular shape blocks	Sector blocks	All blocks
Image 1	54.62	69.60	64.23	68.99	77.58
Image 2	69.66	82.43	75.22	79.29	90.33
Image 3	45.31	60.86	53.73	60.16	70.84
Image 4	32.13	62.65	54.82	62.25	74.70
Image 5	45.80	69.27	59.59	71.70	82.99
Average for images	49.50	68.96	61.52	68.48	79.29

Modification of a method of detection and localization of cloning regions with simultaneous using the blocks of different types of partitioning is developed.

Efficiency analysis of developed modification of a method from the point of view of the detection accuracy of the cloned regions is carried out. The analysis showed that in case of simultaneous use of the blocks of different types of partitioning the relative area size of the revealed region from real region of the clone increases by 1.6 times.

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