EFFECT OF THE ROTATION ON THE VWM ALGORITHM

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Abstract
The first part of the paper describes VWM (Visible Watermarking) algorithm for inserting - removing visible watermark in the image. Effect the rotation on the image with the inserted visible watermark was tested for the angle rotation varied in the range $\theta = 0^o : 3^o : 45^o$. *Experiment is performed with the rotating image and re-rotating image to the regular possition, for watermark blocks insertion* $k = \{2, 3, 4\}$ *and energy of insertion* $\upsilon = 40$. *In the second part of the paper, the results of the experiment are shown. A comparative analysis of the original and recovered image was performed. The comparison was performed on the basis of MSE and Similarity. The obtained results are detailed analysed and presented in a tabular and graphical manner.*

Keywords: Visible watermark, Impulsive noise, rotation.

1. INTRODUCTION

In order to protect the copyrights of multimedia content (usually images), techniques based on the insertion of the digital watermark are used. The most widely used copyright protection technique is the technique for insertion the invisible digital watermark. Invisible watermark can be extracted later for ownership proofing. On the other hand, in order to identify ownership, the technique of inserting the visible watermark is also used. This technique has recently become a widely used technique to prevent the viewers for making unauthorized use. When visible watermark is inserted, it is most often impossible to remove the watermark from the image [1] - [3]. This is in order to protect it more efficiently [4], [5]. However, in certain situations, there may be a need to remove the visible watermark from the image [6]. Many researches were done by researching the techniques for inserting reversible watermark in image but there was many difficulty. After recovering cover image was with visible damages. In the paper [7], scheme for visible-watermark removal and reversible image recovery are proposed. In this scheme, the image with embedded visible watermark is generated after embedding visible watermark into the original image. The recovered image is acquired after removing the visible watermark from the embedded image. Proposed method of inserting visible watermark is one of the most effective methods thus, original image can be exactly recovered.

During the image processing some level of degradation is inevitable. The authors of this paper came up with the idea to perform the VWM (Visible Watermarking Algorithm) algorithm in presence rotation. The authors are set the question: the effect of applying the image rotation on the qualiy of recovered image? The answer on this question was sought through the realization of an experiment within which the VWM algorithm for inserting - removing visible watermark were performed, and after image rotating is applied. Standard test images was used: Lena, Boat and Girl and Watermark image. The experiment was performed by inserting the inverse binary watermark. The watermark is inserted into the blocks, dimensions $k = \{2, 3, 4\}$ with the energy of insertion $\upsilon = 40$. Watermarked images was rotatet with angle varied in range $\theta_{min} = 0^o$; $\Delta\theta = 3^o$; $\theta_{max} = 45^o$. As a quality measure of the recovered image was used Mean Square Error (MSE) and Similarity. The results are presented in tabular and graphically.

The paper is organized as follows: Section 2 describes the VWM algorithm for inserting - removing visible watermark. Section 3 gives results and analysis of the results. Conclusion is given in section 4.

2. ALGORITHMS

In the paper is used algorithm VWM algorithm for watermarking [7], [8] and rotation. The algorithms are coded in Matlab.

A. VWM Algorithm

The VWM embedding algorithm is realized through following steps:

Step 1: The original image I_0 size $M_0 \times N_0$ is divided into nonoverlapping blocks $k \times k$, where $2 \le k \le k_m$, $k_m \in \{\lfloor M_0 / M_w \rfloor, \lfloor N_0 / N_w \rfloor\}$, where $M_w \times N_w$ is size of embedded binary watermark image. The parameter k can be 2, 3 or 4.

Step 2: One bit of the watermark can be embedded in each block B of host image I_0. In Table I is presented manner how blocks can be partioned, depending of parameter k value.

Step 3: Calculate the mean value of the assigned visible watermark region in original image I_0:

$$avg_w = \frac{\sum_{m=0}^{k\times M_w-1} \sum_{n=0}^{k\times N_w-1} I_0(m+\mu_1, n+\mu_2)}{(k\times M_w)\times(k\times N_w)}, \quad (1)$$

where (μ_1, μ_2) present coordinate of watermark image W embedded in I_0, ($k \times M_w$, $k \times M_w$) denotes the region of embedded watermark.

Step 4: Threshold T_w is calculated:

$$T_w = \begin{cases} awg_w + 30, \text{ if } awg_w \le 128, \\ awg_w - 30, \text{ if } awg_w > 128. \end{cases} \quad (2)$$

Step 5: Mean value of each block B is calculated:

$$avg_B = \frac{1}{k^2} \sum_{j=1}^{k} \sum_{i=1}^{k} B(i,j). \quad (3)$$

Step 6: Embedding procedure of each bit of the Watermark into corresponding block is done:

$$B'(i,j) = \begin{cases} B(i,j) + \omega \times \nu, \text{ if } awg_w < T_w, \\ B(i,j) - \omega \times \nu, \text{ if } awg_w \ge T_w, \end{cases} \quad (4)$$

where ω denotes bit of the watermark and υ is the coefficient of inserting the bit (highest value of υ mean more visible watermark).

Step 7: Difference values of parameters d_1 and d_2 are calculated for each block:

$$\begin{aligned} d_1 &= \sum_{B'(i,j)\in S_1} B'(i,j) - \sum_{B'(i,j)\in S_2} B'(i,j) - x, \\ d_1 &= \sum_{B'(i,j)\in S_1} B'(i,j) - \sum_{B'(i,j)\in S_2} B'(i,j) - y, \end{aligned} \quad (5)$$

where S_1, S_2, x and y are parameters from Table I.

Step 8: Modification of the pixel x into the pixel x' and y into the y' was done:

$$x' = 2\times d_1 + \omega + \left\lfloor \frac{\sum_{B'(i,j)\in\{S_1 \cup S_2\}} B'(i,j)}{2\times\left\lfloor \frac{k^2-1}{2} \right\rfloor - 1} \right\rfloor, \quad (6)$$

$$y' = \begin{cases} 2\times d_2 + 0 + \left\lfloor \frac{\sum_{B'(i,j)\in\{S_1 \cup S_2\}} B'(i,j)}{2\times\left\lfloor \frac{k^2-1}{2} \right\rfloor - 1} \right\rfloor, \text{ if } avg_B < T_w, \\ 2\times d_2 + 1 + \left\lfloor \frac{\sum_{B'(i,j)\in\{S_1 \cup S_2\}} B'(i,j)}{2\times\left\lfloor \frac{k^2-1}{2} \right\rfloor - 1} \right\rfloor, \text{ if } avg_B \ge T_w. \end{cases} \quad (7)$$

After implementing the steps above visible watermarked image I_w is obtained.

The VWM algorithm procedure for recovering image is realized through following steps:

Step 1: The watermarked image Iw is divided into nonoverlaped $k \times k$ blocks in the same manner with the embedding procedure, and parameters S'_1, S'_2, x' and y' can also be obtained as in embedding procedure.

Step 2: Using the obtained values for parameters S'_1, S'_2, x' and y', differences d'_1 and d'_2 can be calculated for each $k \times k$ watermarked block B':

$$d'_1 = x' - \left\lfloor \frac{\sum_{B'(i,j)\in\{S_1 \cup S_2\}} B'(i,j)}{2\times\left\lfloor \frac{k^2-1}{2} \right\rfloor - 1} \right\rfloor,$$
$$d'_2 = y' - \left\lfloor \frac{\sum_{B'(i,j)\in\{S_1 \cup S_2\}} B'(i,j)}{2\times\left\lfloor \frac{k^2-1}{2} \right\rfloor - 1} \right\rfloor. \qquad (8)$$

Step 3: Extracted binary watermark ω' from each block can be obtained using:

$$\omega' = \mathrm{mod}(d'_1, 2). \qquad (9)$$

Step 4: Differences d_1 and d_2 can be obtained using:

$$d_1 = \left\lfloor \frac{d_1'}{2} \right\rfloor, \quad d_2 = \left\lfloor \frac{d_2'}{2} \right\rfloor. \qquad (10)$$

Step 5: Pixels x'' and y'' can be recalculated according with following equation

$$x'' = \sum_{B'(i,j)\in S_1} B'(i,j) - \sum_{B'(i,j)\in S_2} B'(i,j) - d_1,$$
$$y'' = \sum_{B'(i,j)\in S_1} B'(i,j) - \sum_{B'(i,j)\in S_2} B'(i,j) - d_2, \text{ if } \omega'=1. \qquad (11)$$

Step 6: Recovered blocks B'' can be obtained according to the parameter υ, pixels x'' and y'' according to following equation:

$$B''(i,j) = \begin{cases} B'(i,j) - \omega' \times \nu, & \text{if } \omega_1 = 0, \\ B'(i,j) + \omega \times \nu, & \text{if } \omega_1 = 1, \end{cases} \qquad (12)$$

where $\omega_1 = \mathrm{mod}(d'_{2},2)$.

Step 7: Recovered image I_r is obtained.

TABLE I

Coefficient mode obtaining for each block

k	$k \times k$ block B	S_1	S_2	x	y
2	$b_{1,1}$ $b_{1,2}$ $b_{2,1}$ $b_{2,2}$	$b_{1,1}$	0	$b_{2,2}$	$b_{1,2}$
3	$b_{1,1}$ $b_{1,2}$ $b_{1,3}$ $b_{2,1}$ $b_{2,2}$ $b_{2,3}$ $b_{3,1}$ $b_{3,2}$ $b_{3,3}$	$b_{1,2}$, $b_{2,1}$, $b_{3,2}$, $b_{2,3}$	$b_{1,3}$, $b_{2,2}$, $b_{3,1}$	$b_{1,1}$	$b_{3,3}$
4	$b_{1,1}$ $b_{1,2}$ $b_{1,3}$ $b_{1,4}$ $b_{2,1}$ $b_{2,2}$ $b_{2,3}$ $b_{2,4}$ $b_{3,1}$ $b_{3,2}$ $b_{3,3}$ $b_{3,4}$ $b_{4,1}$ $b_{4,2}$ $b_{4,3}$ $b_{4,4}$	$b_{1,2}$, $b_{2,1}$, $b_{1,4}$, $b_{2,3}$, $b_{4,1}$, $b_{3,4}$, $b_{4,3}$	$b_{1,1}$, $b_{1,3}$, $b_{2,2}$, $b_{2,4}$, $b_{4,2}$, $b_{4,4}$	$b_{3,3}$	$b_{3,2}$

B. Rotation

Rotation is performed using Matlab function 'imrotate'. First, image is rotated with the angle θ. After roation image is re - rotated with the same angle θ to the start position.

3. EXPERIMENTAL RESULTS AND ANALYSIS

A. Experiment

Algorithms are coded and experiment is performed, in Matlab, according following steps:

Step 1: Applying the VWM algorithm on the original image I_0 watermarked image I_w is obtained.

Step 2: Image I_w is rotated with different value of angle, $\theta_{min} = 0^o$; $\Delta\theta = 3^o$; $\theta_{max} = 45^o$. Rotated image I_{wr} is obtained.

Step 3: Image is re-rotated to the strat position. Recovered image I_r is obtained from the re-rotated image, applying the VWM algorithm.

Image is watermarked with the inverse binary watermark image.

Energy of inserting the bit is set on the value $\upsilon = 40$.

As a measure of the quality of the reconstructed image was used Mean Square Error (MSE) and Similarity:

$$MSE = \frac{\sum_{ij}\left(x_{ij} - y_{ij}\right)^2}{M \times N}, \sqrt{b^2 - 4ac} \qquad (13)$$

$$Similarity = 1 - \frac{\sum_{i=1}^{M-1}\sum_{j=1}^{N-1}(A_{i,j} - A'_{i,j})}{\|A\|}, \qquad (14)$$

where: $i = 1...M$, $j = 1...N$, $x_{i,j}$ - i,j- pixel of the original image, $y_{i,j}$ - i,j - pixel of the recovered image, $M \times N$ – size of image.

B. Base of experiment and results

For the purposes of the experiment, the base of standard images: a) Lena, b) Girl and c) Boat was used and d) binary watermark Fig. 1.. Results are obtained from simulations in Matlab.

Fig. 2. shows look of the image Lena after inserting the watermark with $k = 2$: a) after rotation with ange $\theta = 27^{o}$, b) after rerotation, c) after recovering the image.

Fig. 3. shows look of the image Lena after inserting the watermark with $k = 4$: a) after rotation with ange $\theta = 27^{o}$, b) after rerotation, c) after recovering the image.

Fig. 4.a and Fig. 4.b shows look of rotated image and re rotated image with sequence of watermarked part, respectively.

Fig. 5. - 10. shows graphs of MSE and Similarity for recovered images, for different value of parameter $k = \{2, 3, 4\}$ and for image with different value of luminance.


a)


b)


c)


d)

Fig. 1. *Base of images: a) Lena, b) Girl, c) Boat and d) Watermark*


a)


b)


c)

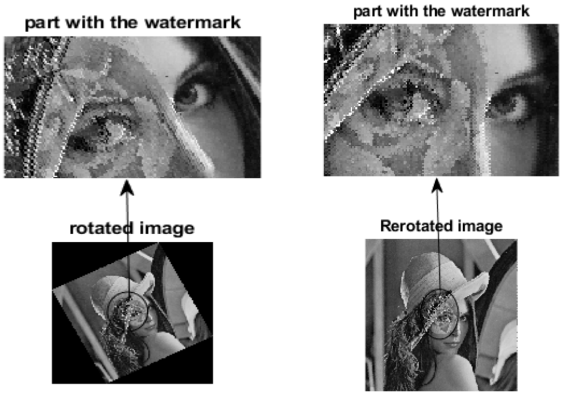
Fig. 2. *Watermarked image Lena with k = 2 and θ = 27°: a) rotated, b) re-rotated, c) recovered from re-rotated image.*


a)


b)


c)

Fig. 3. *Watermarked image Lena with k = 4 and θ = 27°: a) rotated, b) re-rotated, c) recovered from re-rotated image.*



a) b)

Fig. 4. *Watermarked image Lena with k = 2 and θ = 27°: a) rotated and part with the watermark, b) re-rotated and part with the watermark.*

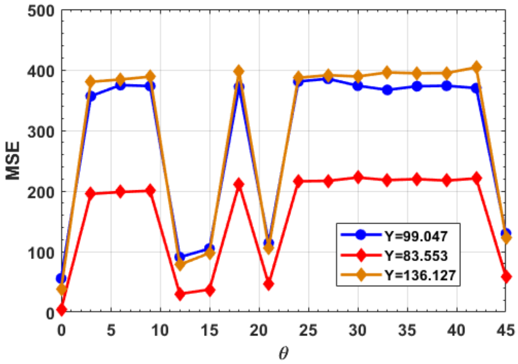


Fig. 5. Quality measure MSE for image with different value of luminance and k = 2.

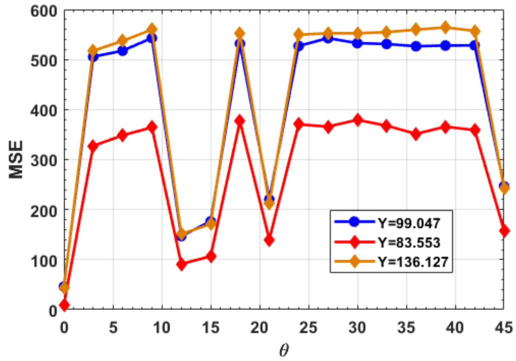


Fig. 6. Quality measure MSE for image with different value of luminance and k = 3.

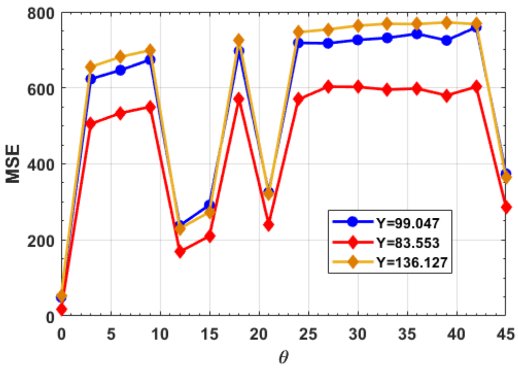


Fig. 7. Quality measure MSE for image with different value of luminance and k = 4.

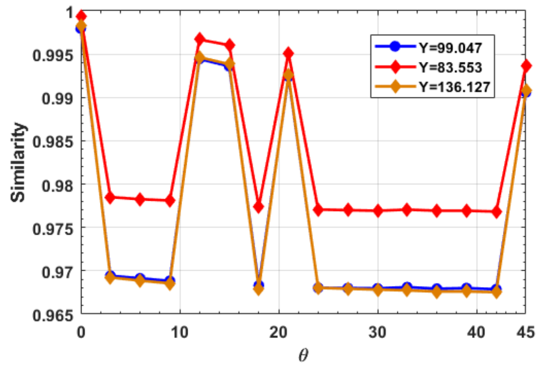


Fig. 8. Quality measure Similarity for image with different value of luminance and k = 2.

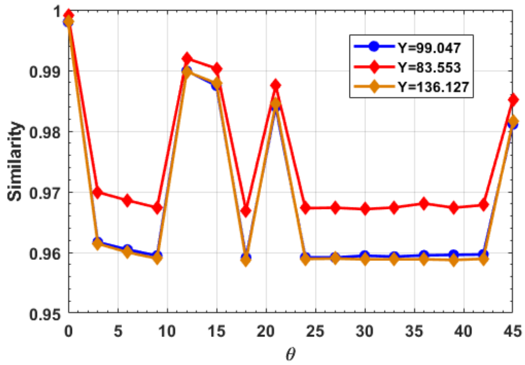


Fig. 9. Quality measure Similarity for image with different value of luminance and k = 3.

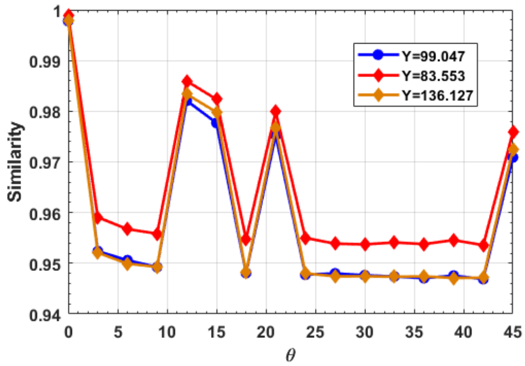


Fig. 10. Quality measure Similarity for image with different value of luminance and k = 4.

C. Analysis

Based on the results shown on fig. 2. and fig. 3. it can be concluded that the rotating the image leads to degradation, and it is difficult to recover the image. Area of image with watermark after recovering is with damage. Based on the figs. 4.a and 4.b it can be concluded that image is more degraded after re - rotation.

Comparing the results presented on figs. 5 - 8 it can be concluded that the MSE is with higher value for $k = 4$. Also it can be concluded for rotation angle $\theta = 12^o$ - 15^o, $\theta = 21^o$ and $\theta = 45^o$ MSE is with the lowest value. MSE for this angles, for luminance $Y = 83.553$ and for $k = 2$ is near value of 50, and for block insertion $k = 4$ is near value of 200. For higher value of luminance Y, MSE leads to take higher values.

Comparing the results presented on figs. 8 - 10 it can be concluded that the Similarity is with higher value for $k = 2$. Also it can be cacluded for rotation angle $\theta = 12^o$ - 15^o, $\theta = 21^o$ and $\theta = 45^o$ Similarity is with the higher value. Similarity for this angles, for luminance $Y = 83.553$ and for $k = 2$ is near value of 0.995, for block insertion $k = 4$ is near value of 0.98,. For higher value of luminance Y, Similarity leads to take lower values.

4. CONCLUSION

In this paper we has analyzed VWM algorithm for inserting visible watermark, and effect of the rotation on the the image recovery. Experiment is peroformed in Matlab. For the purpose of experimental analysis of the efficiency of VWM algorithm for recovering image, the image of the inverse binary watermark was used. The watermark is inserted with the energy of insertion $\upsilon = 40$, in blocks size $k = \{2, 3, 4\}$. Rotation angle is varied in the range range $\theta_{min} = 0^o$; $\Delta\theta = 3^o$; $\theta_{max} = 45^o$. After comparing the visual appearance of the image with rotation and re - rotation, it is concluded that the rotated image is with the visual damage, and after the re - rotation damage is higher. Also, the quality measures of MSE and Similarity show that recovered image, after re - rotation is with the low quality. Also, it can be concluded image with higher value of luminance Y is more susceptible on the rotation.

On the basis of the obtained results, it is concluded that the VWM algorithm is very susceptible on the rotation, recovered image after rotation is with the low quality.

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