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Data Embedding Based on Better Use of Bits in Image Pixels

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***Abstract*—**In this study, a novel approach of image embedding is introduced. The proposed method consists of three main steps. First, the edge of the image is detected using Sobel mask filters. Second, the least significant bit LSB of each pixel is used. Finally, a gray level connectivity is applied using a fuzzy approach and the ASCII code is used for information hiding. The prior bit of the LSB represents the edged image after gray level connectivity, and the remaining six bits represent the original image with very little difference in contrast. The proposed method embeds three images in one image and includes, as a special case of data embedding, information hiding, identifying and authenticating text embedded within the digital images.

Image embedding method is considered to be one of the good compression methods, in terms of reserving memory space. Moreover, information hiding within digital image can be used for security information transfer. The creation and extraction of three embedded images, and hiding text information is discussed and illustrated, in the following sections.

***Keywords*—**Image embedding, Edge detection, gray level connectivity, information hiding, digital image compression.

I. Introduction

EMBEDDING two or more images in one image file represents a good way to use image bits. Image embedding is an important area of research for many researchers in the field of image processing. Rochester *et al.* corporation [1] presented a method for information hiding within an ordinary digital image and to extract it again without distorting the original or losing any information. The proposed method, called "reversible data hiding", solved the dilemma faced by digital image users. In the method, authorized recipients can extract not only the embedded message but also can recover the original image intact and identical bit for bit to the image before the data was added.

ILt Arnold *et al.* [2] used embedded images to identify and authenticate tampering in digital images, since the value of digital images is based on its content. Once the codes are embedded in the data content and the data is manipulated, these codes are modified so the authenticator can examine them to verify the integrity of the data. Checksums are embedded into the least significant bits of the image. A secret numeric key known by both the sender and the recipient protects these checksums. Walton [3] proposed a technique that uses a key-dependent pseudo-random walk on the image. The checksum is inserted in binary form in the least significant bit of selected pixels. This could be repeated for many disjoint random walks or for one random walk that goes through all pixels.

The notion of image embedding allows storing three types of digital images in one image file, i.e. a better way to use the bits for each pixel. The proposed method can be applied to embed only two images, the original and the edge detected image without checking the gray level discontinuity. Also, edge detection can be applied on the original image, then storing the binary values in the least significant bit of the pixel. The two least significant bits can be modified if the gray level connectivity is applied.

Another approach of using the two least significant bits is to write text information within the digital image, and then the extraction of this information is done by using the ASCII character code.

Although the LSBs of the image are disturbed, the resulting image is perceptually equivalent to the original. The human eye cannot detect any difference because changes to the LSB of a pixel affect its value by only one. Since pixel values range from 0 to 255, there will be a very little change in pixel intensity. This is important since the intent is to minimize the degradation of image fidelity during the embedding procedure.

The rest of the paper is organized as follows. Mathematical concepts of edge detection are presented in section 2. In Section 3, methods used in gray level connectivity is discussed. Section 4 discusses the mathematical model used for embedding, extracting the three images, and hiding messages. Section 5, shows the experimental result of the proposed method. Concluding remarks are finally presented in Section 6.

II. Edge Detection

The three basic types of gray level discontinuities in a digital image are points, lines, and edges [4]. The most common way to look for discontinuities is to run a mask, for example a 3x3 mask. The procedure involves computing the sum of product of the coefficients with the gray levels contained in the region encompassed by the mask. The response of the mask at any point in the image is given by:

$$R = \sum_{i=1}^{9} wizi \qquad (1)$$

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where z_i is the gray level of the pixel associated with mask coefficient *wi*. The response of the mask is defined with respect to its center pixel.

Edge detection is the most common approach for detecting meaningful discontinuities in gray level. Different approaches are proposed for edge detection. These approaches include the use of first and second order digital derivatives. An edge is a set of connected pixels that lie on the boundary between two regions. In practice, optics, sampling, and image acquisition imperfections yield edges that are blurred, with the degree of blurring being determined by factors such as the quality of the image acquisition system, the sampling rate, and illumination conditions under which the image is acquired. As a result, edges are more closely modeled as having a "ramplike" profile. The slope of the ramp is inversely proportional to the degree of blurring in the edge.

From many observations, a conclusion is obtained that the magnitude of the first derivative can be used to detect the presence of an edge at a point in an image, i.e. to determine if a point is on a ramp. Similarly the sign of the second derivative can be used to determine whether an edge pixel lies on the dark or light side of an edge. To be classified as a meaningful edge point, the transition in gray level associated with that point has to be significantly stronger than the background at that point, the method of choice to determine whether a value is significant or not, is to use a threshold. Thus, we define a point in an image as being an edge point if its two dimensional first order derivative is greater than a specified threshold [4].
First order derivative in an image is implemented using the magnitude of the gradient. For a function *f(x, y)*, the gradient of *f* at coordinates *(x, y)* is defined as the two-dimensional column vector, equations 2 and 3.

$$\nabla x = \begin{bmatrix} Gx \\ Gy \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \quad (2)$$

The magnitude of this vector is given by:

$$\nabla f = mag(\nabla f) = \left[Gx^2 + Gy^2\right]^{1/2} = \left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2\right]^{1/2} \quad (3)$$

It is a common practice to approximate the magnitude of the gradient by using absolute values instead of squares and square roots:

$$\nabla f = |Gx| + |Gy| \quad (4)$$

Where G_x is the derivative in the x-direction, and G_y is the derivative in the y-direction and approximate the gradient by absolute value. Second order derivatives are obtained using Laplacian. Computation of the gradient of an image is based on obtaining the partial derivatives at every pixel location. These derivatives are implemented for an entire image by using Sobel masks [4] shown is Fig. 1 and Fig. 2. The application of the two components of the gradient is shown in Fig. 3.

$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

Fig. 1 Masks used to compute the gradient at center pixel of the region encompassed by the mask

$$\begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix} \qquad \begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix}$$

Fig. 2 Masks used for detecting discontinuities in the diagonal directions

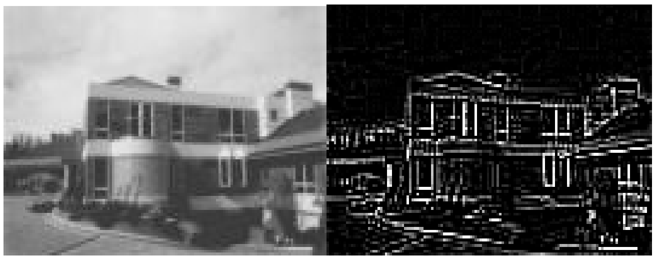

Fig. 3 The application of the two components of the gradient for a sample image

III. Edged Pixel Connectivity

In practice, a set of pixels not often characterizes an edge completely, because of noise, breaks in the edge from non-uniform illumination, and other effects that introduce spurious intensity discontinuities. Edge detection algorithms typically are followed by linking procedures to assemble edge pixels into meaningful edges. Several basic approaches are suited to this purpose [4].

Some methods deal with grayscale connectivity, such as fuzzy grayscale connectivity, in this approach, the pixels of a grayscale image *f* are considered to be vertices of a fuzzy graph, with membership function *f*, which are related to each other by means of a fuzzy relationship. For example, in the original definition of fuzzy grayscale connectivity given by Rosenfeld [6-8], two pixels in a grayscale image are related to each other by the notion of degree of connectedness. This is determined by calculating the minimum of the gray level values along each path joining the two pixels, and by taking the maximum of all those values. In this framework, two pixels are said to be fuzzy connected if their degree of connectedness is the maximum possible, which equals the minimum of the two gray level values at those pixels. Then a grayscale image is said to be fuzzy connected if every pair of pixels of the image is connected. By changing the underlying fuzzy graph, many variants of this basic scheme have been proposed [9,10]. Another approach to grayscale connectivity is based on using regional maxima (or minima) to define grayscale connected components in images that correspond to objects of interest. For instance, functions with a single regional maximum or minimum, called "grayscale blobs" may be tracked through a scale-space decomposition in order to characterize the global structure of images [11, 12].

IV. Data Embedding

There is a huge literature dealing with various technical, application oriented, and legal aspects of data embedding but unfortunately there is no common agreement about the use of terminology [13] in this matter. In literature, one will also often come across terms such as data hiding, steganography, and digital watermarking [14].

One of the earliest data embedding methods is the LSB modification, In this method, the LSB of each pixel is replaced (over-written) by a value zero for the non edged pixel, or one for an edged pixel. This can be done by using the logical operators. The LSB contains the indication for the existence of edged pixel. Changes to the LSB of a pixel affect its value by only one. Since pixel values range from 0 to 255, there will be a very little change in pixel intensity.

The extraction of the LSB can be implemented by checking the odd and even pixel values. The prior LSB is used in this work to contain the binary edged image after pixel connectivity implementation; in this case the original image occupies the remaining six bits.

Alternative use of these two bits, is using the ASCII character code to represent certain characters, for example, the message "go home" is stored with the digital image as (g = 67, o = 6F, h = 68, m = 6D, e = 65). The two least significant bits will take the ASCII character code value in four steps, this means each character needs 4 pixels to get the full code, the second character, needs the next four pixels, and so on.

Fig. 4 shows the first eight pixel values for the original apple picture in Fig. 6a. Fig. 5 illustrates how the eight pixels are used to code the character *g* "hex. 67 = 0110 0111", in the first four pixels, and character *o* "hex. 6F = 0110 1111", in the next four pixels, binary representation starts from left to right. The same process is repeated to other characters till the last character in the text.

1	0	1	0	1	1	1	1
1	0	1	0	1	1	1	1
1	0	0	1	0	1	0	1
1	0	0	1	0	1	0	1
1	0	0	1	0	1	0	1
1	0	0	0	0	0	1	0
1	0	0	0	0	0	1	0
1	0	0	0	0	0	1	0

Fig. 4 Original pixels

1	0	1	0	1	1	0	1
1	0	1	0	1	1	1	0
1	0	0	1	0	1	0	1
1	0	0	1	0	1	1	1
1	0	0	1	0	1	0	1
1	0	0	0	0	0	1	0
1	0	0	0	0	0	1	1
1	0	0	0	0	0	1	1

Fig. 5 Characters "g" and "o" of the message "go home"

To extract the text from the digital image, the logical operator "OR 00" or "AND 11" is used, then from four pixels the binary representation of the character is obtained and the ASCII code for the character can be defined.

V. Experimental Results

Different test images are used in this study. Two samples are presented here, with the results of implementing the data embedding. It is quite clear that the difference between the original image, and the resulted seven and six bits images, is not easily detected (Fig. 6).

The LSB of each pixel, in this Figure contains the same image after applying the edge detection filter, the prior bit to LSB, contains the same information. After applying the gray level connectivity, the result is stored in binary form: 0 for non edge pixel and 1 for edge pixel.

The proposed method is implemented using C++ language. Logical operators AND, and OR are used to embed and extract the bits from each pixel.

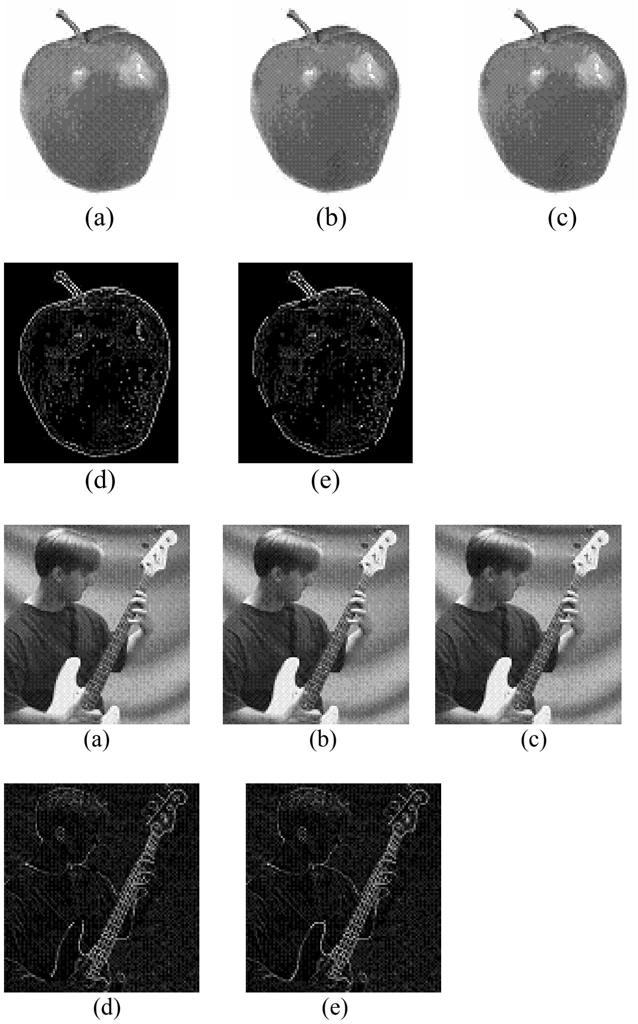

Fig. 6 (a) Original 8 bits/pixel, (b) 7 bits/pixel, (c) 6 bits/pixel, (d) prior to LSB, (e) LSB

VI. Conclusion

In this study, we have introduced a novel approach for image embedding. The two least significant bits of each pixel in the image are modified, each one contains the result after applying the edge detection filter, before and after grayscale level connectivity, i.e. one pixel contains information for three different images. The advantage of the proposed method is to keep the original image and the processed ones all in a single file. Image embedding method is considered to be one of the good compression methods, in terms of reserving memory space. The two LSBs are used to save text information in binary form, coded using ASCII character code.

Another important aspect of the proposed method is that eight bits per pixel in an image can be reorganized to represent much information related to the same image or hiding information. By disturbing two bits only which have no effect on the appearance of the image in comparison with the original one.

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