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# Hiding The Text Into An Image By Max-Plus Algebra

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**Abstract**— Security of an information system becomes very important especially for the information that is transfer through the internet. One of the effort to protect data is by encoding or hiding the data. One of popular technique for hiding text data into images is the LSB method. The weakness of the previous method is that the maximum number of characters that can be hidden must be less than the total number of pixels of the cover image. This article will discuss about how to hide text or character into an images using max-plus algebra. By this method, the number of characters that can be hidden in the image as much as the number of pixels, so this method can hide more characters in the image compared to previous method.

**Keywords**— Max-Plus algebra, Text, Image, LSB, Matrix, Pixel

## I. INTRODUCTION

Recently information technology has developed rapidly like the development of computer hardware and software. By the existence of internet technology, the process of data transfer can be done by others from a separate place and outside the system environment. The ease of data access remotely (using the internet) does not mean that they are always positive or good, but they also make new problems for the information world. The biggest problems when using the internet are slow access speeds and security when transferring data. Communication via the internet is very susceptible to data loss or changed that caused by system errors or actions from non responsibility persons [1]. Errors in data transfer via the internet are caused by two reason, that are the existence of human error or improper user intervention and the existence of technical errors from its system. Many effort have been made by internet users to solve the problem of data transfer, including encoding data that will be sent in order to no user can read the data except the person has the right to receive it. Just not encoding, there is also an authentication process or validation of the data received, this is done to ensure that the data received is correct or does not changed and its sent by the appropriate person.





Steganography is one of methods to protect information by hide data into an object or media. The kind of data or information that can be hidden into an object is the character or the image data. Generally, to hide character or image into

another object, the original text or original image should be converted into binary digits (bits) firstly [2].

## II. LITERATURE REVIEW

Conceptually, the difference between text data and image data can be seen in Table 1.

TABLE I. DIFFERENCES OF ENCRYPT TEXT AND ENCRYPT IMAGE.

Type	Hidden Data	Encrypt Data	Explanation
Text	CDLOIUNRH	KMUJHYDRF	Different
Image RGB	 P <sub>1</sub> = (24,45,233)	 P <sub>2</sub> = (10,65,198)	Its clear P <sub>1</sub> and P <sub>2</sub> is different, but visually are hard to distinguish both
Image Gray	 P <sub>1</sub> = (87)	 P <sub>2</sub> = (114)	Grayscale of P <sub>1</sub> and P <sub>2</sub> is different in value, but visually are difficult to distinguish both

An image consist of pixels that defined as function,  $f(x, y)$ , where  $f(x, y)$  is the light intensity of the pixels at position  $(x, y)$ . It is known as the grayscale [3]. An image is called a digital image if at position  $(x, y)$ , there is an amplitude value. These function are picture elements or pixels [4]. The pixel of an image can be converted into 8 bit (binary digit). The first bit to fourth bit is called LSB or Least Significant Bit because the bit value that changed in this position doesn't have impact on the image [5]. The fifth bit to eighth bit is called MSB or Most Significant Bit, because the bit value that changed in this position will give an effect to the image. For more details LSB and MSB position can be shown in Figure 1. The standard deviation of an image can be formulated by grayscale histogram. To find the standard deviation of image can be show on the following formula

$$L = \frac{h_0 + h_{255}}{2} + \sum_{i=1}^{254} h_i \quad (1)$$

where  $h_0$  are the number of pixels that have a value of 0 and  $h_{255}$  are the number of pixels that have a value of 255, and  $h_i$  is the pixel value at position  $i$

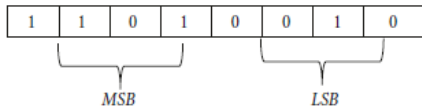


Figure 1. MSB and LSB Illustration

Based on the figure 1 above, starting from the right, the first to fourth bits are called LSB, while the fifth to eighth bits are called MSB.

The famous method to hiding bits of character into image is replacing the first bit of LSB. For example, we will hide 101101101 as bit of character. We want to hide those bits to the first LSB position. Figure 2 shows that pixel bits of adjacent pixels where the first bit of LSB has been replaced with a character bit

```
10100101 01101101 10101101
10001110 01101110 11001010
10110011 01010101 00110011
```

Figure 2. Hiding Bits on First bit of LSB

where  $R_{(i,j)}$  is the MSB of image of matrix on the Red layer at position  $(i, j)$ , and  $G_{(i,j)}$  is the MSB of image of the Green layer at position  $(i, j)$ .

Based on the example above it can be seen that each character consisting of eight bits is substituted into three adjacent pixels, so that the maximum number of characters that can be hidden into the cover image is 1/3 of the total bit of the cover image [6]. Generally the formula of steganography is defined as follows

**Cover image + hidden information = stego image.**

In the LSB method, every character (plain text) is hidden into three pixels of cover image. As consequence of this algorithm, the maximum number of characters that can be hidden into the cover image is 1/3 of the total pixel cover image [7]. In this paper, we propose a new algorithm so that the total text will be hidden can be increased as same as total pixels of the cover image.

### III. MAX-PLUS ALGEBRA

This chapter discusses an algebraic set of all intervals in max-plus algebra which is complemented by maximum operations and summations.

$$a \otimes b = a + b. \text{ for every } a, b \in R.$$

Operations  $\oplus$  and  $\otimes$  are extensions of matrices and vectors in the same way as conventional linear algebra.

In the max-plus algebra, the matrix multiplier  $A \otimes B$  is defined as follows: for any matrix  $A \in Rm \times p$ ,  $B \in Rp \times n$ , we can obtain matrix  $C \in Rm \times n$  by the formula (2)

$$c_{ij} = \bigoplus_{k=1}^p (a_{ik} \otimes b_{kj}) \quad (2)$$

where  $c_{ij}$  is the product of two matrices A and B for  $i = 1, \dots, m, j = 1, \dots, n$  [8].

For a square matrix with degree  $k$ , matrix  $A \in Rn \times n$  denoted by  $A(k)$  and was defined by recursive operation  $A(k) = A \otimes A^{(k-1)}$ , on  $k = 2, 3, \dots$

The set of  $R_{\max}$  with operations  $\oplus$  and  $\otimes$  is called max-plus algebra and denoted by  $R_{\max} = (R_{\max}, \oplus, \otimes, \varepsilon, e)$ . There is  $-\infty$  such that  $\max(a, -\infty) = \max(-\infty, a) = a$  and  $a + (-\infty) = -\infty + a = -\infty$  [9].

For any  $a \in R_{\max}$ , there is a small number  $\varepsilon$  such that

$$\begin{aligned} a \oplus \varepsilon &= \varepsilon \oplus a = a, \\ a \otimes \varepsilon &= \varepsilon \otimes a = \varepsilon \quad [10]. \end{aligned}$$

### IV. PROPOSED METHOD

The type of research method is experimental research. This method will examine the possibility of creating a new coding technique so that it can cover the weaknesses of the pre-existing coding method. In order to increase data security, we use max-plus algebra to hide text to the images. The following algorithm is the result of this research about how to hide text into the image using max-plus algebra

- (1) Convert text to ASCII then change to bitwise form.
- (2) Convert pixels of image to bitwise form.
- (3) Change the MSB from the pixel of the cover image to the  $2 \times 2$  matrix form.
- (4) Find  $M_{(i,j)} = R_{(i,j)} \otimes G_{(i,j)}$
- (5) Replace the text bit to the LSB cover image at the red layer with the following rules:
  - (a) If  $m_{11} > m_{12}$ , then replace the bit-1 of text to the bit-2 of LSB and replace the bit-2 of text to the bit-1 of LSB.
  - (b) If  $m_{11} \leq m_{12}$ , then replace the bit-1 of text to the bit-1 of LSB and replace the bit-2 of text to the bit-2 LSB.
  - (c) If  $m_{21} > m_{22}$ , then replace the bit-3 of text to the bit-4 of LSB and replace the bit-4 of text to the bit-3 of LSB.
  - (d) If  $m_{21} \leq m_{22}$ , then replace the bit-3 of text to the bit-3 of LSB and replace the bit-4 of text to the bit-4 of LSB.
- (6) Replace the text bit to the LSB cover image at the green layer with the following rules:
  - (a) If  $m_{11} > m_{12}$ , then replace the bit-5 of text to the bit-2 of LSB and replace the bit-6 of text to the bit-1 of LSB.
  - (b) If  $m_{11} \leq m_{12}$ , then replace the bit-5 of text to the bit-1 of LSB and replace the bit-6 of text to the bit-2 LSB.
  - (c) If  $m_{21} > m_{22}$ , then replace the bit-7 of text to the bit-4 of LSB and replace the bit-8 of text to the bit-3 of LSB.
  - (d) If  $m_{21} < m_{22}$ , then replace the bit-7 of text to the bit-3 of LSB and replace the bit-8 of text to the bit-4 of LSB.

Here  $m_{ij}$  is the matrix element of the image matrix at the row  $i$  and column  $j$ . For more details, we will show the illustration through the flowchart as in Figure 3.

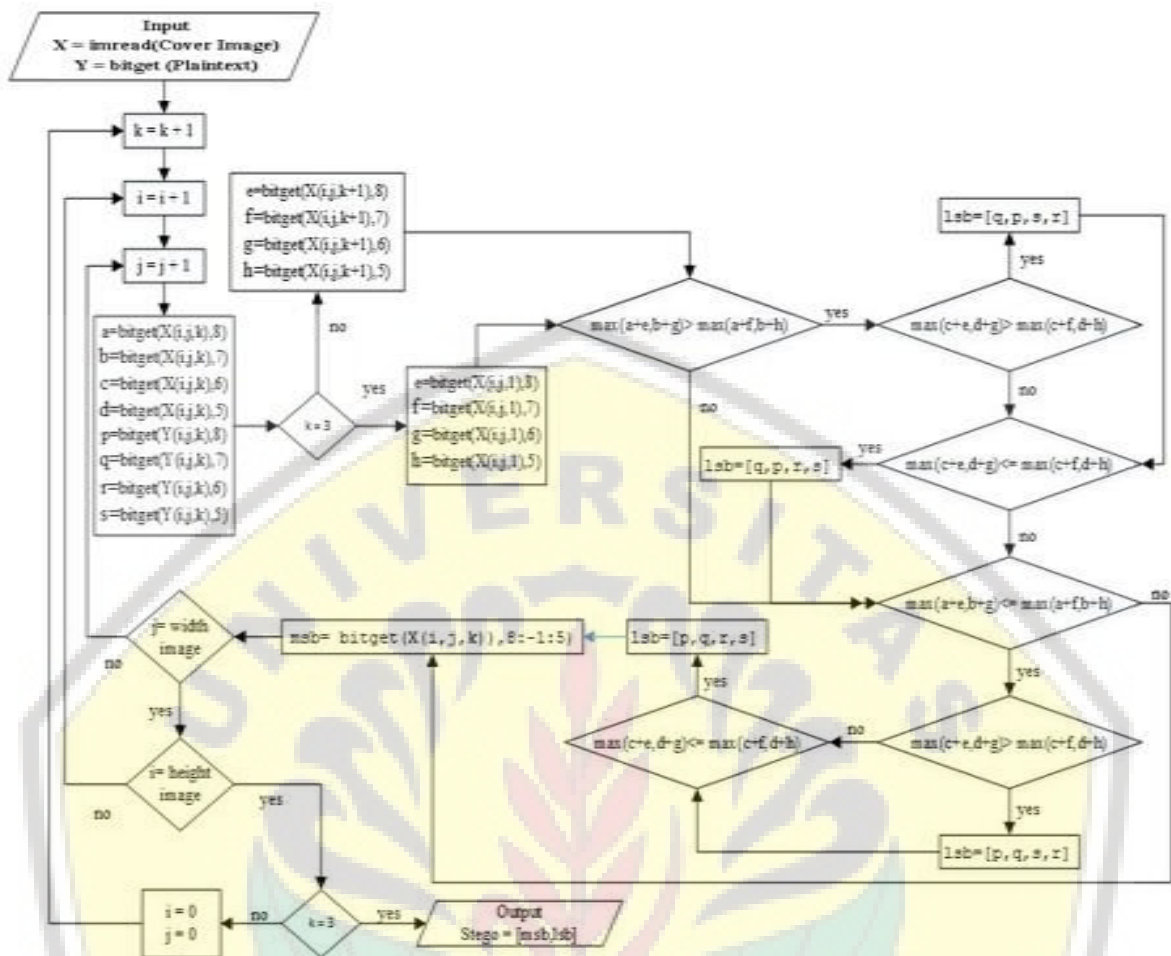


Figure 3. Flowcharts illustration of hiding the text

The following method to display the text from the stego image.

- (1) Change the pixels of stego image to 8-bit form.
- (2) Find the stego image matrix by formula (3)

$$M_{(i,j)} = R_{(i,j)} \otimes G_{(i,j)}, \quad (3)$$

Where :  $R_{(i,j)}$  is the Most Significant Bit of image matrix on the Red layer at position  $(i, j)$ ,  
 $G_{(i,j)}$  is the Most Significant Bit of cover image matrix on the Green layer at position  $(i, j)$ ,

- (3) Change LSB on red and green layer by the rule:
  - (a) If  $m_{11} > m_{12}$ , then replace the bit-1 by the bit-2.
  - (b) If  $m_{21} > m_{22}$ , then replace the bit-3 by the bit-4.
 Here  $m_{ij}$  is the element of the stego image matrix on the row  $i$  and column  $j$ .
- (4) Combine LSB on red layer and LSB on green layer into one
- (5) LSB on red layer + LSB on green layer show the value of character that be hidden

Basically the process of encryption and decryption on the steganography method using max-plus algebra is almost the same, which is to do the multiplication of MSB matrix values on the red and green layers.

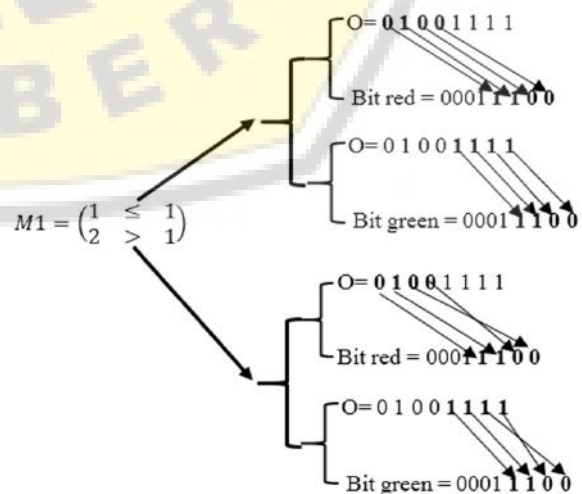


Figure 4. Hiding Process

V. RESULT

To test our method, we will hide text "OKE" to the image. The example data is shown in table 2.

TABLE 2. EXAMPLE DATA

PIXEL				TEXT			
Pixel	Layer	Value	Bit	MSB	Char	ASCII	BIT
1	Red	28	00011100	$R = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}$	O	79	01001111
	Green	104	01101000	$G = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$			
2	Red	146	10010010	$R = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$	K	75	01001011
	Green	67	01000011	$G = \begin{pmatrix} 0 & 1 \\ 0 & 1 \end{pmatrix}$			
3	Red	200	11001000	$R = \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$	E	69	01000101
	Green	98	01100010	$G = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$			

$$M1 = R \otimes G = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \otimes \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix}$$

$$M2 = R \otimes G = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \otimes \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix} = \begin{pmatrix} 1 & 2 \\ 1 & 1 \end{pmatrix}$$

$$M3 = R \otimes G = \begin{pmatrix} 1 & 1 \\ 0 & 0 \end{pmatrix} \otimes \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = \begin{pmatrix} 2 & 2 \\ 1 & 1 \end{pmatrix}$$

Based on the sample data above the characters O, K, E is converted to decimal (79,75,69) using the ASCII (American Standard Code for Information Interchange) table. Then the decimal value is changed to 8 bits (binary digits). Then do the max-plus multiplication process between the MSB matrix in the red layer and the MSB matrix in the green layer.

TABLE 3 PIXELS AFTER PROCESS

PIXEL BEFORE				PIXEL AFTER			
Pixel	Layer	Value	Bit	M	Layer	Bit	Value
1	Red	28	00011100	$\begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix}$	Red	00011001	25
	Green	104	01101000		Green	01101111	111
2	Red	146	10010010	$\begin{pmatrix} 1 & 2 \\ 1 & 1 \end{pmatrix}$	Red	10010100	148
	Green	67	01000011		Green	01001011	75
3	Red	200	11001000	$\begin{pmatrix} 2 & 2 \\ 1 & 1 \end{pmatrix}$	Red	11000100	196
	Green	98	01100010		Green	01100101	101

The hiding process shown on figure 4, and calculation results can be seen in table 3. From the calculation of the "O" character if hidden it will change the red pixels from 28 to 25 and green pixels from 104 to 111. The "K" character if hidden will change the red pixels from 146 to 148 and green pixels from 98 to 101. The "E" character if hidden will change red pixels from 200 to 196 and green pixels from 98 to 101.

Changes of pixel values in each of these layers cannot be observed visually or are insignificant because the value of the change is less than 100.

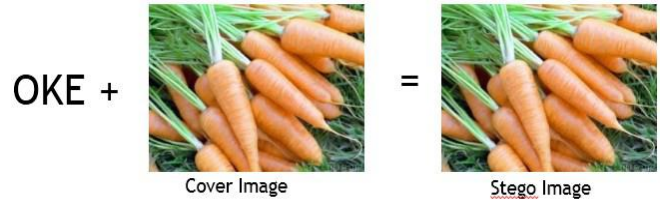


Figure 5. text "OKE" is hidden inside the carrot image

On Figure 5, it can be seen that the text "OKE" when hidden in a carrot image using the newly steganography method does not cause significant changes or in other words it cannot be distinguished visually.

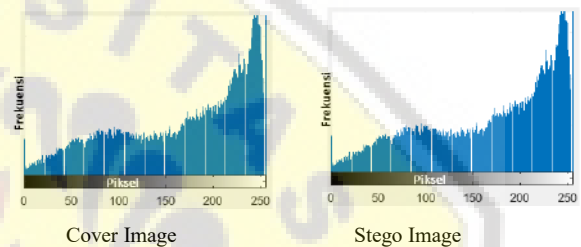


Figure 6. Histogram Grayscale

On Figure 6 it can be seen that the grayscale histogram before and after text insertion has no difference. Its happen because the ability of the eye cannot see the difference of pixels if difference of pixels value less than 100. In experiment the pixel difference is less than 10.

The next analysis, we will compute the correlation coefficients of two vertically, horizontally and diagonally neighboring pixels of cover image. To do this analysis, we take 850 adjacent pixels on stego image. Then we calculate the coefficient of correlation by the formula (4)

$$CC = \frac{covarian(x,y)}{\sigma_x \sigma_y} = \frac{\sum_{i=1}^N x_i - E(x)}{\sqrt{\sum_{i=1}^N (x_i - E(x))^2}} \frac{\sum_{i=1}^N y_i - E(y)}{\sqrt{\sum_{i=1}^N (y_i - E(y))^2}} \quad (4)$$

$$E(x) = \frac{1}{N} \sum_{i=1}^N x_i \quad ; \quad E(y) = \frac{1}{N} \sum_{i=1}^N y_i$$

Where  $x_i$  : the original image pixel value on the i position

$y_i$  : the pixel value of the stego image on the i position

N : total pixels

TABLE 4 CORRELATION

Image	Vertical	Horizontal	Diagonal
Cover	0.98696	0.90359	0.9615
Stego	0.98696	0.90344	0.9615

Based on table 4. It can be seen that vertical and diagonal correlation coefficients are the same, this shows that the relationship between pixels both vertically and diagonally is the same. The correlation difference only at horizontally, and it is too small so it can be ignored.

## VI. CONCLUSION

This algorithm has been tested to hide many text / string on some images. The result is stego image has insignificant difference when compared to cover image so visually it is very difficult to distinguish. One character can be hidden in one pixel of image by matrix multiplication under max-plus algebra operation. Maximum character that can be hidden as same as the number of image pixels. This is the novelty of this method where, in the previous method, size of secret image is always smaller than the image pixels.

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