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Two-Level Singular Value Decomposition Analysis in Color Image Watermarking Process

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Abstract*— The process of watermarking the image at this time is a necessity, especially related to the copyright of an image that may be circulating on the internet in the digital era today. Two-Level Singular Value Decomposition is a method used to check the color composition of an image and can be seen whether there has been a change (insertion) of a message in the image. Tests carried out by the insertion process, the extraction of messages is known to the difference with pretty good results.*

Keywords— *Watermarking, Color Image, Decomposition Two-Level Singular.*

1. Introduction

In recent years digital watermarking has been widely used both in protecting digital sound, digital text, digital video, digital images and others. Digital watermarking is a technique for inserting data into digital loads. Some of the watermarking methods aim to protect copyrights from inappropriate use[1], [2].

Watermarking methods generally require specific keys to be able to add robustness and maintain image quality degradation. Unlike watermarks for copyright protection, we consider using a watermark to insert a data index, where the index data means a memo that can be read by someone, for example a place and date when a digital photograph has been taken[3].

With so many watermark methods introduced for copyright protection it is not appropriate to insert data indexes, because they require specific keys and do not sufficiently insert a certain amount of data. Although some watermarking methods to protect copyright have no specific key, they cannot insert a certain amount of data. Two Level Singular Value Decomposition breaks down an original image into four sub band and each sub-band can be used for an appropriate purpose.

Two Level Singular Value Decomposition is the development of the Singular Value Decomposition algorithm which has a way of working based on the watermark correlation value where the value will be tested based on the level of resilience, changes of images that are given watermarking[4]–[6]. Two Level Singular Value Decomposition accommodates all processes in the Singular algorithm Value Decomposition by adding the resilience function to the color composition in the image.

Choosing Two Level Singular Value Decomposition because this algorithm is good enough to do the watermarking process and the modification process so that the message will not be lost even though the modification process is done as well as from the process manual also has many changes compared to the Singular Value Decomposition algorithm.

This study applies the Two-Level Singular Value Decomposition algorithm to digital image watermark by inserting index data on the image header and analyzing the Two-Level Singular Value Decomposition algorithm to process watermarking on images and test results with the MATLAB tool.

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2. Theories

2.1 Image

The image can also be interpreted as a collection of points with a certain color intensity that forms a unity and has an artistic sense[7]. Image as one of the multimedia components that play a very important role as a form of visual information. In general, digital image representation requires a large memory. The bigger the image size, of course the greater the memory it needs. On the other hand, most images contain duplication of data.

Duplicating data in an image can mean two things. First, it is probable that a pixel with neighboring pixels has the same intensity, so storing each pixel wastes space. Second, the image contains many parts (regions) the same, so this same part does not need to be encoded repeatedly because of redness[8]. The image is not the same as the text which only provides information clearly with the words that are presented, while the image provides clear information by giving a visual picture and sometimes the information provided can spur the imagination of people who see the image to deduce information from the image.

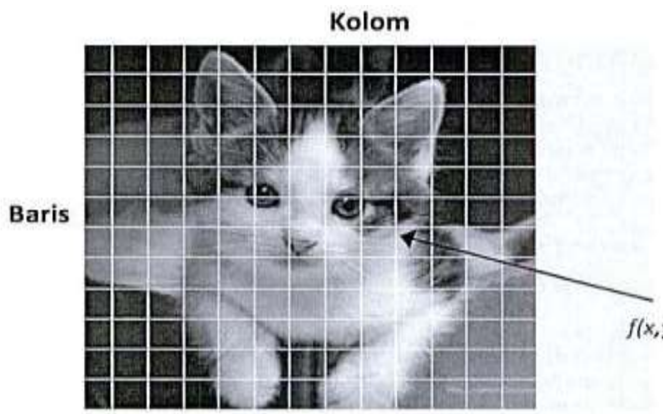

Figure 1. Sample Image

2.2 Pixel

Each pixel represents not only one point in an image but a section in the form of a box which is the smallest part (cell). The value of a pixel must be able to show the same average value for all parts of the cell. Also, in the discussion of digital images there is also the term image resolution. Image resolution is the level of detail of an image. The higher the image resolution, the higher the level of detail of the image. The unit in measuring image resolution can be a physical size (number of lines per mm / number of lines per inch) or it can also be a whole image size[3], [9], [10].

2.3 Two-Level Singular Value Decomposition

The Two-Level Singular Value Decomposition (SVD) method is one of the techniques in numerical analysis used to "digitize" the matrix. In the perspective of image processing, the singular value of an image has good stability, where when there is little disturbance given to the image, the singular value does not change significantly. Another advantage is the matrix size of the SVD[6], [11] method transformation is not fixed and can be either square or circular. Then the singular value contains the property information of the linear image equation.

Suppose that A is a nonzero matrix of size m x n, then a can be represented as a multiplication of the following:

1. $A=USP^2$

2. $w = \frac{U_w S_w (Vw) - s}{a}$

U in the equation above is an orthogonal matrix measuring m x m, V is an orthogonal matrix measuring m x n and S is a diagonal non-square matrix measuring n x m.

The above decomposition is called singular value decomposition. The value of S is called the singular values of A, the columns of U which are orthonormal vectors are called the left singular vectors of A and the columns of V are called the right singular vector of A. If A is an image then S has luminance values from image layers produced by left and right singular vectors. Right singular vectors represent horizontal details, while left singular vectors represent vertical details of the image. A slight change in singular values does not affect image quality.

3. Methodology

In this study, watermark insertion was carried out in the spatial domain. In general, watermarking is divided into two parts, namely the insertion process and the extraction or detection process. The steps taken are as follows:

1) Insertion Phase
   At the insertion stage, the steps taken are as follows:
   a. Select the image (digital image) to be used as the watermark carrier image. The selected image is a grayscale image with two dimensions.
   b. Select the image to be used as a watermark. The watermark image is chosen as a binary image with a smaller size than the carrier image.
   c. Determines the algorithm used for insertion.
   d. Create image container matrix and make adjustments to the watermark image because the size is not the same as the carrier image.

The algorithm used in this study is the algorithm proposed by Ruizhen Liu and Tieniu Tan. Namely by adding directly between the watermark image at a certain intensity with the diagonal matrix of the SVD decomposition of the carrier image. Adjustments must be made if the size of the watermark is not the same size as the S matrix. This can be done by placing the watermark on a zero matrix of the same size as S at a certain position, the formula used is as follows:

$F = U\,S\,V^T;$
$S' = S + a.w$
$S' = U_w S_w V_w{}^t$
$F_w = U S_w V^t$

The proposed algorithm is non-blind type, meaning that the result of the insertion process is not only in the form of an image containing a watermark, but also additional information obtained from the calculation of the SVD on the carrier image and the watermark image. This additional information is not shared with the image that the watermark has inserted, but is to be kept for the purposes of further extraction.

2) Extraction Stage
   At the extraction stage, the steps taken are as follows:
   a. Select the image where the watermark has been inserted.
   b. Provides the parameters needed in extraction, namely: original image, watermark image, S, V and U matrix and its intensity. These parameters are generated in the previous insertion process.
   c. Extraction.
   d. Returns a watermark image whose size is adjusted to the carrier image.

For the message extraction process is done using a formula.

$F_{w^*} = U^* S_{w^*} V^{*T}$
$D_* = U_w{}^* S_{w^*} V_{wT}$

$$W^* = (1/a)(D^* - S)$$

4. Results and Discussion

The watermarking process is done by first determining the image file to be inserted in the message and also the image itself, the initial step of the author determines the image with the file name web.jpg with dimensions of 200x300 as follows:

Figure 2. Media

Two Level Singular Value Decomposition process works on the RGB pixel in the image, to get the pixel value in the image can not be done manually and must use special software, in this study the author uses Matlab R2014a, here are the composition values for Pixel R:

```
>> aeci=uint8(0);
>> aeci(:,:,1)

ans =

  Columns 1 through 27
```

214	216	220	222	222	220	217	215	223	222	221	218	214	210	207	205	204	207	210	210	208	206	207	208	208	208	208
215	217	220	223	224	222	220	218	210	210	210	209	208	205	203	202	205	208	211	210	208	206	207	208	208	208	208
219	220	222	222	221	219	214	214	199	200	202	203	204	203	203	202	205	208	211	211	208	207	207	209	208	208	208
220	220	219	217	213	209	205	203	200	201	203	205	205	205	205	204	206	209	212	211	209	207	208	210	209	209	209
212	211	211	209	207	205	203	202	207	207	208	209	208	207	204	205	204	210	212	212	210	208	209	210	210	210	210
200	200	201	203	204	206	207	208	207	208	208	208	207	205	203	202	207	210	213	213	210	209	209	211	210	210	210
204	204	205	205	207	208	210	211	208	208	209	209	209	208	206	205	208	211	214	213	211	209	210	211	211	211	211
217	215	213	210	208	207	207	206	208	209	211	212	213	213	212	211	208	211	214	214	211	209	210	212	211	211	211
209	210	210	211	211	212	212	212	208	209	210	210	211	212	212	212	211	211	212	212	213	213	214	214	212	212	212
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214	214	215	215	216	216	217	217	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	222	223	224

Figure 3. R Pixel Composition

Next is to determine the composition of Pixel G as follows:

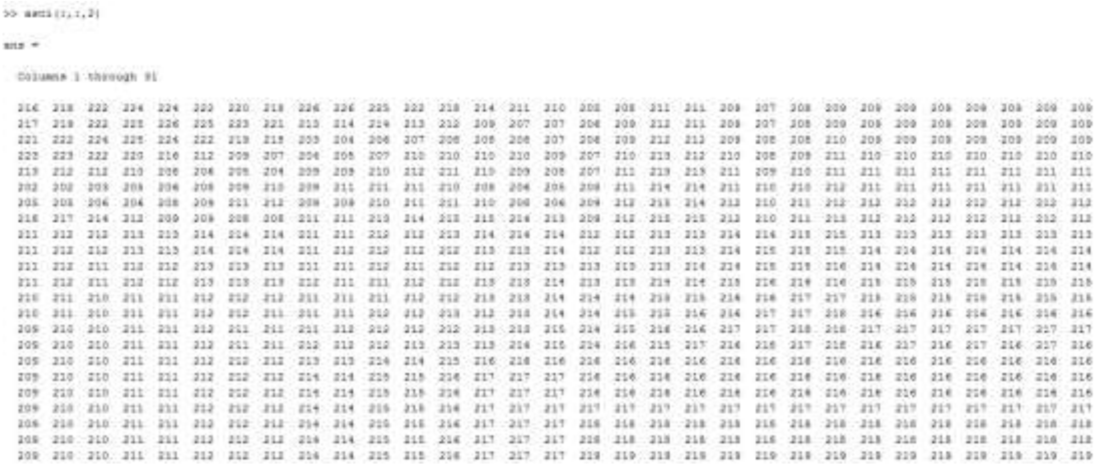

Figure 4. G Pixel Composition

Next is to determine the composition of Pixel B as follows:

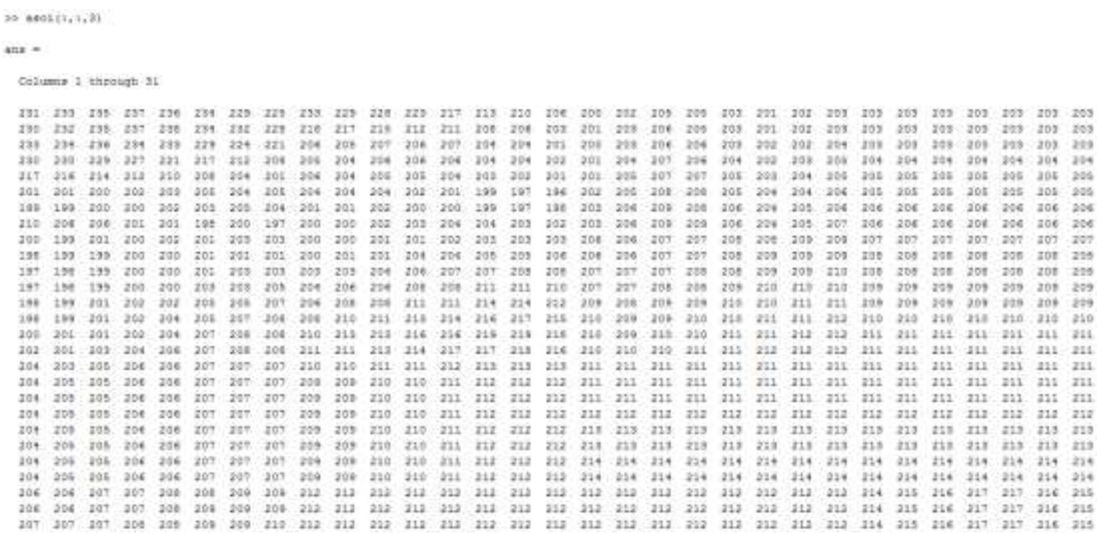

Figure 5. B Pixel Composition

Figures 3 through 5 are some of the pixel values of R, G, B that are in the image, the Two Level Singular Value Decomposition process is done by taking a pixel value randomly from the existing value, so that it is easy to do calculations the author takes the value of existing pixels and the results are as follows in the form of a matrix:

$$A = \begin{bmatrix} 2 & 4 \\ 1 & 3 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$$

Then the matrix value is processed by the Two-Level Singular Value Decomposition algorithm as follows:

$$A.A^t = \begin{bmatrix} 2 & 4 \\ 1 & 3 \\ 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} 2 & 1 & 0 & 0 \\ 4 & 3 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 20 & 14 & 0 & 0 \\ 14 & 10 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

After getting the matrix values to be processed, the next step is to determine the eigenvalues using the following formula:

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$$\begin{bmatrix} 20-\lambda & 14 & 0 & 0 \\ 14 & 10-\lambda & 0 & 0 \\ 0 & 0 & -\lambda & 0 \\ 0 & 0 & 0 & -\lambda \end{bmatrix} x = (W - \lambda i)x = 0$$

From $|W - \alpha I$ get 4 item eigenvalues

$\alpha = 0, \alpha = 0$

$\alpha = 15 + akar\ pangkat\ 221{,}5 \sim 29.883$

$\alpha = 15 - akar\ pangkat\ 221{,}5 \sim 0.117$

Then the following equation is obtained by substituting the first eigenvalue

$19.883x1 + 14x2 = 0$

$14x1 + 9.88x2 = 0$

$x3 = 0$

$x4 = 0$

7. Conclusion

The watermarking process using Two-Level Singular Value Decomposition can run well and the color analysis of the inserted pixel can also be accurately known where any pixel has changed due to insertion or extraction. This research can still be developed further by combining with other algorithms so that the results of the decomposition watermarking process can be better.

8. References

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