Digital Watermarking For Color Images Using Enhanced Karhunen–Loève Transform

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Abstract- *Digital watermarking for color images using enhanced Karhunen - Loève transform has been implemented in this paper. Digital watermarking is widely used in security of the data communication, medical and defense departments etc. This paper presents a method for blind digital watermarking of color images. The proposed scheme performs a de-correlation of the RGB color bands of the image to be watermarked using a Karhunen– Loève transform (KLT), then marks the coefficients of the KLT of the first band obtained. The novelty of the method resides in the fact that the KLT basis images used for the transforms are not related to the image being marked, but are from an image taken as the secret key used throughout the scheme. The watermarking of the chosen KLT coefficients is performed using an IID. Gaussian sequence. The method shows good robustness to attacks and signal processing operations, in particular to JPEG compression, filtering, re-sampling and noise addition, maintaining at the same time a high image quality. In addition, the scheme is secure against protocol attacks such as copy attack and ambiguity attack.*

Keywords- KLT Transform, and distance measures

I. INTRODUCTION

Advanced watermarking is the way toward inserting mystery data inside sight and sound substance (like pictures or video also, sound streams) for security purposes. The watermark, that is, the flag added to advanced media, can be identified and recovered afterward, so as to achieve different security undertakings. A normal watermarking framework comprises of three extraordinary segments: the installing strategy, the extraction calculation what's more, the watermark. The last can be covered up in the media in numerous ways, which are for the most part grouped relying upon the area in which the implanting procedure takes place.Within the specific circumstance of computerized pictures, we can distinguish watermarking in the spatial area, which depends on the immediate adjustment of pixel esteems in the first picture. Probably the most well-known plans in this area are the Least Significant Bit

In any case, watermarking calculations that work in the spatial area are by and large thought to be helpless against assaults, making them pointless for down to earth applications. A more successful inserting procedure can be performed in the change space, where to insert the watermark the change coefficients are changed utilizing at least one of the accompanying strategies:

A watermarking framework might be named non-dazzle, semi-visually impaired or daze contingent upon the utilization it makes of the unique picture and the watermark in the extraction procedure. Non-daze techniques require the first media (now and then even the first watermark) in the location stage and concentrate the watermark utilizing connection based methods. Be that as it may, this prerequisite restricts their ease of use, since the first information is not generally simple to acquire. Semi-daze plots just utilize the unique watermark, or some other helper data, in the deciphering procedure without the need of the first media. Daze calculations utilize neither the first information nor the watermark also, in this way they are all the more difficult to devise, regardless of whether they are especially appropriate in some application situations, e.g. proprietorship security [11]. Along these lines, just visually impaired watermarking plans can be effectively utilized as a part of security applications whose object is to demonstrate the responsibility for advanced media [12]. A watermarking plan can likewise be delegated either delicate or then again vigorous. A delicate plan is utilized to recognize changes of the underlying information and is by and large connected in information validation, duplicate control and exchange following. The last mentioned, on the opposite, is described by a high protection from assaults what's more, can be considered as a standout amongst the most fascinating and across the board utilizations of digital watermarking. In fact, hearty watermarking gives a technique to ensuring possession rights against unlawful dissemination of pictures, music and motion pictures, with the goal that the property of a computerized substance can be followed and demonstrated. Conceiving a component ready to secure these advanced resources and their related possession rights has turned into a subject of awesome significance and much exertion has been spent in later a long time so as to get a powerful answer for this issue. Be that as it may, despite the fact that a wide range of methodologies have been endeavored, there is presently no plan that can be considered both very secure and ready to safeguard picture quality. To be sure, the way toward concocting another watermarking calculation requires making a trade off among the impalpability of the covered up stamp, keeping in mind the end goal to keep up high caliber in the advanced media, the heartiness of the installed watermark regarding endeavors to expel it and the security of the watermarking process, which ought not uncover any piece of information about the nearness of concealed information.

In this paper, we present a novel watermarking plan for shading pictures, in view of the Karhunen– Loève change (KLT),

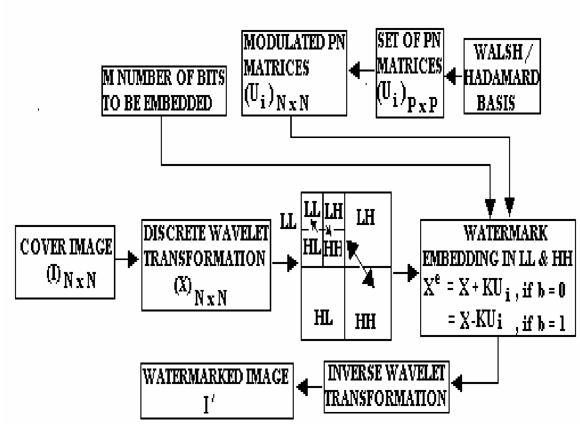

Figure1: DWT block diagram of digital watermarking

which utilizes a regularly appropriated, zero mean, pseudo-arbitrary succession as a watermark. The oddity of the strategy lives in the way that the KLT premise pictures utilized for the changes are most certainly not identified with the picture being stamped, yet are from a picture that is the mystery enter utilized as a part of the watermarking plan. Test comes about show great vigor against an extensive variety of flag preparing activities and assaults. Additionally, the nature of the unique picture is protected amid the watermarking procedure. Whatever remains of the paper is composed as takes after. Segment 2 presents a point by point portrayal of the KLT, though Section 3 presents the most applicable works identified with computerized. Watermarking in light of KLT. Area 4 depicts the proposed

Watermarking strategy and is isolated as takes after: Subsection portrays the methodology for producing the keying material, though Subsections 4.2 and 4.3 are centered, separately, on the portrayal of the watermark installing and discovery methods. The methodology for figuring the watermark grouping is given in Subsection 4.4. In Section 5 test comes about are displayed, to demonstrate the adequacy of the arrangement. At long last, in Section 6 we close talking about open issues furthermore, conceivable enhancements of the proposed watermark calculation.

I. Karhunen-L Transform (ICA)

The KLT is an orthogonal direct change that maps vectors between two spaces. Practically equivalent to straight changes are theDCT, the Fourier change and the Hadamard change, be that as it may, KLT varies from every one of them in light of the fact that the premise capacities it utilizes are processed from an arrangement of vectors and are not characterized a priori. In the accompanying, we give a short meaning of the KLT; for a more point by point

Now we consider the *Karhunen-Loeve Transform (KLT)* (also known as *Hotelling Transform* and *Eigenvector Transform*), which is closely related to the*Principal Component Analysis (PCA)* and widely used in data analysis in many fields.

Let ϕ_k be the eigenvector corresponding to the kth eigenvalue λ_k of the covariance matrix Σ_x, i.e.,

$$\Sigma_x \phi_k = \lambda_k \phi_k \qquad (k = 1, \cdots, N)$$

or in matrix form:

$$\begin{bmatrix} \cdots & \cdots & \cdots \\ \cdots & \sigma_{ij} & \cdots \\ \cdots & \cdots & \cdots \end{bmatrix} \begin{bmatrix} \phi_k \end{bmatrix} = \lambda_k \begin{bmatrix} \phi_k \end{bmatrix} \qquad (k = 1, \cdots, N)$$

As the covariance matrix $\Sigma_x = \Sigma_x^{*T}$ is Hermitian (symmetric if $\mathbf{x}$ is real), its eigenvector ϕ_i's are orthogonal:

$$\langle \phi_i, \phi_j \rangle = \phi_i^T \phi_j^* = \begin{cases} 1 & i = j \\ 0 & i \neq j \end{cases}$$

and we can construct an $N \times N$ unitary (orthogonal if $\mathbf{x}$ is real) matrix $\mathbf{\Phi}$

$$\mathbf{\Phi} \stackrel{\triangle}{=} [\phi_1, \cdots, \phi_N]$$

satisfying

$$\mathbf{\Phi}^{*T}\mathbf{\Phi} = \mathbf{I}, \quad \text{i.e.,} \quad \mathbf{\Phi}^{-1} = \mathbf{\Phi}^{*T}$$

The N eigenequations above can be combined to be expressed as:

$$\mathbf{\Sigma}_x\mathbf{\Phi} = \mathbf{\Phi}\mathbf{\Lambda}$$

or in matrix form:

$$\begin{bmatrix} \ddots & \cdots & \cdots \\ \vdots & \sigma_{ij} & \vdots \\ \cdots & \cdots & \ddots \end{bmatrix} [\phi_1, \cdots, \phi_N] = [\phi_1, \cdots, \phi_N] \begin{bmatrix} \lambda_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \lambda_N \end{bmatrix}$$

Here $\mathbf{\Lambda}$ is a diagonal matrix $\mathbf{\Lambda} = diag(\lambda_1, \cdots, \lambda_N)$. Left multiplying $\mathbf{\Phi}^T = \mathbf{\Phi}^{-1}$ on both sides, the covariance matrix $\mathbf{\Sigma}_x$ can be diagonalized:

$$\mathbf{\Phi}^{*T}\mathbf{\Sigma}_x\mathbf{\Phi} = \mathbf{\Phi}^{-1}\mathbf{\Sigma}_x\mathbf{\Phi} = \mathbf{\Phi}^{-1}\mathbf{\Phi}\mathbf{\Lambda} = \mathbf{\Lambda}$$

Now, given a signal vector $\mathbf{x}$, we can define a unitary (orthogonal if $\mathbf{x}$ is real) Karhunen-Loeve Transform of $\mathbf{x}$ as:

$$\mathbf{y} = \begin{bmatrix} y_1 \\ \vdots \\ y_N \end{bmatrix} = \mathbf{\Phi}^{*T}\mathbf{x} = \begin{bmatrix} \phi_1^{*T} \\ \vdots \\ \phi_N^{*T} \end{bmatrix} \begin{bmatrix} x_1 \\ \vdots \\ x_N \end{bmatrix}$$

Where the ith component y_i of the transform vector is the projection of $\mathbf{x}$ onto ϕ_i:

$$y_i = \langle \phi_i, \mathbf{x} \rangle = \phi_i^T \mathbf{x}^*$$

Left multiplying $\mathbf{\Phi} = (\mathbf{\Phi}^{*T})^{-1}$ on both sides of the transform $\mathbf{y} = \mathbf{\Phi}^{*T}\mathbf{x}$, we get the inverse transform:

$$\mathbf{x} = \mathbf{\Phi}\mathbf{y} = \begin{bmatrix} \phi_1 & \cdots & \phi_N \end{bmatrix} \begin{bmatrix} y_1 \\ \vdots \\ y_N \end{bmatrix} = \sum_{i=1}^{N} y_i \phi_i$$

The KLT, otherwise called main segment investigation (PCA), has been connected in different papers to characterize techniques for watermarking grayscale and shading pictures. A few plans, generally non-visually impaired and semi-dazzle, have been proposed in distinctive works, which we talk about in whatever is left of this segment. As a first case, let us consider crafted by Wang in which the picture is decorated into non-covering pieces also, the KLT of the arbitrary field is gotten. At that point, a watermark formed by a pseudo-arbitrary grouping is embedded into the in the first place arrange coefficients of all pieces and the backwards KLT is connected. To confirm the nearness of the watermark, the first KLT change grid (i.e. the one processed from the unique picture) is required. After the coefficients' extraction, a relationship with the watermark arrangement is finished. A few other methods for utilizing the coefficients and the keys are expressed as could reasonably be expected, be that as it may, none is expressly clarified. In the trial area, the recommended watermarked plot is tried just against three sorts of assaults, i.e. low-pass separating, re-scaling and JPEG pressure.

III. PROPOSED METHOD

Watermarking scheme has implemented as below

1. Choose an image W with the size (M*N), M and N are rows and columns.
2. Decompose the image in the contourlet transform domain as thirty two subbands with contourlet coefficients.

3. Select the high frequency subbands with directionality and anisotropy.
4. These subbands are used to increase the robustness.
5. The watermark image to be embedded can be arranged as a set of matrices $W_{s,d}(i, j)$ with the size ($_{WM}*_{WN)}$ and pseudo random binary values
   s and d are indicate the scale and the direction of contourlet sub bands.
6. Watermarked image is generated as the combinations of watermark image are product with the same size of pseudo random data and highest frequency subband of original image.
7. Embedded watermark into the sub bands of an image is accomplished according to

$$O'_{s,d}(i, j) = O_{s,d}(i, j) + \Omega M_{s,d}(i, j) W_{s,d}(i, j)$$

Where $O_{s,d}(i, j)$ and $O'_{s,d}(i, j)$ are the original contourlet coefficient and the watermarked contourlet coefficients.

8. Perform inverse operation for entire watermarked image.
9. Extract the original image and secret image from the watermarked image.
10. Calculate the MSE and PSNR values from the images
    $MSE = (O'_{s,d}(i, j) - O_{s,d}(i, j))^2/M*N$
    $PSNR = 10*\log (2^8-1)^2/MSE$

IV. EXPERIMENTAL RESULTS

The watermarking technique proposed in this paper is a plan that uses an important mystery picture IK, of size M × M as the watermarking key. The first picture to be watermarked, of size R × R, will be called Io in the accompanying. For effortlessness of documentation, we consider square pictures, yet the strategy can be inconsequentially stretched out to rectangular pictures. From the watermarking key IK the accompanying are registered: an arrangement of KLT eigenvectors (premise pictures) to be utilized as a part of the watermarking process; a watermark which is an i.i.d. Gaussian grouping s, i.e. a Gaussian circulation with invalid mean and standard deviation equivalent to σ2 s . The arbitrary esteems are registered introducing a pseudo-irregular generator with a seed gotten from the KLT premise pictures of IK. These two stages are talked about in the accompanying subsection that presents the age of the data that is univocally and covertly connected with the proprietor of the watermark. To register an arrangement of eigenvectors of IK, the three shading segments RGB of the picture are considered. The pixels make up an irregular field of vectors of size 1 × 3, thus the KLT of the shading segments is registered. Give us a chance to call the three eigenvectors e1, e2 and e3. Duplicating the focused (i.e. with zero mean) pixels of a picture by this orthonormal premise will deliver three channels; for instance, (x, y) is a segment vector speaking to a focused pixel estimation of directions (x, y) at that point pixels of the main channel can be processed as takes after: (x, y). Note that in this first exemplification we utilize this change to figure the eigenvectors of IK. This sort of change has likewise been utilized as a part of the pressure field, to assemble a distinguishable KLT [21]. In any case, different eigenvectors registered with marginally extraordinary techniques are conceivable: these strategies recommend a future research bearing for us. The new three channels of sizeM×M, which we call L1, L2 andL3, are viewed as separately.At the present time, onlyL1 is utilized for the watermark addition, on the grounds that for the most part it contains the biggest measure of vitality display in the picture. In this manner, it is less delicate to assaults to the watermark, since harming this channel would to a great extent debase the subsequent picture. The picture L1 is then isolated into an arrangement of b × b non-overlapping sub-pictures of size n × n, where b = M/n. In our analyses we utilized n = 8; be that as it may, likewise bigger estimations of n might be reasonable choices. This arrangement of sub-pictures is dealt with as an arbitrary field, and considering them as vectors of size 1 × n2, another KLT (identified with L1) is figured. The n2 eigenvectors gotten, which we call k1, k2, . . . , kn×n, can be translated as an arrangement of premise pictures comparable to the DCT premise pictures. This is because of the way that the eigenvectors shape a reason for the irregular field of sub-pictures from which they have been processed. Summing up every one of these premise pictures, weighted with fitting intensification coefficients (i.e. the parts of the vectors ui figured with the KLT from vectors vi), will deliver the remade sub-pictures Subsequently, the vectors e1, e2, e3 and k1, k2, . . . , kn×n are the first components got from IK that are utilized amid the watermarking process. Watermark installing Each time a watermarking substance needs to implant a watermark into a shading picture Io of size R × R, the initial step is to focus its pixels, i.e. the mean pixel is figured and is consequently subtracted from every one of the pixels of the picture. At that point the primary KLT is connected utilizing the vectors e1, e2 and e3 of the watermarking key. This activity produces three channels, Φ1, Φ2 and Φ3, and the one related with the eigenvector e1 is picked (i.e. Φ1). Next, this channel of sizeR×R, is partitioned into non-covering sub-pictures of size n×n making l = R2/n2 sub-pictures. These sub-pictures are focused (subtracting the mean sub-picture of the channel) and changed by applying the KLT with the vectors k1, k2, . . . , kn×n. Each sub-picture will have n2 coefficients. We regard these coefficients as highlights of the picture and we implant the watermark in a subset of them. The ebb and flow adaptation of the calculation embeds the watermark into the arrangement of coefficients

Figure2: cover image ‘lena’ Performed watermarking.

Table1 comparison of PSNR values for different images

Image	DWT Watermarking PSNR (dB)	**Proposed (CT) watermarking PSNR (dB)**
Lena	38.1	**39.54**
Barbara	37.06	**39.12**
Peppers	36.61	**38.09**

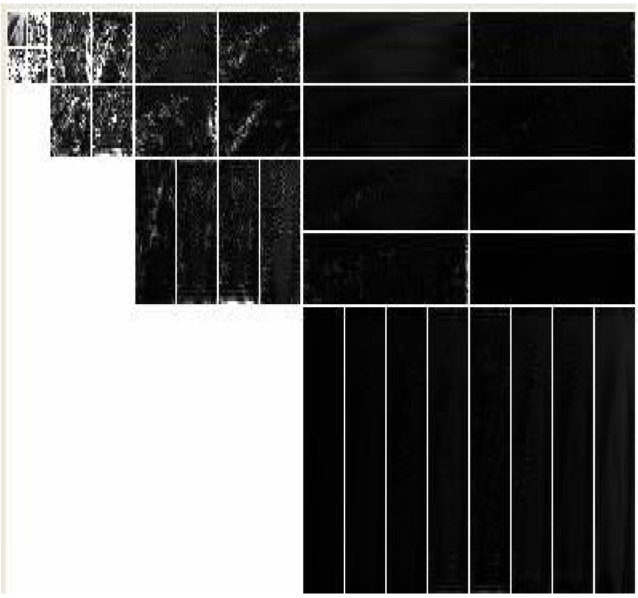

Figure3: contourlet transform subbands

The watermark at high frequency subband of an image is sensitive to many image processing methods such as low pass filtering, lossy compression, noise, and geometrical distortion. On the other hand, the watermark at low frequency subband of an image is sensitive to others image processing such as gamma correction, histogram equalization, and cropping. In this paper, we proved robustness of our proposed watermarking scheme. Then extracted watermark image is shown in below figure.

V. CONCLUSIONS

The proposed scheme performs a de-correlation of the RGB color bands of the image to be watermarked using a Karhunen– Loève transform (KLT), then marks the coefficients of the KLT of the first band obtained. The novelty of the method resides in the fact that the KLT basis images used for the transforms are not related to the image being marked, but are from an image taken as the secret key used throughout the scheme. The watermarking of the chosen KLT coefficients is performed using an IID. Gaussian sequence. The method shows good robustness to attacks and signal processing operations, in particular to JPEG compression, filtering, re-sampling and noise addition, maintaining at the same time a high image quality. In addition, the scheme is secure against protocol attacks such as copy attack and ambiguity attack.

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