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Analysis of Time Optimization for Watermark Image Quality Using Run Length Encoding Compression

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Abstract: Internet technology continues to have a significant impact on digital media such as text, images, audio and video. One effect is the ease of exchange, distribution, and duplication of digital data; on the other hand, this ease also raises the problem of digital data being protected by copyright or digital data is confidential. Watermarking is a solution to the problem of digital data copyright protection. Extensive research on watermarking was conducted before one of them was a hybrid DWT-DCT-SVD. Several studies have found weaknesses in the process of message insertion; for example, the time to insertion of a watermark image is relatively long, particularly for large images. The problem of long message insertion time is that it is necessary to continue research on watermarking to apply the compression process to the original image before the watermark image insertion process is performed. The original image to be inserted into the watermark image is compressed using the run-length encoding algorithm. The result of the RLE compression shows that the image file size becomes large because the image dataset used has various intensity values. The results from watermarking obtained by watermarked images with RLE compression preprocessing have better imperceptibility than watermarked images without preprocessing RLE compression.

Keywords: WATERMARKING; DWT; DCT; SVD; COMPRESSION; RLE

1. Introduction

The rapid growth of the internet, technology, and applications utilizing digital multimedia technologies has emphasized the importance of copyright protection for multimedia data (Divecha & Jani, 2013). Digital images can be protected using a digital watermarking method. A digital watermark can be classified based on several criteria as a visible or invisible identification code that is permanently embedded in the host image. Copyright protection to multimedia data using invisible watermarking is implemented to a private symbol.

A watermarking method can be implemented in the base pixel/spatial domain or the transform domain (Hartung & Kutter, 1999). (Mathur et al., 2016) developed a new algorithm that embeds a watermark in the pixel domain with shell-based pixel selection for watermark insertion and extraction. (Munir, 2015) implemented a chaos-based pixel domain watermarking algorithm with copyright protection and high sensitivity, but it has the drawback of low capacity as it requires insertion of the watermark in each pixel of the host image, and the size of the host image should be larger than that of the watermark image. The watermark signal distributed over the image makes the watermarking scheme more robust compared to pixel-based methods because of the irregular distribution of the inverse transform value (Reddy & Chatterji, 2005). Watermarks can also be embedded in the transform domain, such as the discrete cosine transform (DCT), the discrete wavelet transform (DWT), and the singular value decomposition (SVD) (Rahman, 2013).

Discrete wavelet transform (DWT) uses filter principle, it has to divide an image into four subbands, the subbands are a set of four nonoverlapping multiresolution, Approximation sub band denoted as LL, Horizontal sub-band denoted LH, Vertical sub-band denoted as HL, and Diagonal sub-band denoted as HH. These four subbands: LH, HL, and HH subband represent the finest scale wavelet coefficients and LL subband stands for the coarse-level coefficient (Mallat, 2009). The process can be repeated to obtain multiple scale wavelet decomposition (A. K. Singh et al., 2014b). Discrete wavelet transform is a generah function in computational, especialy for JPEG 2000 format and generally could do well in image watermarking for pixel localization and have the characteristics of multiresolution corresponding to HVS (Susanto et al., 2017). Discrete wavelet transform is very suitable to identify areas in the host image where a watermark can be imperceptibly embedded because of its excellent pixel frequency localization attributes (A. K. Singh et al., 2015). This Discrete wavelet transform method is robust against under of signal processing noise without significant degradation of the image quality (A. K. Singh et al., 2014a).

Based on the results of a research (Faizal et al., 2012) the shortcomings in the transformation of DWT could be compensated using the discrete cosine transform method, the stated that discrete cosine transform is a method has wavelet where travel time is faster than the DWT method, and discrete cosine transform method has secure copyright protection. The DCT watermarking method is robust against the attack of filtering and gaussian noise, such as fragile, JPEG, and cropping (Rachmawanto et al., 2017). The DCT method is one of transform domain could process the signal, this input signal is converted into a frequency domain. This transform domain would produce two kinds of coefficients, which consists of the AC coefficients and DC coefficients (Susanto et al., 2017). Embedding watermark in the DC coefficient could make significant changes in the images, but other writing (Khan & Jeoti, 2010) said DC coefficient is expressed as a based from which to insert watermark where image in many studies (Khan & Jeoti, 2010; Santhi & Thangavelu, 2011; P. Singh et al., 2014) prove that the DC coefficient is ROI to insert watermark, where watermarked image imperceptibility have excellenet quality and robust against various attacks, so resistant to attack and imperceptibility is maintained. In another study by (Setiadi et al., 2017), Discrete Tchebichef Transform is proven to be extremely efficient to reduce algorithm complexity so that the time waste for embed process and extracting watermark is about five times faster than Discrete cosine transform. Matching two or more watermarking algorithm will produce maximal results (Al-Haj, 2007), in this paper, the proposed combination is DWT, DCT, and Singular Value Decomposition (SVD).

SVD is composed of three vectors in which one vector consists of diagonal matrix and two vectors consist of orthogonal matrices (Srivastava, 2013). SVD of a given image block results in three matrices [U D V]. The singular value can be against the image processing operation, and the coefficients of the matrix U and matrix V can represent the image feature. The singular value decomposition is imperceptible scheme for digital images, both in RGB and grey scale, also quite robust against attacks compression and filtering, such as JPEG compression (Santhanam. MS, 2008). An Experiment in this paper, Run Length Encoding (RLE) compression is the proposed preprocessing of the watermarking.

RLE compression is the most popular compression algorithm, RLE is generally used especially to compress the attribute values in column stores (Divya R. Jariwala, 2017). RLE compression algorithm is one of a lossless compression method where sequences that show redundant data are stored as a single data value stand in for the repeated block and how many times it pop up in the image. RLE is one of loseless data compression method, the lossless compression reduces data without data loss. Modern digital imaging have produced a great amount of data that can rapidly saturate transmission and storage system (Xia et al., 2015). A great amount of data need more travel time when the data will be processed. In this paper, RLE have been developed to reduce the image volume before watermarking process.

The experiment in this study is an imperceptible and robust combined discrete wavelet transform (DWT), discrete cosine transform (DCT), and Singular Value Decomposition (SVD) with RLE compression. Run-length encoding compression is proposed to compress the image, the image compressed will be watermarking processed using Discrete wavelet transform (DWT), Discrete cosine transform (DCT), and Singular Value Decomposition (SVD) method. Run-length encoding is an extremely easy form of data compression in sequences in which the same data value occurs in many consecutive data elements are stored as a single data value and count, rather than as the original run (Nagarajan, 2011). Image compression is reducing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows the time required for images to be watermarked fastly. Data compression schemes give the optimized solution to elapse the image watermarking time. The next step after compressing the image is watermarking process. The use of DCT on small blocks may pose blocking effects and unintended artifacts on the overall image. These disadvantages of DCT can be eliminated by using Discrete Wavelet Transform (DWT) which is more compatible with the Human Visual System (Abu et al., 2014), this approach also needs SVD computation where the watermark is embedded on the singular values of the cover image DWT sub bands. Proposed algorithm combines the advantages and remove the disadvantages of these three most popular transforms. These three methods are provided a good imperceptibility and high robustness against various kinds processing attacks.

2. Method

In this paper, the proposed combination of DWT, DCT, and SVD due to yield a good imperceptibility and robustness that has been implemented through two process are embedding and extraction. The RLE compression that has been implemented could reduce the redundant data to elapse the watermarking process more efficient, it can be seen in Fig. 1.

The steps of compression with the Run Length Encoding (RLE) method are; first, input image data, second, read image dimensions, third, read pixel values one by one, fourth, compare the j-th pixel value with the j-th pixel value + 1, if the j-th pixel value is the same as the j-th pixel value + 1 then store the pixel value in the same variable, if the jth pixel value is different from the j+1 pixel value then create a new variable, then calculate the total pixels in each variable, fifth repeat the third and fourth steps until the nth pixel, sixth display the pixel value and the total number of pixels with the same value, as shown in Fig. 2.

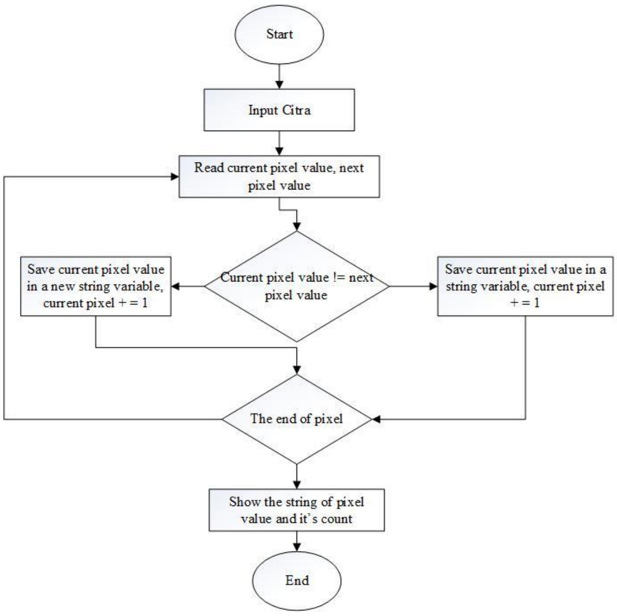

Fig. 1. RLE compression flowchart.

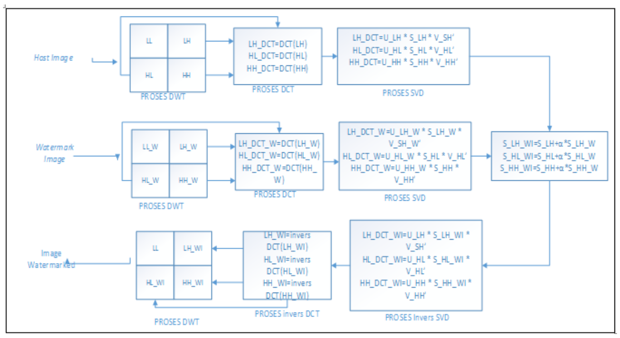
Fig. 2. Flowchart of the DWT–DCT–SVD method

The proposed method comprises four main steps. The first step is to apply the DWT method to the host and watermark images. The second step is to apply the DCT method to images in the LH, HL, and HH subbands on the watermark image and host image. The third step is to apply the SVD method to the watermark and host images. The fourth step is to insert the watermark image on the host image.

3. Results and Discussion

In the experiment in implementing the proposed method, the image used is Public - Domain - Test Images, where the image is taken from a site on the internet. The image data that has been obtained will be compressed using the Run Length Encoding method. The resulting image from the compression process will be stored and then the watermarking process will be carried out using the DWT-DCT-SVD method. The RLE method for image compression is shown in Fig. 1, the DWT-DCT-SVD method for the proposed watermarking is shown in Fig. 2, and Fig. 3 shows the histogram of the watermarked image extraction results before and after compression.

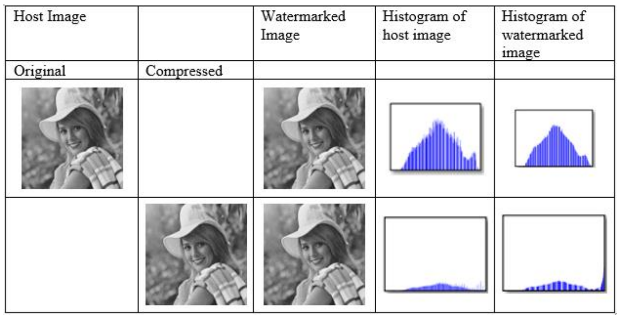

Fig. 3. Watermarked image extraction results.

Fig. 3 shows a histogram of the watermarked images with and without RLE compression. It is shown that the histogram result of the host image using compression is as good as that obtained using no compression.

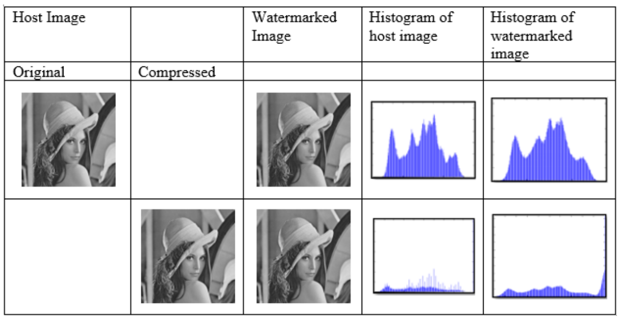

Fig. 4. Watermarked image extraction results.

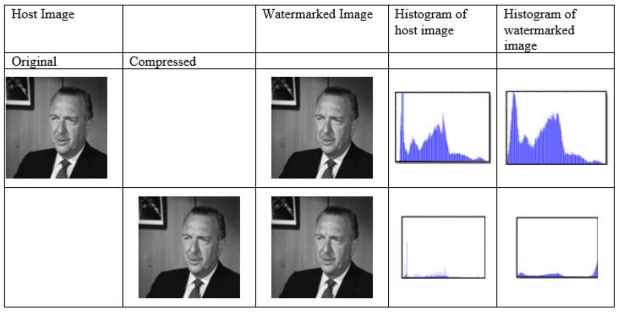

Fig. 5. Watermarked image extraction results

Table 1. Elapse time results

	NO COMPRESSION	RLE COMPRESSION
Elaine	0.0015	0.0019
Walter	0.007	0.007
Lenna	0.0017	0.0019

Table 2. Embedded PSNR results

	NO COMPRESSION	RLE COMPRESSION
Elaine	28.7541	31.4502
Walter	30.0385	28.7772
Lena	28.5481	28.7775

Table 3. PSNR extraction results

	NO COMPRESSION	RLE COMPRESSION
Elaine	32.2659	32.2531
Walter	31.2820	31.2465
Lena	32.2656	32.2483

Table 4. Elapse time results with Alpha = 0.1

	NO COMPRESSION	RLE COMPRESSION
Elaine	0.0017	0.0014
Walter	0.0007	0.0005
Lena	0.0020	0.0016

Table 5. Embeded PSNR results with Alpha = 0.1

	NO COMPRESSION	RLE COMPRESSION
Elaine	28.4052	31.0237
Walter	29.6193	28.5409
Lena	28.2162	28.4878

Table 6. PSNR extraction results with alpha = 0.1

	NO COMPRESSION	RLE COMPRESSION
Elaine	32.2657	32.2643
Walter	30.5296	31.2614
Lena	32.2543	32.2610

Table 7. Elapse time results with alpha = 0.3

	NO COMPRESSION	RLE COMPRESSION
Elaine	0.0014	0.0014
Walter	0.0007	0.0005
Lena	0.0015	0.0015

Table 8. Embeded PSNR results with alpha = 0.3

	NO COMPRESSION	RLE COMPRESSION
Elaine	27.6310	30.0721
Walter	29.6193	28.5409
Lena	27.4737	27.8282

Table 9. PSNR extraction results with alpha = 0.3

	NO COMPRESSION	RLE COMPRESSION
Elaine	32.1880	32.2595
Walter	30.5296	31.2614
Lena	32.0120	32.2609

Table 1 describes the time elapse of the embedding process with and without the host image compressed using RLE. The host image compressed is as quick as the host image is not compressed. The different number of elapsed times for embedding using RLE compression and without compression is in the back point, so the elapsed time is not influential for embedding processing. As shown in Table 1, the Walter Image with RLE compression has less elapsed time than that with no compression.

Table 2 describes the PSNR results of the embedding process; the image host with RLE compression obtains a PSNR better than that with no compression. Known from Table 2 above, image Elaine and image Lena obtain a good PSNR using RLE Compression.

Table 3 describes the PSNR result of the extraction process; the image host with RLE compression obtains a PSNR number as good as that with no compression. As shown in Table 2, all datasets obtained good results.

Table 4 describes the time elapse of the embedding process with and without the host image compressed using RLE. The host image compressed is as quick as the host image is not compressed. As shown in Table 4, all datasets obtained good results.

Table 5 describes the PSNR results of the embedding process; the image host with RLE compression obtains a PSNR better than that with no compression. Known from Table 5 above, images Elaine and Lena obtain a good PSNR using RLE Compression.

Table 6 describes the PSNR result of the extraction process; the image host with RLE compression obtains a PSNR number as good as that with no compression. As shown in Table 6 above, all datasets obtain a good result.

Table 7 describes the time elapse of the embedding process with and without the host image compressed using RLE. The host image compressed is as quick as the host image is not compressed. As shown in Table 7, the image of Lena with RLE compression had less elapsed time than that with no compression.

Table 8 describes the PSNR results of the embedding process; the image host with RLE compression obtains a PSNR better than that with no compression. Known from Table 8 above, image Elaine and image Lena obtain a good PSNR using RLE Compression.

Table 9 describes the PSNR result of the extraction process; the image host with RLE compression obtains a PSNR number as good as that with no compression. As shown in Table 9 above, all datasets obtain a good result.

5. Conclusion

Based on the experimental results, it can be seen that the quality of the watermarked image does not suffer from image defects, which result in changes to the original image. In compressed images before watermarking, the watermark insertion time decreased at an insertion alpha of 0.01. The elapsed time increased in the compressed images because the size of the image increased after compression; the larger the image size, the higher the required elapsed time. Compressed image imperceptibility is better than imperceptibility; this can be seen with no damage to the watermarked image. The PSNR quality of the compressed image is better than that of the uncompressed image, embedded PSNR and Extracted PSNR measurements.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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