Robust Reversible Watermarking via Invariant Image Classification and DHS

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Abstract: ***In this paper a new reversible watermarking scheme is proposed based on Dynamic Histogram Shifting (DHS). It adaptively takes care of the local specificities of the image content. Further a reference image is derived which is a copy of image itself. This reference image is invariant to the watermark insertion process. For identifying parts of the image that can be watermarked, Classification process is used. Further, Embedder and Extractor both use same reference image. Hence synchronization exists between embedder and extractor for message extraction and image reconstruction. For sensitive images like medical or military images, our scheme can insert more data with lower distortion than other methods.***

Keywords: Dynamic Histogram Shifting, Image Classification, Reversible Watermarking, Prediction error.

1. Introduction

During the last decade, reversible watermarking has found a huge surge of experimentation in its domain as there is a huge need to recover the original image after extracting the watermark arises in various applications such as law enforcement, medical and military image system, it is crucial to restore the original image without any distortions [1]. Encoding an identifying code into digitized music, video, picture, or other file is known as a digital watermark. The main purpose to embed code into digital signal is to trace ownership or protect privacy (content protection or authentication). Among different kinds of digital watermarking schemes, reversible watermarking has become a research hotspot recently. Compared with traditional watermarking, it can restore the original image after watermark extraction. Robust reversible watermarking aims at providing robustness against unintentional attacks. In robust watermarking schemes, watermark is designed to survive normal image processing operations. The watermarking scheme is used for content authentication and copywriting issues. There are two major constraints: the reversible data hiding scheme should provide a high embedding capacity and the embedding distortion should be low. Further, the image is not protected once the watermark is removed. So, for continuous protection of image watermark restored in most applications as long as possible. This is the reason why, there is still a need for reversible techniques that introduce the lowest distortion possible with high embedding capacity. Figure 1 shows the block diagram of a basic reversible watermarking system. In this paper, Section 2 describes basic and dynamic histogram shifting modulation. The proposed method is discussed in Section 3. Section 4 provides experimental results. Section 5 provide conclusion of the paper.

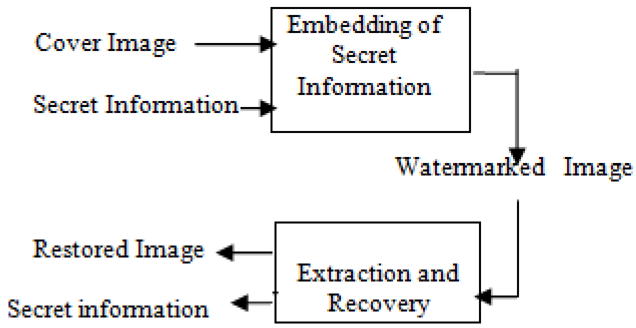

Figure 1: Basic Reversible Image Watermarking Scheme.

2. Basic and Dynamic Histogram Shifting

A graphical representation, similar to a bar chart in structure, that organizes a group of data points into user specified ranges. The histogram condenses a data series into an easily interpreted visual by taking many data points and grouping them into logical ranges or bins. An image histogram is a graphical representation of the number of pixels in an image as a function of their intensity. Image histogram describes the frequency of the intensity values that occur in an image. Image histograms are an important tool for inspecting images. Histograms are made up of bins, each bin representing a certain intensity value range. The histogram shifting technique embeds data by shifting the histogram bins. This method first constructs an image histogram of a cover image to obtain a pair of peak and zero points. Then, data are embedded by shifting the histogram bins. In [2] a novel reversible watermarking approach based on image histogram modification is developed.

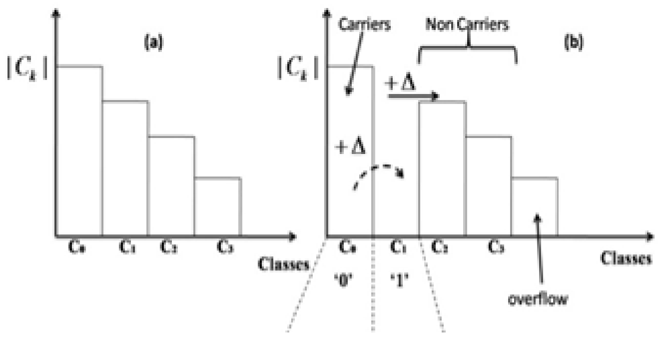

Figure 2: Histogram shifting modulation (a) Original histogram. (b) Histogram of the watermarked data

The basic principle of Histogram Shifting modulation, illustrated in Fig. 2 in a general case, consists of shifting a range of the histogram with a fixed magnitude threshold, in order to create a 'gap' near the histogram maxima (C_1 in Fig. 2). Pixels, or more generally samples with values associated to the class of the histogram maxima (C_0 in Fig. 2(b)), are then shifted to the gap or kept unchanged to encode one bit of the message, i.e., '0' or '1'. Samples that belong to the class C_0 are known as "carriers". Other samples as "noncarriers" are simply shifted. At the extraction stage, the extractor just has to interpret the message from the samples of the classes and invert watermark distortions (i.e., shifting back shifted value). In order to restore exactly the original data, the watermark extractor needs to be informed of the positions of samples that have been shifted out of the dynamic range such samples are referred as overflows(OF) or underflows (UF) (Fig. 2(b) only illustrates "overflows"). Before embedding, pair of peak and zero point is found. Only pixels with values between peak and zero points undergo modification during embedding process.

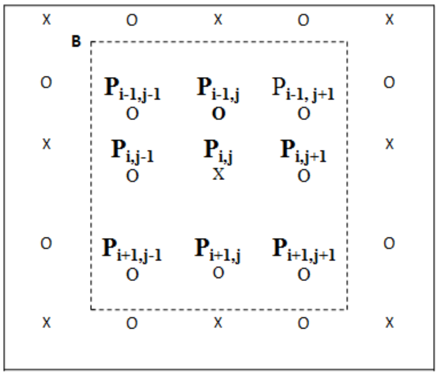

Figure 3: 3x3 pixels block $\hat{p}_{i,j}$ is estimated through its four nearest neighbours.

Considering the pixel block in Fig.3, the prediction error $e_{i,j}$ of the pixel $p_{i,j}$ is given by

$$e_{ij} = p_{i,j} - \hat{p}_{i,j} \qquad (1)$$

where $\hat{p}_{i,j}$ is the predicted value of pixel $p_{i,j}$ derived as in [3], [4] from its four nearest neighbour pixels :

$$\hat{p}_{i,j} = \frac{(p_{i-1,j} + p_{i,j+1} + p_{i+1,j} + p_{i,j-1})}{4} \qquad (2)$$

Prediction errors that encode the message belong to the carrier class; other prediction errors are non carriers. This predicate is static for the whole image and does not consider the local specificities of the image signal. The basic idea of our proposal is thus to gain carriers in such a region by adapting the carrier class depending on the local context of the pixel or of the prediction-error to be watermarked. Dynamic Histogram Shifting modulation is used to achieve this goal. Consider the dashed 3x3 pixel block (Fig3). Let us assume that we aim only at modulating the prediction errors $e_{i,j}$ (or equivalently $p_{i,j}$) indicated by in leaving intact their immediate neighborhood. Because of the local stationary of the image signal we can assume that contiguous prediction errors have the same behaviour. As a consequence, we consider the prediction-error neighborhood to better define the location carrier class Cc of on the prediction error dynamic. Based on this approach, the reference class is determined dynamically for each prediction-error of the image. In fact, it allows compensating the prediction-error in textured regions. Our dynamic histogram shifting modulation requires performing the watermarking of the image in several passes. Here in, one quarter of the image pixels are watermarked at each pass in order to ensure that their prediction-error neighborhood remains unchanged. Going through the image into several passes in order to watermark all the pixels is not new. This is the case of most methods working with HS applied to pixel prediction-errors [3], [4].

3. Proposed Method

Our scheme relies on three main Steps.

i)Read Cover Image And Find Predictive Error Values,
ii)Embedding Process,
iii)Extracting Process.

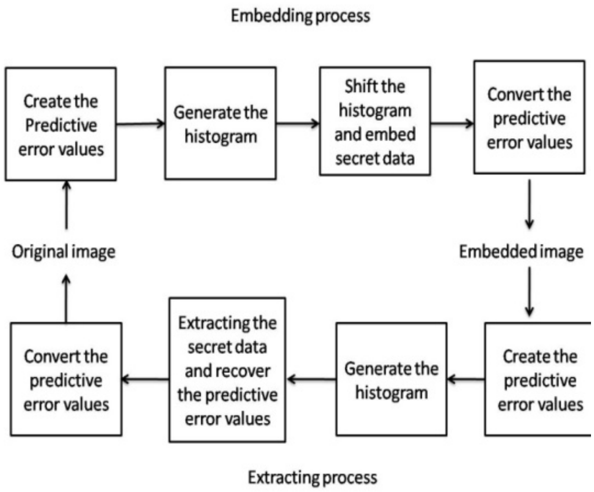

Figure 4: Block diagram of Embedding and Extracting Process

1)Read the cover image like gray scale image. Then find predictive error values for cover image using (1). Then find histogram of that predictive error value, find peak points and zero points.
2)Embedding process: Make histogram shifting based on peak and zero points. Then secret image converted into binary sequence. After that binary sequence embedded into predictive error values. Finally we get distortion less embedded image.

3) Extracting process: Finally we find predictive error values for embedded image. Then recover the binary values from embedded image's Predictive error values.

Then binary sequence converted into secret image.

The invariant classification method is used for making pixel region watermarking either with PHS or DPEHS based, that exploits a reference image $\hat{I}$ derived from the image I itself based on two constraints:

i) $\hat{I}$ remains unchanged after I has been watermarked into I_w(watermarked image), i.e., I and I_w have the same reference image;
ii) $\hat{I}$ keeps the properties of an image signal.

The regions of the image are independently watermarked taking advantage of the most appropriate HS modulation. Distinguishing two regions where HS is directly applied to the pixels or applied dynamically to pixel Prediction errors respectively. PHS (for "Pixel Histogram Shifting") and the later as DPEHS (for "Dynamic Prediction-Error Histogram Shifting"). For medical images, PHS may be more efficient and simple than the DPEHS in the image black background, while DPEHS will be better within regions where the signal is non-null and textured. To discriminate regions that will be PHS or DPEHS watermarked, consider a 3x3 dashed pixel box, To decide whether the block belongs to background or not, the block is characterized by predictor error value $\hat{p}_{i,j}$ and then compared with threshold Δ.

If $\hat{p}_{i,j} < \Delta$ then block $\in$ PHS region, Otherwise block $\in$ DPEHS region

4. Simulation Results

The performance of the proposed method is evaluated in MATLAB simulator. Suitable threshold value is chosen. Then for each pixel corresponding 3x3 pixel block selected for each pixel, then each pixel are predicted using (2). Then predicted image is displayed in figure 7. Then error value is found using (1), corresponding error image is displayed in figure 8. The message to be inserted is converted into binary and inserted into image. After extracting process original image is recovered as shown in figure9.

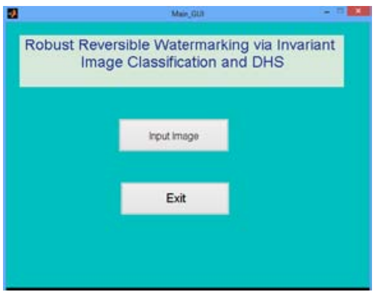

Figure 5: GUI using guide in Matlab

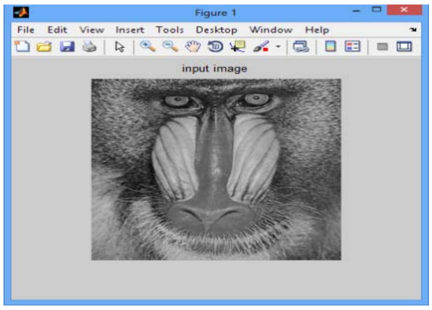

Figure 6: Input Baboon Image

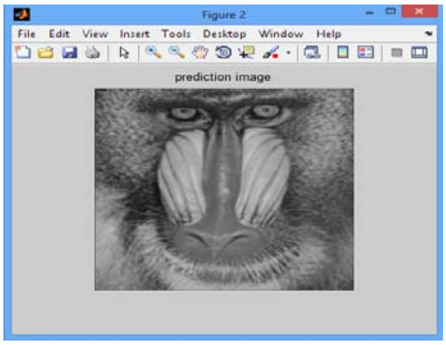

Figure 7: Prediction Image

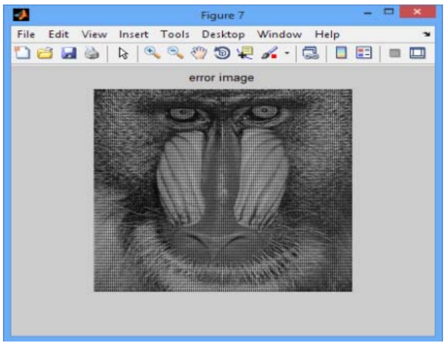

Figure 8: Error Image

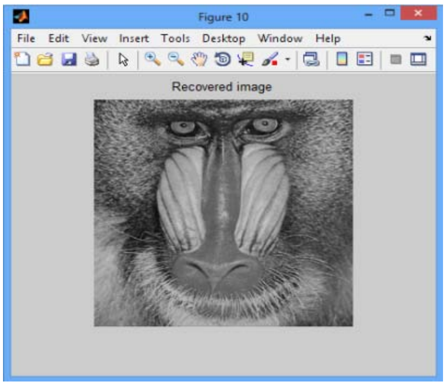

Figure 9: Recovered Image

5. Conclusion and Future Work

Distinguishing two regions in an image where HS is directly applied to the pixels or applied dynamically to pixel Prediction-errors respectively based on threshold value selection is an important factor. In this report DPEHS is major contribution of this work. The proposed method gives a very good compromise in terms of capacity and image quality preservation for both medical and natural images. This scheme can still be improved further either by combining DPEHS with expansion embedding (EE) modulation or better pixel prediction. As watermark usually makes fragile many solutions proposed [5], [6] about watermark robustness are discussed.

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