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# USING CIRCULAR BLOCKS FOR DETECTION OF FORGED REGIONS IN DIGITAL IMAGES

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In this work, the use of circular blocks for the detection and location of cloned regions was investigated to improve the detection accuracy. The procedure to develop circular and sector blocks in a digital image was presented. The modified method developed for the detection and location of cloned regions allows locating a cloned region with the use of circular blocks in a more accurate way.

**Keywords:** digital image forgery, forgery detection, cloning, circular block

## Introduction

Widespread use of modern digital cameras and digital image (DI) processing software (such as Adobe Photoshop and GIMP) has lead to the emergence of image forgery hardly detectable to the human eye. Since the tools of these graphic editors are rather easy to use, the number of image forgeries has been increasing day by day. Digital images are of primary importance in cyberspace and are used in the printed media, medicine, science, forensic proceedings, etc. It is essential not only to detect forged regions, but to determine their borders as accurately as possible. Therefore, solving the problem of accurate detection of forged regions in digital images is an *urgent* issue.

## Statement of the problem and purpose of the study

In this paper, we discuss cloning, one of the commonest methods used for digital image forgery. In cloning, parts of the DI are changed with parts of the same image.

Implementation of this approach with graphics editors such as Adobe Photoshop and GIMP generally involves the use of specific tools (*Rectangular Marquee Tool*, *Lasso Tool*, *Eraser Tool*, etc.). The tools mentioned make it possible to create a cloned region of an irregular shape.

In [1, 2], a method has been developed to detect and locate cloned regions using standard blocks. For the purpose of methodology, a standard block means a square-shape block of any size. Investigations performed with that method revealed that the 8 x 8 block has the most favorable size among standard blocks. However, the results of the experiments have shown that the use of standard blocks does not allow for proper accuracy in the size and location (shape) of the detected forged regions.

To detect cloned regions more accurately, one should use the blocks of non-standard shape.

The *Purpose* of the study was to investigate the potential for the use of circular blocks in DI, and to develop a modification of the method for the detection and location of cloned regions using circular blocks in order to improve the detection accuracy.

The detection accuracy was assessed by the percentage ratio of the area of detected cloned region to the actual area of cloned region. The actual area of cloned region was determined as the difference between the original image and the forged image. The area was measured in pixels.

To accomplish the purpose of the work, the following problems were to be solved:

1. To elaborate the procedure of obtaining circular blocks;
2. To modify the method for the detection and location of cloned regions in order to use circular blocks;
3. To use computational experiments to conclude whether it is expedient to use circular blocks.

**Procedure of obtaining circular blocks**

Let us address the development of a circular block based on a square-shaped block (Fig.1)

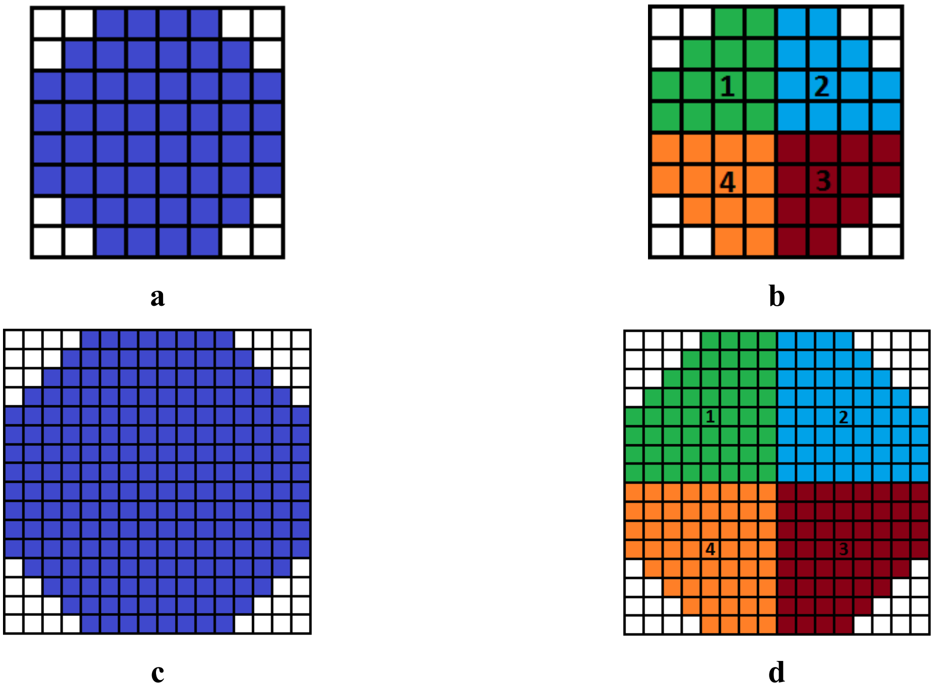



**Figure 1.** Decomposition of a square-shaped block into: a – round 8x8 block; b – sectors of a round 8x8 block; c – round 16x16 block; d – sectors of a round 16x16 block

The brightness matrix $S$ of a square-shaped DI block will be used as a basic one. The brightness matrix $L$ of a circular block is formed from the brightness values of marked pixels (Fig. 1 a, c) of matrix $S$, whereas the values of non-marked pixels are zeroed. Aside from a circular block, one can obtain sector-shaped blocks (Fig. 1 b, d). In this case, we will get four sector matrices $L_1, L_2, L_3, L_4$ to be filled in a similar way, i.e., e.g., matrix $L_1$ will contain the values of pixels of matrix $S$ located in zone 1 (Fig. 1 b, d), whereas the values of other pixels are zeroed.

**Method for the detection and location of cloned regions using circular blocks**

Let us modify the basic method in order to use circular blocks for the detection and location of cloned regions.

Briefly, the procedure of the method for the detection and location of cloned regions in a DI using circular blocks is as follows.

1. Divide the brightness matrix $Y$ of a DI into $p \times p$ overlapping blocks $C = \{c_1, c_2, \ldots, c_s\}$, $\bigcup_{i=1}^{s} c_i = Y$, (here each block $c_i$ is obtained by a single-pixel right shift, left shift, down-shift or up-shift of block $c_{i-1}$).

2. For a block pair considered, $c_i, c_j$, $i = 1, \ldots, s$, $j = i+1, \ldots, s$ obtain circular subdivision blocks $c_i^{'}$ and $c_j^{'}$, respectively. For each subdivision:

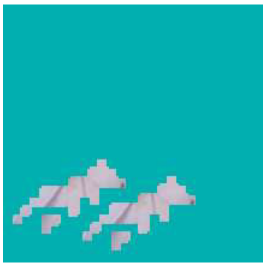
3. Calculate the correlation coefficient $\delta = Correlation(c_i', c_j')$.

4. Analyze the value of correlation coefficient $\delta$ to determine pairs of blocks $c_i^{'}$ and $c_j^{'}$ suspected for belonging to cloned regions and to a clone prototype.

Fig. 2 shows a sample of application of the modification method developed for the detection and location of cloned regions.

a

b



c

d

**Figure 2.** Results of the application of the modification method for the detection and location of cloned regions using the blocks of circular shape: a – original image, b – forged image, c – result of the detection using 8x8 square-shape blocks, d – result of the detection using 8x8 circular-shape blocks

To improve the accuracy of detection of clone borders, let us use not only circular blocks, but also sector-shaped blocks (Fig. 1 b, d) within the process. In this case, briefly, the procedure of the method for the detection and location of cloned regions in a DI using circular blocks is as follows.

1. Divide the brightness matrix $Y$ of a DI into $p \times p$ overlapping blocks $C = \{c_1, c_2, \ldots, c_s\}$, $\bigcup_{i=1}^{s} c_i = Y$, (here each block $c_i$ is obtained by a single-pixel right shift, left shift, down-shift or up-shift of block $c_{i-1}$).

2. For a block pair considered, $c_i, c_j$, $i = 1, \ldots, s$, $j = i+1, \ldots, s$ obtain circular subdivision blocks $c_i^{'}$ and $c_j^{'}$, respectively. For each subdivision:

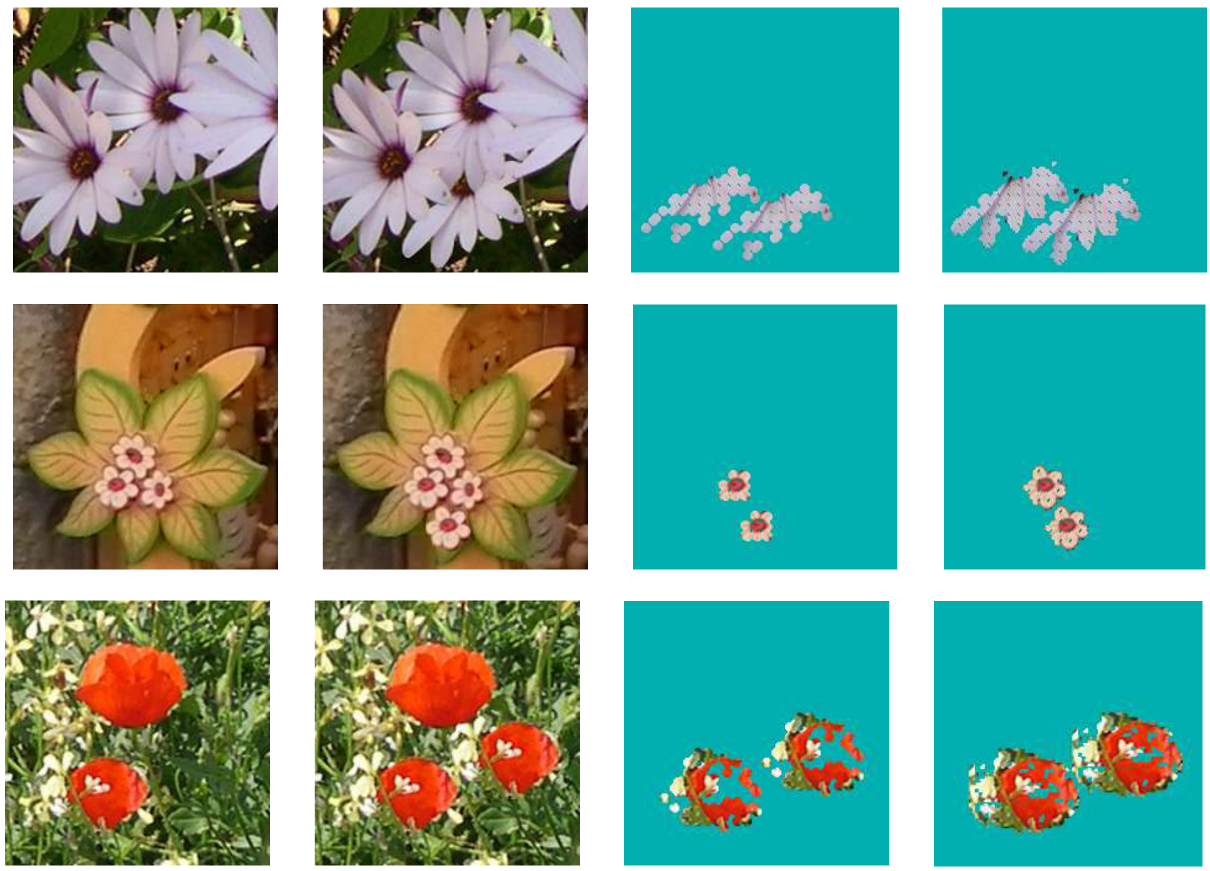
2.1. Calculate the correlation coefficient $\delta' = Correlation(c_i', c_j')$

2.2 Analyze the value of correlation coefficient $\delta'$ to determine pairs of blocks $c_i^{'}$ and $c_j^{'}$ suspected for belonging to cloned regions and to a clone prototype. If the suspected blocks are not found, obtain sector-shaped blocks $c_i^k$ and $c_j^k$, $k = 1, \ldots, 4$. For each subdivision:

2.2.1 Calculate the correlation coefficient $\delta^k = Correlation(c_i^k, c_j^k)$

2.2.2 Analyze the value of correlation coefficient $\delta^k$ to determine pairs of blocks $c_i^k$ and $c_j^k$ suspected for belonging to cloned regions and to a clone prototype.

Fig. 3 shows a sample of application of the modification method developed for the detection and location of cloned regions using circular and sector-shaped blocks.



**a** **b** **c** **d**

**Figure 3.** Results of the application of the modification method for the detection and location of cloned regions using circular and sector-shaped blocks: a – original image, b – forged image, c – result of the detection using circular-shaped blocks, d – result of the detection using circular and sector-shaped blocks

The use of circular and sector-shaped blocks for the detection and location of cloned regions allowed increasing the detectable area of cloned region, as compared to the use of circular blocks only. E.g., regarding the images presented at Fig.3, the ratio of area of detected cloned region to actual area of cloned region increased 1.34, 1.57, and 1.47 times, as compared to the use of circular blocks only.

Hereinafter, by "using circular blocks" we mean "using circular and sector-shaped blocks".

A computational experiment was performed to analyze the efficiency of the method developed for the detection and location of cloned regions using circular blocks based on the accuracy of detection of cloned regions. Within the experiment, the size of a cloned region was arbitrarily selected depending on the specific image, and irrespective of the size of subdivision blocks used in experiments. The cloned region boundary was subjected to blurring to get the improved visual embedding into the image. After application of cloning technology, the forged digital image obtained was saved using lossless format. The results of the experiments are presented in Tables 1 and 2.

**Table 1.**

Accuracy of the detection of a cloned region with blurred boundaries using the square-shaped and circular blocks

| Types of subdivision | Percentage ratios of area of detected cloned region to actual area of cloned region | | |
|---|---|---|---|
| | Max | Min | Average |
| Blocks of square shape | 69.17 | 32.13 | 47.51 |
| Blocks of circular shape | 74.69 | 49.66 | 63.42 |

**Table 2.**

Evaluation of the accuracy of the cloned region detection with the method developed by means of a relative mean error of the area of detected cloned regions

| Types of subdivision | Relative mean error of the area value (%) |
|---|---|
| Blocks of square shape | 52.49 |
| Blocks of circular shape | 36.58 |

## Conclusions

A procedure was developed to obtain circular blocks based on a square-shaped block of the DI matrix. A method for the detection and location of cloned regions was modified in order to use circular blocks. A computational experiment was performed to analyze the efficiency of the method developed for the detection and location of cloned regions using circular blocks based on the accuracy of detection of cloned regions. The experiment showed that the ratio of area of detected cloned region to actual area of cloned region increases more than 1.3 times, and relative mean error of the area value decreases 1.44 times, as compared to the use of square-shaped blocks. The results obtained prove that it is expedient to use circular blocks for the detection and location of cloned regions.

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## ВИКОРИСТАННЯ КРУГЛИХ БЛОКІВ ДЛЯ ВИЯВЛЕННЯ ОБЛАСТІ ФАЛЬСИФІКАЦІЇ В ЦИФРОВИХ ЗОБРАЖЕННЯХ


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У статті досліджується використання круглих блоків при виявленні та локалізації областей клонування для підвищення точності виявлення клонованих областей. Наводиться методика побудови круглих і секторних блоків у цифрових зображеннях. Розроблена модифікація методу виявлення та локалізації областей клонування, що дозволяє більш точно локалізувати клоновану область з використанням круглих блоків.



**Ключові слова:** фальсифікація зображень, виявлення фальсифікації, клонування, круглий блок.


## ИСПОЛЬЗОВАНИЕ КРУГЛЫХ БЛОКОВ ДЛЯ ВЫЯВЛЕНИЯ ОБЛАСТИ ФАЛЬСИФИКАЦИИ В ЦИФРОВЫХ ИЗОБРАЖЕНИЯХ


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В статье исследуется использование круглых блоков при обнаружении и локализации областей клонирования для повышения точности обнаружения клонированных областей. Приводится методика построения круглых и секторных блоков в цифровых изображениях. Разработана модификация метода обнаружения и локализации областей клонирования, что позволяет более точно локализовать клонированную область с использованием круглых блоков



Ключевые слова: фальсификация изображений, обнаружения фальсификации, клонирование, круглый блок.