The aim of the work is to increase the accuracy of detection of integrity violation regions of the digital image by developing a method of detection and localization of regions of the integrity violation of the digital image obtained as a result of cloning. The method of detection and localization of 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. The technique of simultaneous use of square, triangular, round blocks and blocks of irregular shape in case of cloning is provided. Providing the computational experiment the accuracy increase 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. 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.
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)](image)

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 expertize 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 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 $C = \{c_1, c_2, \ldots, c_i\}$, $\bigcup_{i} c_i = Y$, 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 $c_i$, $i = 1, \ldots, s$, is considered together with all $c_j$, $j = i + 1, \ldots, s$, accordingly. For each pair:

3. To calculate a proximity measure $\delta = \text{Metrica}(c_i, c_j)$;

4. To test accessibility of pair of blocks $c_i, c_j$ to regions of clone and its prototype by the analysis of measure of proximity value $\delta$;

5. If the pair of blocks $c_i, c_j$ are the areas of clone and its prototype, then $\text{res} = \text{res} \cup c_i \cup c_j$, else test the pair of blocks on suspiciousness by analysis of measure of proximity value $\delta$;

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 $c_{ni}^t$ and $c_{ni}^d$ of blocks $c_i, c_j$:

6.1.1. To calculate a proximity measure $\delta_{ni}^t = \text{Metrica}(c_{ni}^t, c_{ni}^d)$;

6.1.2. By analysis of measure of proximity value $\delta_{ni}^t$ determine to reveal accessibility of blocks $c_{ni}^t$ and $c_{ni}^d$ to regions of clone and its prototype;

6.1.3. If the pair of blocks $c_{ni}^t$ and $c_{ni}^d$, are the regions of clone and its prototype, then $\text{res} = \text{res} \cup c_{ni}^t \cup c_{ni}^d$;

6.2. To obtain irregular shape blocks $c_{ns}^t$ and $c_{ns}^d$:

6.2.1. To calculate a proximity measure $\delta_{ns}^t = \text{Metrica}(c_{ns}^t, c_{ns}^d)$;

6.2.2. By analysis of measure of proximity value $\delta_{ns}^t$ to reveal accessibility of blocks $c_{ns}^t$ and $c_{ns}^d$ to regions of clone and its prototype;

6.2.3. If the pair of blocks $c_{ns}^t$ and $c_{ns}^d$, are the regions of clone and its prototype, then $\text{res} = \text{res} \cup c_{ns}^t \cup c_{ns}^d$;

6.3. To obtain sector blocks $c_{ns}^s$ and $c_{ns}^s$:

6.3.1. To calculate a proximity measure $\delta_{ns}^s = \text{Metrica}(c_{ns}^s, c_{ns}^s)$;

6.3.2. By analysis of measure of proximity value $\delta_{ns}^s$ to reveal accessibility of blocks to regions of clone and its prototype;

6.3.3. If the pair of blocks $c_{ns}^s$ and $c_{ns}^s$, are the regions of clone and its prototype, then $\text{res} = \text{res} \cup c_{ns}^s \cup c_{ns}^s$;

7. To output the obtained region $\text{res}$.

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.
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.
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.

**Література**


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