Message Hiding in Animated GIF Using Multibit Assignment Method

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Abstract—**Steganography is a science of hiding information. Steganography hides message in certain media such image, text, audio, and video. One of the media is animated GIF. Animated GIF is an image that has a simple animation. Animated GIF can hides message in its frame. Hiding message in animated GIF needs a specific method to embed the message such multibit assignment. Multibit assignment is method to embed message in palette based image and animated GIF is a palette based image. Multibit assignment can hold more than one bit each color in pixel. So that it's possible to embed message in animated GIF using multibit assignment. In this paper propose a method to embed message in animated GIF using multibit assignment method.**

Keywords—steganography, animated GIF, multibit assignment

I. INTRODUCTION

Steganography is an ancient art of hiding information. Digital technology gives us new ways to apply steganographic techniques, including one of the most intriguing—that of hiding information in digital images. [1]. Steganography can hide data in certain media with binary files like image, audio, text, and video.

One of image format that can be used is GIF (Graphics Interchange Format) image. GIF image commonly used on internet. GIF image divided into 2 kinds of format, gif87a and gif89a [2]. Gif87a is the first kind of GIF image with palette based image. Gif89a is a development of previous GIF image which only has one frame. In gif89a it can has one or more frame so that the GIF image can played simple animation. Because of its feature that can played simple animation, gif89a with more than one frame often called with animated GIF.

GIF image can applied steganographic techniques. Some of the techniques are LSB method, adaptive method, and multibit assignment method. Multibit assignment method can applied to a palette based image like animated GIF [3]. With multibit assignment method the piksel not only can carry one bit each color but also can carry more than one bit, so that it's called with multibit assignment. Other advantages using multibit assignment method is it can handle color change because it use distance color value to set neighbor in usable multibit assignment.

In this paper propose a method to embed and extract a message in animated GIF using multibit assignment method.

After embedding a message into animated GIF, the embedded animated GIF will be evaluated. The evaluation method consist of two measurement, subjective and objective measurement. Subjective measurement with human visual system (HVS) and objective measurement with structural similarity index measure (SSIM) and peak signal to noise ratio (PSNR). This evaluation method is to measure image difference between animated GIF before embedding process and animated GIF after embedding process.

II. PROPOSE METHOD

In this section, a propose method to embed and extract message using in animated GIF using multibit assignment method is described.

A. Embedding Message

Embedding message in animated gif need some input, the animated gif itself, a secret key, a treshold D, and message that want to embed in animated GIF.

Embedding method is shown in Fig. 1. Embedding method has a several step. First, read a cover animated GIF from the input. Animated GIF then slice into frames. Then selected one frame from the slice frames. From the selected frame, then take the color palette. Using this color palette then producing usable multibit assignment. Multibit assignment process need treshold D and key to produce the usable multibit assignment. Producing process of usable multibit assignment follow from the paper [3] with some modification. Some modification made are the neighbors color is short by distance first before bit assignment process and the color changing process not use random way but checked shortly because the neighbors color is shorted.

The selection process of frame and pixel can be random or sequential. If selection of frame and pixel do randomly, we need an algorithm to produce pseudo-random number, because the random number should have generate the same number. The pseudo-random number used in producing multibit assignment, choosing frame, and choosing pixel to embed the bit message.

After producing usable multibit assignment, then choose pixel to embed the bit from the message. Message is a digital file that has a binary file and the message convert to bit stream first. Message can be encrypt before it embedded to make it more secure. If the message is choose to encrypt, the process must do

the encryption first before embedding message into pixel in frame. Encryption process used AES (Advanced Encryption Standard) and use key from the input.
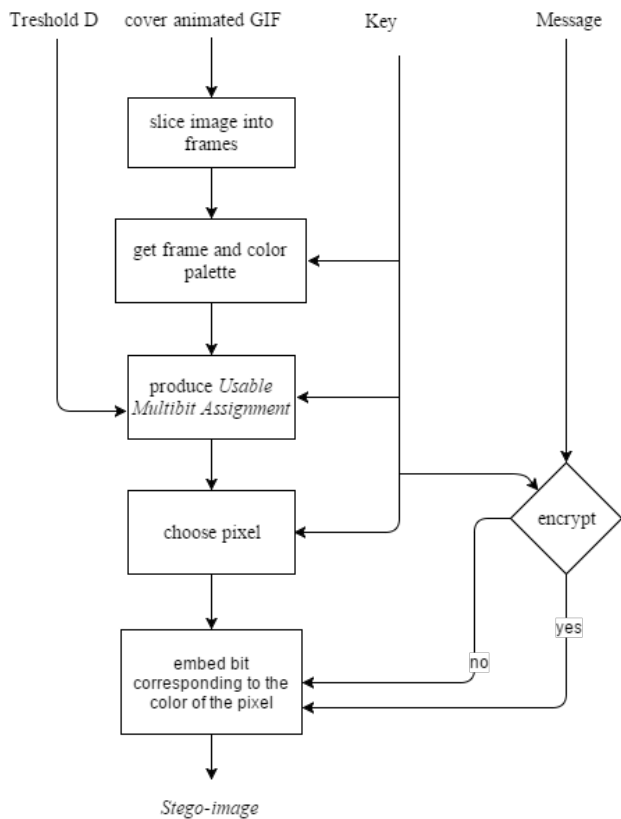

Fig. 1. Embedding method

The next step is embedding bit from message to corresponding color of the pixel. In here, do check for embed bit, if bit assign in the color is a prefix from the message bit then no modification needed. Otherwise, find a neighbor of the color from the usable multibit assignment that its assign bit coincident with prefix of message bit sequence. If there are several suitable neighbors then select neighbor with the lower distance.

After all the message embed in pixel in animated GIF's frames, then saved the embedded animated GIF which create the stego-image. And the embedding process done.

B. Extracting Message

Extracting message in embedded animated GIF Seed some input, the animated GIF that had embedded message, the key, and treshold D.

Extracting method can be seen in Fig. 2. Extracting method has some same step from embedding method like it has to slice the image into frames, choose a frame and color palette, producing usable multibit assignment, and choosing a pixel where the embed message is.

The different process from the embedding process is in extracting after choosing a pixel we don't evaluate to put bit message there, but we extract bit from the pixel. Pixel

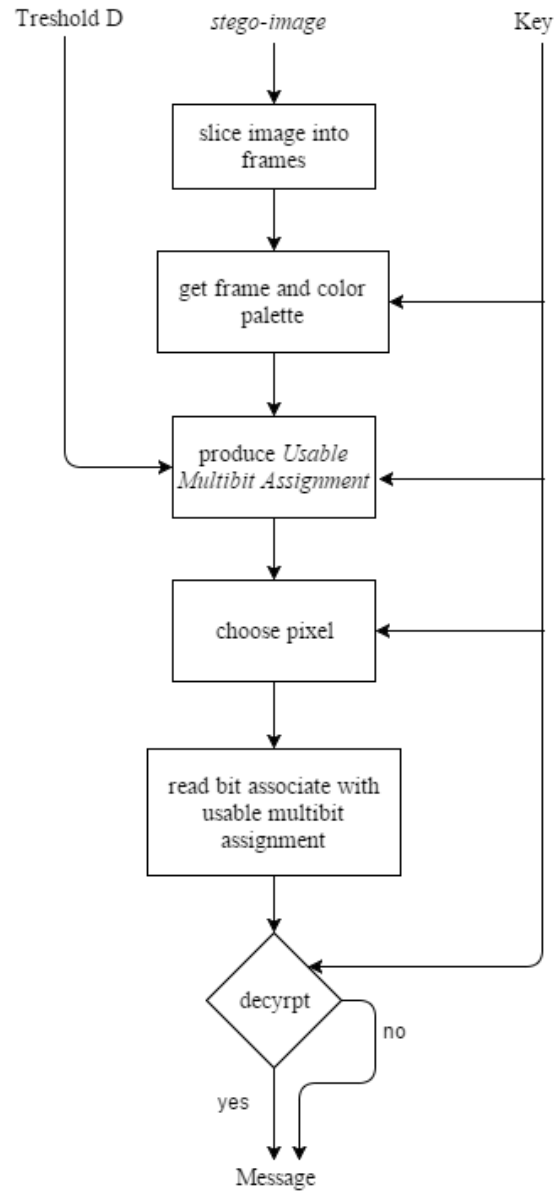corresponding to color that carry bit in usable multibit assignment.

Fig. 2 Extracting Method

After all the bit message had been read, then its decide whether to decrypt the message or not. Decryption process use key to get the message, if the key not same with embedding process the message will not the same. After all the bit message has been obtained, then the bit stream of the message convert again into the message that same with embedding process. Extracting process done and we get the message from the stego animated GIF.

III. RELATED TOPICS

A. Pseudo-random Number Generator

Pseudo-random number generator (PRNG) needed for producing usable multibit assignment. The PRNG used is

ISAAC random number generator which cryptographic secure pseudo-random number generator. ISAAC is a stream cipher and can seeded with key, so that the random number change by its key.

ISAAC initialize with function below. ISAAC random number generator that is used is based on Rosetta Code (2016). The complete code is in Rosetta Code [4].

```
// zeroise mm array
FOR i:= 0 TO 255 DO mm[i]:=0;
// check seed's highest array element
m := High(seed);
// inject the seed
FOR i:= 0 TO 255 DO BEGIN
// in case seed[] has less than 256 elements.
   IF i>m THEN randrsl[i]:=0
   ELSE randrsl[i]:=seed[i];
END;
// initialize ISAAC with seed
RandInit(true);
```

B. Evaluation Method

Evaluation method consist of two measurement, subjective and objective. Subjective measurement with human visual system (HVS) is simply done by see the distortion that happened in embedded animated GIF. The indicator is if no distortion realized it can say subjective measurement has passed. For objective measurement used SSIM and PSNR to calculate measurement.

1) Structural Similarity Index Measure (SSIM)

Structural Similarity Index Measure (SSIM) is objective methods for assessing perceptual image quality traditionally attempted to quantify the visibility of errors between a distorted image and a reference image using variety of known properties of the human visual system [5]. SSIM value range from 0 to 1, which 1 is the best value, that's mean two image are identical. Because of animated GIF has more than one frame, so it's must calculate its mean for all frame by using Mean SSIM (MSSIM).

The formula is used as follow:

$$MSSIM(X,Y) = \frac{1}{M}\sum_{j=1}^{M} SSIM(x_j, y_j) \quad (1)$$

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C1)(2\sigma_{xy} + C2)}{(\mu_x^2 + \mu_y^2 + C1)(\sigma_x^2 + \sigma_y^2 + C2)} \quad (2)$$

$$\mu_x = \sum_{i=1}^{N} w_i x_i \quad (3)$$

$$\sigma_x = (\sum_{i=1}^{N} w_i(x_i - \mu_x)^2)^{\frac{1}{2}} \quad (4)$$

$$\sigma_{xy} = \sum_{i=1}^{N} w_i(x_i - \mu_x)(y_i - \mu_y) \quad (5)$$

X and Y stand for cover and reference animated GIF that want to calculate. $w = \{w_i | i = 1,2,...,N\}$ used a 11x11 circular-symmetric Gaussian weighting function. $C1 = (K_1L)^2$

with $K_1 = 0,01$. $C2 = (K_2L)^2$ with $K_2 = 0,03$. L is maximum bit in pixel $= (2^{bits\ per\ pixel} - 1)$.

Indicator used for MSSIM is the value of MSSIM above 0,95. If this indicator pass, the embedded animated gif is in good quality.

2) Peak Signal to Noise Ratio (PSNR)

Peak signal to noise ratio is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. PSNR often used to measure if embedded image has a good quality or not. Because of animated GIF has more than one frame, so it's must calculate its mean for all affected frame by using Mean PSNR (MPSNR).

The formula is used as follow:

$$MPSNR = \frac{1}{M}\sum_{j=1}^{M} PSNR(I_j, K_j) \quad (6)$$

$$PSNR(I,K) = 10 \times \log_{10}\left(\frac{MAX^2}{MSE(I,K)}\right) \quad (7)$$

$$MSE(I,K) = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}(I(i,j) - K(i,j))^2 \quad (8)$$

MAX is maximum bit of the color, m and n are the width and height of the image. Indicator used for MPSNR is the value of MPSNR above 30. If this indicator pass, the embedded animated gif is in good quality.

IV. IMPLEMENTATION AND EVALUATION

It has been succeeded to implement the embedding and extracting method in animated GIF using multibit assignment method that develop in environment Visual Studio Community 2015 using WPF (Windows Presentation Foundation). After implement the method, next step is to evaluate the software that has an implementation of the embedding and extracting method. Software that has been build named GifStegApps.

Evaluation conducted with 3 cases, they are case to evaluate validity of the embedding and extracting process, case to evaluate impact of the image after embedding process, and case to evaluate effect of treshold D in stego image quality. Animated GIF that is used in this evaluation is get from https://www.youtube.com/watch?v=mcixldqDIEQ and then converted to animated GIF. Animated GIF that shown in evaluation is only its thumbnail because the animated GIF has 22 frames. The cover animated GIF named Amazing Nature Time Lapse Cut.gif.

A. Evaluation of Validity of Embedding and Extracting

Validity of embedding and extracting process is determine by doping the embedding process, set all input such a animated GIF, key, treshold D and message file that Wat to embed, and after that generate the stego animated GIF. The stego animated GIF then extracted using extracting method. If the message from extracting process is the same with the message in embedding process, we can said that it has passed the test.

Table 1 Embedding Process

File Type	File Content
Message File	Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nunc congue dolor sed felis aliquam, vel tincidunt augue tempor. Morbi sed gravida diam, ac faucibus leo. Donec mattis dui non elit vestibulum viverra vel in orci. In ultrices felis id turpis malesuada commodo. Interdum et malesuada fames ac ante ipsum primis in faucibus. Quisque enim nunc, laoreet vitae eleifend sollicitudin, tristique vitae nulla. Quisque feugiat turpis nec magna sodales ullamcorper.
Cover Animated GIF	

Table 2 Extracting with same key and different key

File Type	File Content
Extracted Message File (using right key)	Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nunc congue dolor sed felis aliquam, vel tincidunt augue tempor. Morbi sed gravida diam, ac faucibus leo. Donec mattis dui non elit vestibulum viverra vel in orci. In ultrices felis id turpis malesuada commodo. Interdum et malesuada fames ac ante ipsum primis in faucibus. Quisque enim nunc, laoreet vitae eleifend sollicitudin, tristique vitae nulla. Quisque feugiat turpis nec magna sodales ullamcorper.
Extracted Message File (using wrong key)	~¤±+µü+q†m'š³¨h0¶YµŒ0¥‹Äoj-?øM_Ž¤™Ê>ª^ÝäEKñíâZŠE[¶¼1)šº0è\□?ÙÊ„S" u:©³?Ïl¬×a+´ßcHN"“';«²¢VÉ~n•fÈr¢¬Ñ´~÷Å*&¨ L¦\□Êƒrslæ_"_9 ⊟µkÌK":›-uÒc v'vhñÉDÄTé`]Ç‡ïêÉyR¸º³žFêX±®)¶þ¶8®Õíª&3µ å‚JS´q]d¶À((&ë; .Û%½mê.ÅË}^JÙa%Í]dp*Ó%¯¨I"ªšéÓÁEVã¡øËí ¿UZÇ)
Stego animated GIF	

Table 1 is shown a thumbnail of animated GIF and message File. In table 2 shown extracted message file using correct and wrong key. From this we can conclude that the process of embedding and extracting process is valid.

B. Evaluation The Impact of The Image After Embedding

Evaluation the impact of the image after embedding is determinis by using subjective and objective measurement MSSIM and MPSNR. Subjective measurement give Renault that no distortion can be seen. Embedded message file used has 5 kinds, there are document (dokumen.docx), globe.gif, Logo ITB.png, message.txt, and ringtone mp3.

Table 3 Objective Measurement

Cover Image	MSSIM	MPSNR
Amazing Nature Time Lapse Cut-dokumen.gif	0,997179541252172	41,534
Amazing Nature Time Lapse Cut-globe.gif	0,992835604474124	38,956
Amazing Nature Time Lapse Cut-Logo ITB.gif	0,954713988734906	36,878
Amazing Nature Time Lapse Cut-message.gif	0,999886050313063	51,891
Amazing Nature Time Lapse Cut-ringtone.gif	0,972820839184033	38,06

From Table 3 all MSSIM value above 0,95 and all MPSNR value above 30, it means that evaluation of the impact has pas the objective measurement.

C. Evaluation of Effect of Treshold D

Effect of treshold D is valuable to evaluate because the treshold D is an input parameter used to produce usable multibit assignment. This treshold D affect usable multibit assignment because this value used to determine that color is neighbor or not.

The evaluation conduct by testing embedding process with many variant of treshold D. The maximum value of treshold D is $255\sqrt{3} \approx 441$. From that maximum value we divided the treshold D into 5, which are 20, 120, 220, 320, and 420.

By using the cover animated GIF that define before, and message file used is dokumen.docx and 5 treshold D value we got five stego file which named Ujia5-<number>.gif, the number is different from lower treshold D to bigger treshold D.

Table 4 First attempt

Cover Image	MSSIM	MPSNR
Uji5-1.gif	0,992963710328006	23,175
Uji5-2.gif	0,987110892076783	23,729
Uji5-3.gif	0,981435601610836	20,527
Uji5-4.gif	0,979235657814684	19,146
Uji5-5.gif	0,978096444519192	18,362

Table 4 shown that MSSIM for all is above 0,95 but the MPSNR not acceptable. From this we can conclude that the bigger value of treshold D, the quality of the image became not good. Because the result not acceptable, then we use another treshold D with lower value below 20. Treshold D that used in Second attempt are 4, 8, 12, and 16.The embedded Renault saved with name Uji52-<number>.gif which number indicates treshold D from lower to bigger.

Table 5 Second attempt with lower treshold D

Cover Image	MSSIM	MPSNR
Uji52-1.gif	0,99979684095731	62,29
Uji52-2.gif	0,999430285357232	49,845
Uji52-3.gif	0,99894982046304	43,628
Uji52-4.gif	0,997025078172963	29,779

Table 5 shown that MSSIM for all value is above 0,95 and MPSNR for Uji52-1.gif, Uji52-2.gif, Uji52-3.gif is above 30 and the las is below 30. For the value above 30 the embedded animated GIF has passed the objective measurement. From that table we can conclude that a lower treshold D give a better quality for embedded animated GIF. This happened because lower treshold D means that the neighbors of the colors has a near distance, which mean the color is almost same, but only different some RGB value.

V.   CONCLUSION

Method for embedding message in animated GIF using multibit assignment is performed with slicing image into frames, and then producing usable multibit assignment based on color palette, and then embedding bit message corresponding to the color of the pixel.

Method for extracting message in embedded animated GIF using multibit assignment is performed with slicing image into frames, producing usable multibit assignment, and read bit message corresponding to the color of pixel in usable multibit assignment.

Evaluation conducted result that in subjective measurement, no distortion has discovered, and in objective measurement the value off MSSIM is above 0,95 and the value of MPSNR is above 30. The quality of an embedded animated GIF is in good quality.

The quality of an embedded animated GIF is depend on treshold D. The bigger value of treshold D make color changing process not giving better result because color change with another with big distance. Embedded animated GIF gets a better result with small value of treshold D. In the future studies, the value of treshold D may be adaptively selected in different region according to the magnitude of local fluctuation, giving a better visual imperceptibility.

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