

Watermarking Schema for Digital Still Images Based on Geometrical Transformation

Dedicated to Prof. Dr. Karlheinz Tröndle on the occasion of his retirement and 65th birthday

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Abstract: In real time watermarking applications robustness and computational complexity are playing very important role. In this paper we focus on new algorithm for inserting of watermark in digital still images. This algorithm is based on simple but efficient geometrical transformation of image and has fast embedding and extracting watermark pattern with acceptable robustness. Proposed method is illustrated on one example. It has been shown that it is possible to confirm existing of the watermark also in JPEG compressed image.

Keywords: Watermarking, cryptography, DCT, copyright protection, still images, geometrical transformation

1 Introduction

Thanks to the rapid expansion of digital technologies and multimedia, users are able to use a huge number of multimedia products. Owners of the multimedia products have a goal to retain copyright controls provided by the law in order to protect their right. For this purpose new technologies are developed and one of them is watermarking technique. There has been significant recent interest in watermarking, especially for watermarking of video contents.

Digital watermarking provides a way to imperceptibly embed digital information into digital media content. A unique advantage of a digital watermark is that

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the information is imperceptibly bound to the original medium. In practice it is still very difficult to design good watermarking algorithms.

A variety of imperceptible watermarking schemes have been proposed over the last few years. Most of the methods are said to be suitable for either copyright protection or authentication. Watermarking methods are often evaluated based on the common properties of robustness, tamper resistance and fidelity. Watermarking can be used for owner identification, to identify the content owner, to identify the buyer of the content or similar purposes.

A number of technologies are being developed to provide protection from illegal copying [1, 2, 3, 4]. Two complementary techniques are encryption and watermarking. Watermarking compliments encryption by embedding a signal directly into content. Thus, the goal of a watermark is to always remain present into data. It should be noted that embedded signaling or watermarking can be used for a variety of other purposes other than copyright control.

Usually watermark embedding simply adds globally or locally attenuated watermark pattern to the multimedia data. The watermark is put into image by insert coder and the existence of watermark in a suspicious work is shown by decoder. In discussions of the watermarking systems, distinction is generally made between blind detectors, which have no knowledge of the original, and informed detectors (or non-blind detectors), which use the original media content in order to assist in detection of watermark.

Geometrical transformation, as rotation, cropping, scaling, shifting, etc., often considered by numerous authors [5] in the sense of the attack to the various watermark schemes. It is common opinion that the geometrical transformation are not suitable for robust watermark embedding. That is true, only if one applies such transformation to the whole picture, while in the common pictures which are distorted by poor optical lenses it is difficult to notice distortion. Moreover, those transformation are extremely simple and one can implement fast building and extracting algorithm. In the applications where speed of embedding and extracting plays an important role this approach seems to be very useful.

The subject of this paper is protection of digital still images using geometrical transformation. In order to protect the copyright of digital images we proposed one method where we first modify a picture and than add an quasi invisible structure to the image in order to identify the owner.

In this method there are two different watermarking keys. The first one is position of lines where watermark pattern will be inserted. These positions are known only to the owner of the content. The other one is choosed geometrical transformation law which is familiar also only to the owner of the content. Knowledge about both watermarking keys is enough to check existence of watermark patter

into image. It is clear from above that this method does not need original image for detection of watermark.

2 Watermarking Requirements

Different applications have demanding requirements in terms of detection and visibility and require robustness to intentional attacks. Digital watermarking is a complex technology involving many conflicting requirements and trade-offs.

For the watermarking of the images a number of different characteristics are desirable [3, 6]. The basic three requirements are:

1. **Invisibility:** The digital watermark inserted into picture should be invisible or at list hard to perceive
2. **Security:** Without the knowledge of exact parameters, unauthorized removal of the watermark must be impossible once it has been embedded, even if the basic scheme of watermark insertion is known
3. **Robustness:** The watermark should be such that it can not be manipulated by intentional or unintentional operations

We shall show that proposed method fulfills basic requirements for watermarking. In order to avoid problems with invisibility in proposed method geometrical transformation has been done only in a few lines (it depends from size of the image) and it is not possible to notice distortion in the picture.

The invisibility can be problem only with pictures where content of the image has geometrical form. This method is not the best for applications in this case. The test with insertion of the watermark into picture of chess table will be described in section 4.

3 Insertion of the Watermark

The basic idea in our method is to use well known law of the geometrical transformation to build watermark in at least one, or more, of the chosen regions in the image. Using this way we shall avoid visible distortion in the image.

Builed watermark has unique key which consists from three parameters. The first parameter is choice of geometrical transformation law which will be used. For instance, geometrical transformation law in our paper is simple imitation of optical lens distortion. The second parameter is the choice of the number of selected regions where watermark will be inserted. After experiments we concluded that

satisfied results for images with 256 lines will be obtained if four regions for inserting of watermarks are used. The third parameter is choice of displacements of the selected regions. The procedure for choosing of regions is highly dependent by specified image. In order to make right decision for regions it is necessary to make some transforms into image before procedure for choosing of regions.

The algorithm for watermarking embedding procedure is presented in block schema which is showed in Fig.1. Block schema consists of six blocks.

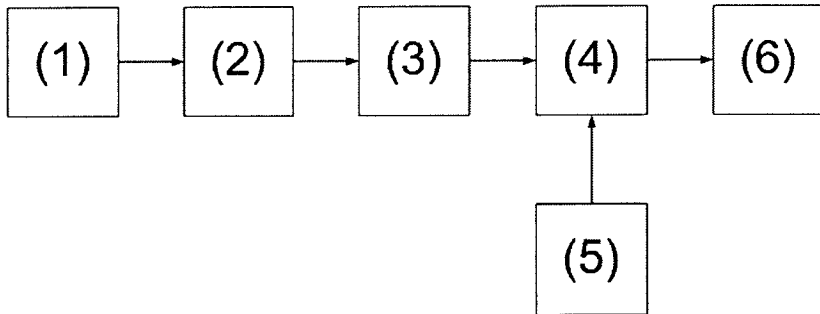


Fig. 1. The block schema for inserting of watermark: (1) Line histogram match and region computing and embedding. (2) Interpolation. (3) Interpolation filtering. (4) Computing watermark sequence. (5) Watermark key (geometrical transformation law). (6) Embedding watermark into regions and resizing of image to original dimension ratio.

In the first step we must make decision in which regions of the picture shall we insert watermark. In order to make good choice it is necessary to make line histogram match in the original picture, and direction of such line is not necessarily horizontal. This is important step because the quality of this watermark method is directly dependent from image contents. Fortunately, most pictures have suitable contents, except those which have strictly geometrical form or computer produced pictures.

In our method we decided after tests that the best results will be obtained if we transform four lines into picture with size 256×256 pixels. After geometrical transformation of four lines has been performed, obtained picture will have 12 lines more, but it is not visible change for human perception. Inserted watermark will be hard to perceive.

Geometrical transformation has been presented in Figure 2.(a). Better understanding of geometrical transformation is possible from Figure 2.(b). The key for geometrical transformation will be familiar only to the owner of the picture. Practically the watermark key is number of pixels in three additional lines from choosed

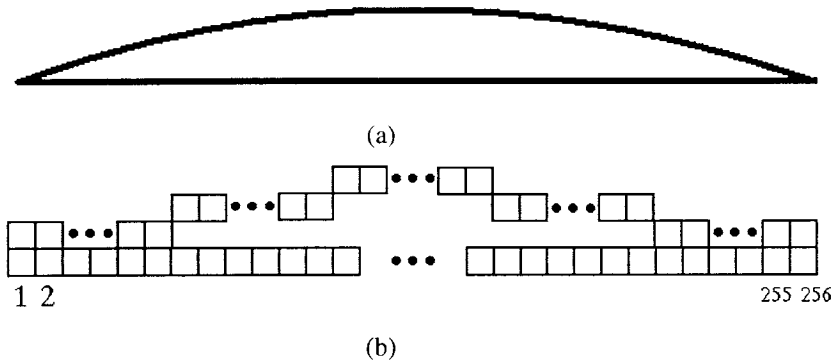


Fig. 2. Geometrical transformation law

line. Starting from every optimal chosen line we compute certain number of pixels using known geometrical law. In such way we obtain modified lines. This line do not satisfied Cartesian coordinates so it is necessary to use some kind of geometrical transformation of the picture. It is important to point that this transformation is not applicable to entire picture. In this method we build new quadrilateral region in the existing image. The region consists of modified line, with watermark information, and certain number of new pixels. Those pixels can be obtained by using interpolation (block 2 in the Fig. 1.). In this paper we used "cubic-spline" interpolation. Good results can be also obtained using other known interpolation methods.

It is easier to make first interpolation of all four choosed lines and than using known geometrical law replace pixels with corresponding values from the choosed lines. After interpolation it is necessary to perform interpolation filtering (block 3 in Fig. 1.).

Spatial transformation needed to distort an image is determined through tie points [7]. These are points in the image for which we know their corrected positions in the final image. We will illustrate this concept with the example of a distorting correct quadrilateral region in an image.

We model such a distortion using a pair of bilinear equations:

$$x' = c_1x + c_2y + c_3xy + c_4$$

$$y' = c_5x + c_6y + c_7xy + c_8.$$

We have 4 pairs of tie point coordinates. This enables us to solve above equations in order to obtain the 8 coefficients.

We can set up the matrix equation using the coordinates of the 4 points:

$$\begin{pmatrix} x'_1 \\ y'_1 \\ x'_2 \\ y'_2 \\ x'_3 \\ y'_3 \\ x'_4 \\ y'_4 \end{pmatrix} = \begin{pmatrix} x_1 & y_1 & x_1y_1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & x_1 & y_1 & x_1y_1 & 1 \\ x_2 & y_2 & x_2y_2 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & x_2 & y_2 & x_2y_2 & 1 \\ x_3 & y_3 & x_3y_3 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & x_3 & y_3 & x_3y_3 & 1 \\ x_4 & y_4 & x_4y_4 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & x_4 & y_4 & x_4y_4 & 1 \end{pmatrix} \begin{pmatrix} c_1 \\ c_1 \\ c_2 \\ c_2 \\ c_3 \\ c_3 \\ c_4 \\ c_4 \end{pmatrix}$$

In shorthand we can write this equation as

$$[X'Y'] = [M][C],$$

which implies

$$[C] = [M]^{-1}[X'Y'].$$

Having solved for the coefficients we can use them in our original bilinear equations above to obtain the corrected pixel coordinates (x', y') for all selected pixels (x, y) in the original image.

To use for more complex forms of distortion, for example complex lens distortion, one can use higher order polynomials plus more tie points to generate correct distortion coefficients.

After embedding of watermark we apply low-pass filter, to avoid aliasing effect, to the obtaining region and finally necessary dimension adjustments, i.e. the image must be resized to original dimension ratio (block 6 in Fig. 1.).

Watermark extracting is simple. Starting from the begin for each point $a(x, y)$ we seek point which satisfy known law i.e. $a(x + \Delta x, y + \Delta y)$. If certain number of the points are founded, the existing of the watermark is confirmed. Searching continue to the end of the image and it is successful if most of the embedded regions are founded. Then owner can reconstruct original picture, from watermarked image, using simple inverse procedure.

4 Experimental Results

In order to prove that the proposed image watermarking is effective, we illustrate described method with experimental results. The tested image is a gray-scale standard Cameraman with 256×256 pixels. Geometrical law which we use for watermarking in this example is simplify imitation of the optical lens called fish eye. Histogram matching of lines in the picture is not correctly done so this case can

be considered as the worst. Only one of the regions is constructed and it is wide for additional lines and simple low-pass filter is applied. The original image is presented in Fig.3. Fig.4. shows the watermarked image with inserted watermark.

It is obviously that watermark is not visible by observer.

The second test we made includes printing watermarked picture on the high quality laser printer and scanning this copy by the scanner.

It is well known fact that scanner introduce almost all geometrical attacks to the watermarked picture but in our case notification an extraction of the watermark is better than 85%

We tested also JPEG compresses images. It is possible to conclude that if the level of compression is not to high the confirmation of existing of the watermark inserted with proposed method is better than 80%.



Fig. 3. Original image.



Fig. 4. Watermarked image.

Because of own nature our method is the most sensitive for picture with geometrical forms and some of the computer produced pictures. In order to investigate that fact we inserted a watermark, under the same conditions as in the example above, into chess table picture. The watermarked picture of chess table is shown in Fig. 5. It is obviously that watermark is not visible by eye but some simple measurements, easily possible to perform in this type of the pictures, can exactly locate positions of the watermark.

From above reason this watermarking scheme is recommended preferably for images where the contents of the image is not strictly geometrical.

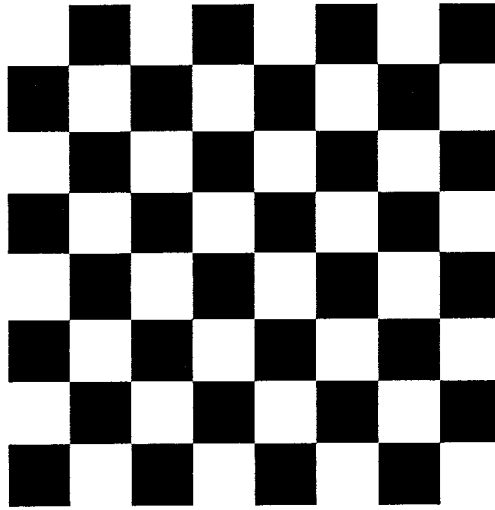


Fig. 5. The watermarked image of chess table.

5 Conclusion

The subject of this paper is presentation of simple technique for protection of digital still images. In order to protect the copyright of digital still images we proposed one method based on the geometrical modification of some suitable parts of the picture. Obtained experimental results are satisfied. Geometrical law used in this example is simple but there are other possibilities such embedding ISBN number through regions etc. This method does not need original image for detection of watermark.

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