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Chapter XII

Hiding Images Using Dynamic Bit-Replacement and Human Visual System

Chin-Chen Chang and Kuo-Feng Hwang
National Chung Cheng University, Taiwan.

A simple image hiding scheme in spatial domain is proposed in this chapter. The main idea is to utilize a threshold mechanism to embed as much information of the secret image into the cover image as possible. The changing of the cover image is hard to be discovered by the human eyes because the threshold mechanism is setup especially to fit the human visual system. The experimental results show that the human visual system has improved the quality in terms of perceptibility. On the hiding capacity issue, the proposed method has capability to embed two times the size of the secret image of previous work. A partial encryption strategy is used for the security of the secret image. In addition, a two-dimensional permutation function, torus automorphism, is also introduced in this chapter.

INTRODUCTION

Information hiding is a delivering secret data technique, that is achieved by a camouflage mechanism; that is, concealing the secret data from other unimportant data. To camouflage digital images, we must make good use of one of their important features - tolerance to a certain degree of data loss, which comes from the limited resolution of the human retina.

There are many data hiding techniques have been developed. For example, Hwang, Chang and Huang (2000) used neural networks to embed the copyright owner's logo into the image for copyright protection. This type application of information hiding is called digital watermarking. However, different applications of information hiding have to meet their own requirements. Our work is aimed at image hiding, which refers to the embedding of a secret image into another unimportant image. The negligible image is called the "cover image."

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When the embedding process is done, the cover image has been slightly changed. We call the changed image a "stego-image." Steganography is the term used for the information hiding technique (Pfitzmann, 1996). Image hiding is useful to deliver confidential images, which are well-camouflaged. The main requirements for image hiding techniques are embedding capacity and security. Of course, the difference between the cover image and the stego-image should be perceptually invisible. This is a basic request.

Many works about image hiding have been developed. Chen, Chang and Hwang (1997) embed the VQ (vector quantization) code of the secret image into the cover image by 3 LSBs (least significant bits) replacement method. The main advantage of this method is that the secret image's size can be four times that of the cover image's. However, time consuming is a disadvantage caused by using VQ compression. Liaw and Chen (1997) proposed a gray value replacement method to embed a secret image into a cover image. The authors find each pixel p' in the cover image for the pixel p in the secret image whose pixel values are closed. The stego-image is produced by replacing the pixel value of p' with that of p. This method will suffer a problem from a large difference histograms of pixel values between the cover and secret images; i.e., there may exist many pixels in the secret image that cannot find suitable pixels in the cover image with close gray values to allow gray value replacement. This problem is pointed out by Wu and Tsai (2000). In addition, Wu and Tsai also proposed a method to embed a gray-level secret image into a gray-level cover image. Their method is based on the feature of gray-level similarity among the adjacent pixels of a natural image. The main advantage of Wu and Tsai's method is that the extracted secret image is the same as the original one. It is useful when the secret image is lossy not allowable. However, most natural images are distortion allowable. Consequently, the lossless secret image is not a requirement in most of image hiding techniques. Wu and Tsai's method will be reviewed in the section *A Review of the Previous Work*.

What we shall propose in this chapter is a spatial domain image hiding technique. The proposed technique, taking into consideration the properties of the human visual system, embeds as much information of the secret image into the cover image as possible. It uses dynamic bit-replacement method to embed secret data. For the capacity issue, this technique has the capability to embed two times the size of the secret image of Wu and Tsai's method. We apply partial encryption strategy for the security issue rather than using a pseudo-random number generator. As the experimental results show, both the qualities of the stego-image and the retrieved secret image are acceptable for practice.

The rest of this chapter is organized as follows. The next section reviews the human visual model and the torus automorphism. The previous work, Wu and Tsai's method, is briefly reviewed in the section following. The *Proposed Method* section describes the details of the proposed embedding algorithm. The experimental results of the proposed image hiding scheme are demonstrated in the section following. The last section presents the conclusions for this work.

RELATED WORK

Human Visual System

In 1996, Kuo and Chen (1996) proposed a human visual model for DPCM (differential pulse code modulation). They considered the Weber's law (Stockham, 1972) in their model. In 1998, they applied the human visual system to the vector quantization (VQ) image compression scheme (Kuo and Chen, 1998). The human visual system is used to evaluate the

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