Multichannel Color Image Watermarking Using PCA Eigenimages

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Abstract. In the field of image watermarking, research has been mainly focused on gray image watermarking, whereas the extension to the color case is usually accomplished by marking the image luminance, or by processing color channels separately. In this paper we propose a new digital watermarking method of three bands RGB color images based on Principal Component Analysis (PCA). This research, which is an extension of our earlier work, consists of embedding the same digital watermark into three RGB channels of the color image based on PCA eigenimages. We evaluated the effectiveness of the method against some watermark attacks. Experimental results show that the performance of the proposed method against most prominent attacks is good.

1 Introduction

Digital watermarking is actually, an emerging field in computer science, electrical signal processing and communication. And it is intended by its developers as the solution to the problems of data copyright, content protection and ownership proof. Digital watermarking is technically the process of inserting pieces of information into digital data (audio, video, or still images), that can be detected or extracted later to make an assertion about this data.

Current watermarking techniques described in the literature can be grouped into three main classes. The first includes the transform domain methods, which embed the data by modulating the transform domain signal coefficients. The second class includes the spatial domain techniques. These embed the watermark by directly modifying the pixel values of the original image. The transform domain techniques have been found to have the greater robustness. The third class is the feature domain technique. This technique takes into account region, boundary and object characteristics. Such watermarking methods may present additional advantages in terms of detection and recovery from geometric attacks, compared to previous approaches.

Among the various digital image watermarking approaches proposed, few focused on color images. In the present paper we propose a new watermarking method for color images, using the Principal Component Analysis technique for encoding and decoding the watermark. Thai Duy Hien et al [1] were the first to introduce the PCA domain watermarking, and their method allowed...
to insert the watermark in the image luminance. Consequently, it was possible for them to embed a large amount of random watermark in principal components, and the orthogonal basis functions of image are determined by data, and they are adaptive to data. Cox et al [2] proposed a DCT domain watermarking for color image, and according to their algorithm, the image is converted to YIQ representation, and the watermark is embedded in the brightness component. Y. Kutter et al [4] proposed a digital watermarking method that consists of embedding the watermark in the blue channel of each pixel by modifying its pixel value.

Consequently, and by extension to the above cited papers we propose a different color image digital watermarking algorithm, using the PCA technique to embed the watermark separately, into the different three RGB channels of the color image.

The main advantage of this new approach is that the same or multi-watermark can be embedded into the three color channels of the image in order to increase the robustness of the watermark. In this watermarking algorithm we are using the PCA technique because of its suitable ability to extract the significant features of the image.

2 Proposed Algorithm

In digital image processing field, the PCA or also called the KL transform, is considered as a linear transform technique to convey most information about the image to principal components.

In the present algorithm, we, first, separate the image to three color RGB channels, and we separately apply the PCA transform of each of the sub-images before we proceed to the proper watermarking process.

2.1 PCA

In order to extract the principal components of an image, which are obtained from the eigenvectors of the image correlation matrix, we extract the principal components of sub pixels of the image channel by estimating the PCA transformation matrix. Thus, it is sufficient to present the image by giving values of the first few components.

In fact we need to extract the principal component of sub pixels of each sub-image by finding the PCA transformation matrix $[\varphi]$. Each sub pixel is transformed by the PCA transformation matrix $[\varphi]$.

It is then of primary importance to find the transformation matrix $[\varphi]$, going through the following process:

Task 1: For numerical implementation and convenience we divide the image I to a certain number of sub-images. We consider each sub-image an independent vector (vector of pixels). Thus, the image data vector can be written as:

$I = (i_1, i_2, i_3, \ldots, i_m)^T$ where the vector $i_i$ is the $i^{th}$ sub image and T denotes