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Watermark Embedding and Extraction using Histogram Shifting and Butterworth Filtering

Kiran
Scholar (M.Tech (CSE))
Department of Computer Science and Applications
Kurukshetra University, Kurukshetra,
Haryana, India

Dr. Kanwal Garg
Supervisor (Assistant Professor)
Department of Computer Science and Applications
Kurukshetra University, Kurukshetra,
Haryana, India

Abstract-In the digital image watermarking community, developing a robust watermarking method has withdrawn attention in recent years. In this paper, robust image watermark algorithm is proposed which is based on histogram shape and Butterworth filtering that resist against geometric attack and signal processing attack by using invariance property of histogram to scaling and without exploiting robust feature of pixel position statistically. In this method, embedding of watermark is done by bin shifting within group by maintaining histogram shape. At watermark detection site, watermark is detected by calculating relationship between bins of group. Watermark scheme is blind in nature.Experimental results show that the proposed method is robust to rotation, scaling and translation attacks, as well as some signal processing attacks and maintain good quality.

Keywords: Geometric Attack, Histogram Shape, PSNR, Quality

I. INTRODUCTION

In today's era, technology has made the transmission of digital media objects as a walk in the park and digital media can be easily reproduced and manipulated, so copyright protection of digital media content is necessary, Digital watermarking is solution to this problem. Digital watermarking is a technique in which pattern of bits is inserted into original image or cover image with the help of algorithm called embedding algorithm and resultant is called watermarked image or stego image which is further attacked either intentionally or unintentionally that results in distorted image . At the receiver side, watermark is extracted with the help of extraction algorithm and get the extracted image[1]. In this paper, emphasis is done on image watermarking.Attack can be classified into geometric attack and signal processing attack. Geometric can be further classified into invertible attack and non-invertible attack. Invertible attack includes affine transformation such as rotation, scaling, translation and random bending attacks and non-invertible attack includes cropping[2].Spatial location of pixels changes when the watermarked image is rotated and scaled , but in the case of shearing attack, watermark sequence is partially lost. Geometric attacks are more challenging than signal processing attack as geometric attacks produces synchronization errors between the embedder and extractor. Geometrical attacks can change the spatial position of pixels and the physical position of watermark. The watermark is still present, but the detector is no longer able to extract it[2]. Whereas the content-preserving imageprocessing operations such as addition of noises, common compression and filtering operations reduces watermark energy, do not introduce synchronizationproblems. Robustness to common signal processing attacks can be achieved by embedding watermarks into the low-frequency component of an image[3]. Geometric attacks induces two types of distortion in image. One is shifting of pixel in image and other is modification of value of pixel of image, call it as interpolation errors. Interpolation errors includes edge halos, blurring and aliasing[4].In this paper, interpolation errors only distort the value of pixel, does not do the blurring, aliasing, and edge halos as the histogram is independent of the pixels position.

II. RELATED WORK

Giri et alpresented channel wise watermarking scheme for colored image based on DWT. In algorithm, level one DWT is applied on each distinguished color channel. The algorithm is robust against various attacks like Gaussian noise, JPEG compression, salt and pepper noise[5].Khanduja et.al [6] proposed robust multiple watermarking technique for relational database. He not only did ownership protection but also recovered the information .In 2014, Eswaraiah et.al presented fragile ROI based medical image watermarking technique with tamper detection and recovery. In his algorithm Fragile watermark is stored in LSBs of ROI region and tempered information of ROI part is recovered without any loss. Run length encoding scheme is used to enhance the embedding capacity. Limitation of this algorithm is RONI part is not reversible[7].Joshi et al presented paper on secure medical image watermarking. In his paper he embed dual watermark. For the embedding, DWT and Arnold transform is used. It is used only on gray scale images. Both DWT and Arnold transform enhances the security[8].Lin et.al proposed an algorithm in which a 1-dimension watermark signal derived from the image was proposed to resist rotation, scaling and translation (RST) distortion, but the implementation is a very simple example so the improvement is also needed[9]. Kang et.al presented an image watermarking algorithm that uses combination of DWT–DFT (discrete wavelettransform-discrete Fourier transform) is robust against both affine transformation and JPEG compression, however, therobustness of the informative watermark against median filtering and random bending needsto be improved[10]. Lu.et.al derived a hash-based image watermarking algorithmthat was composed of mesh generation and hash-based content-dependent watermark. Thewatermark can be detected without knowledge of original images by sharing the exploitedPrivateKey in the detector. In addition to the image watermarking there was other watermark form and content [11]. Xiang *et al.* exploited the statistical property of histogram shape, which is invariant to pixel position shifting and insensitive to cropping. The mean concept is used in the Gaussian filtered low-frequency components of images to resist geometric attacks[2]. In Xuansen et.al[12], watermark is embed into groups but group consist of three bins and used the statistical invariant property of histogram shape. In, Wang et.al. Binary watermark sequence is embedded based on histogram based and the distances between adjacent elements of histogram are calculated[13] .

In this paper, Butterworth low pass filter is used to extract the low frequency component of image, then embeds the watermark into this by maintaining histogram shape property, which is independent to pixel position and robust against geometric attacks. It is applied to all images and provides higher robustness because the embedding range selection step is entirely based on the histogram shape. The outstanding advantage of this algorithm is to keep the statistical characteristics of original image with small distortion, and strong anti- attacks.

III. HISTOGRAM

In Digital image processing, Histogram is a simple and effective tool to represent intensity value in a digital image. The Histogram of image is a plot of the number of occurrences of gray levels in the image against the gray level values. It provides a convenient summary of intensities in an image, but unable to convey any information regarding spatial relationships between pixels[14]. Histogram is independent of pixel position, that's why this property is used in this paper to maintain robustness against geometric attack like rotation, scaling, translation. Robustness against geometric attack is attained by implementing an invariant property histogram shape (ratio of population of bins). Emergence probabilities of all gray scale varies from small too high in histogram, but it can be same in theoretical way. Histogram of gray scale image reflects the different gray-scale map. Image histogram is a statistical expression.

The histogram of a digital image I with gray levels in the range [0, L] is a discrete function

$$H(k) = \{h(k) \mid k=0, 1 \ldots\ldots L\} \qquad (1)$$

$h(k)$ denotes the number of pixels corresponding to k gray levelof the digital image I and

$$X*Y = \sum_{k=0}^{255} h(k) \qquad (2)$$

Where X and Y are number of rows and number of columns of image I respectively. Value of I(x, y) represents intensity value at spatial position (x, y). In 8 bit gray scale image, 8 bits represents bit depth. There are 256 gray levels are there i.e. from 0 to 255 means each pixel of gray scale image possess intensities value within range of 0 to 255. The relation between the number of the bins Land the bin width M[2]is depicted as

$$L = 2^p / M \text{ if } Mod(2^p / M)=0$$
$$\lfloor 2^p / M + 1 \rfloor \text{ otherwise} \qquad (3)$$

Where $h(k)$ includes those pixels between (i-1*).* Mand i.M-1, p is bit depth.

IV. HISTOGRAMWATERMARK EMBEDDING ALGORITHM

Step 1: Read the image file, get the data matrix of original image I(i, j), i = 1: M, j = 1: N, Mand N respectivelystand for the row and column of host image .

Step 2: Apply Butterworth low pass filter to extract low frequency component of image (I_{low}).

$$I_{low}(u, v)=I(u, v)* H(u, v) \qquad (4)$$

Where

$$H(u, v) = 1 / [1 + D(u, v) / Do]^{\wedge}(2*n)$$

is butter-worth filter[11] and in this paper, Do is set to 40 and order is 1. I(u, v) represents image in transform domain , I_{low} (u, v) is low frequency component of image in transform domain. After applying Butterworth low pass filter, test images are shown in Fig. 3.

Step 3: Construct the histogram of low frequency component of image

$$H_{low}(k)=h_{low}(k) ,k=0,1\ldots\ldots L \qquad (5)$$

Denotes number of pixels of intensity value k

Step 4: Select the groups whose number of pixels is greater than T_a. Denote these number of groups as S and choose Lgroups with most number of pixels out of Sfor watermarkembedding.

Step 5: The watermark W is a key-based PN sequence of length L is embedded by maintaining histogram shape (ratio between numbers of pixels of two bins). It is represented as W= {w(i)|*i*= 0, 1, . . . , L}

$$b1/b2 >= T_c \text{ if } w(i)=1$$
$$b2/b1>=T_c \text{ if } w(i)=0 \qquad (6)$$

Watermark embedding is done in the low frequency component of image and get the low frequency component of watermarked image (I^w_{low}).

Step 6: Watermarked image is obtainedby merging high frequency component of image (I_{high}) and low frequency component of watermark image (I^w_{low})[15].

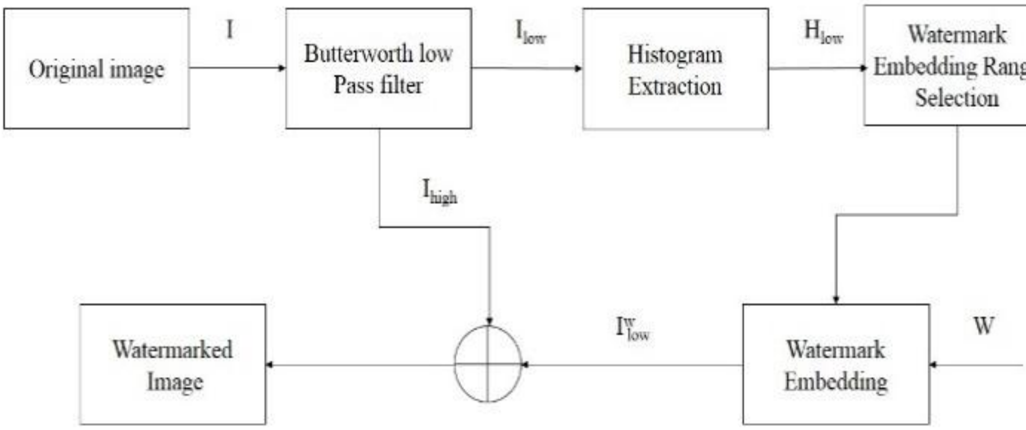
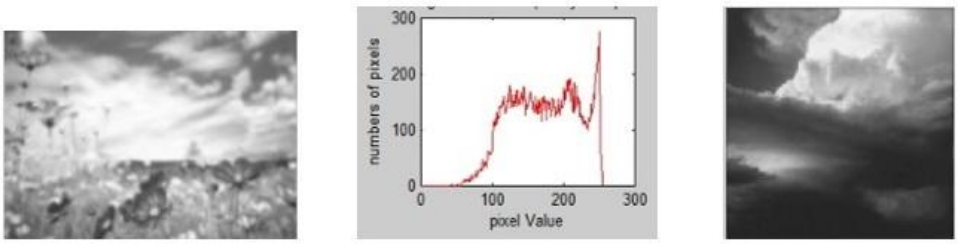


Fig 1. Block Diagram of Watermark Embedding Process[15]

Fig.2(a) Original Scene **Fig.2(b) Original Image** **Fig.2(c) Original Flower**



(a)Filtered Scene (b) Histogram of Filtered Scene (c) Filtered Image

(d) Histogram of filtered Image (e)Filtered Flower (F) Histogram Of Filtered Flower

Fig.3. FilteredFlower, Scene& Image and their Histogram

V. WATERMARK EMBEDDING PROCESS

The watermark embedding process of the proposed method Consist of four steps: Butter-worth filtering, histogram construction, embedding range selection, and histogram based watermark embedding.

A. Embedding Range Selection

In this phase, location is extracted of adding watermark. For this firstly the host image I is passed through a Butterworth low pass filter to extract its low-frequency component I_{low}. Then the histogram $H_{low}$of I_{low}will be extracted, which can be expressed as

$$H_{low} = \{h_{low}(k) \mid k=0,1,\ldots.255\} \qquad (7)$$

Where $h_{low(k)}$ represents the number of pixels in I_{low}whose pixel values are k. Combine the neighboring two gray levels in H_{low}as one bin. Two adjacent bins constitutes a group. Number of pixels in the kth group is denoted as N_{dk}. Range for watermark embedding is based on number of pixels in group and T_a. T_a is predefined threshold that controls robustness, quality and embedding rate whose value in this paper is set to 0.008*M*N. Scan all groups of D vector , choose the groups that satisfy predefined threshold . If $N_{dk}$is greater than a pre-defined threshold T_a, then the kth group will be selected for watermark embedding, otherwise drop the kth group .In this way, candidatures are choosed for watermarking. Selected groups are Sand the length of the watermark as L, where L ≤ S. Choose L groups with most number of pixels out of Sfor watermarkembedding and leave the rest groups. So, watermark embedding range selection is completed by accompanying this step.

In order to correctly extract watermark at receiving site, safe band is introduced between chosen watermarked groups and non-watermarked groups. Safe band is implemented by shifting the numbers of pixels from selected non-watermarked groups to nearest watermark groups. If number of pixels in non-watermark group (N) is greater than T_b then $N\text{-}T_b$ pixels are randomly shifted in such way it is no longer belong to this group in terms of intensity. This value controls robustness and visual quality. By increasing T_b robustness is increased, but visual quality degrades. So, T_b is 0.004*M*N is set.

B. Watermark Embeddi

After the embedding range is selected, watermark embedding is done by shifting number of pixels within group from one bin to another if certain criteria is not fulfilled. To achieve this, firstly ratio of number of pixel of consecutive bins of that group is calculated. Denote the numbers of pixels in bin1 and bin2 as b1 and b2respectively. The watermark W is a key-based PN sequence which is represented as:

$$W= \{w(i)|i= 0, 1, . . . , L\} \qquad (8)$$

Choosing of PN sequence is that, it offered a good synchronization capability due to its correlation property. Theauto-correlation value of one sequence is large while cross-correlation value between two different sequences is very low. Regeneration capability at detector side is good[12]. The number of watermarking data bits should be less than the number of groups of the histogram as one group carry one watermark bit. The watermark is detected without knowledge of original images by sharing the private key in the detector. The private key is shared with the detector during the decision-making for presence of the watermark as used in [11]

The embedding rule for the ith watermark bit is computed as:

w(i) ==1

If b1/b2 >= Tc then no operation required

Else randomly select N_{w1} pixels and assign the pixels from bin2 to bin1 is assign in such a way that intensity value of N_{w1} pixels of bin2 is modified to intensity value of bin1. By doing this ratio is no longer remain less than Tc. where Tcis a pre-defined threshold balancing the robustness and perceptual quality. In this paper Tc is set to 2.

w(i)==0

If b2/b1 >= Tc then no operation required

Else randomly select N_{w0} pixels and assign the pixels from bin1 to bin2 in such way that intensity value of N_{w0} pixel of bin1 is altered to intensity value of bin2 and histogram of image in regards to bin is changed but not to group. N_{w0} and N_{w1} is computed as:

$$N_{w1}=Tc.b1-b2/1+Tc$$

$$N_{w0}=Tc.b2-b1/1+Tc$$

By doing so, all L bits of watermark are embedded and low-frequency component of the watermarked image (I^{w}_{low}) is obtained. Each selected group carry one watermark bit.I^{w}_{low} and the high-frequency component of I (I_{high}= I-I_{low})are merged and got thewatermarked image. The High frequency component of the original Scene,Image& Flower in Fig.4

Fig 4.High Frequency Component of Scene, Image &Flower

VI. HISTOGRAM WATERMARK EXTRACTION ALGORITHM

Step 1: After reading the watermarked image file I` , get a data matrix I`(i, j), i = 1: M, j = 1: N, M and Nstand for the row and column of host image.

Step 2: Apply Butterworth low pass filter to extract low frequency component of watermarked image ($I`_{low}$)

Step 3: Construct histogram of detected low frequency component of watermarked image

$H`_{low}$ (k)=$h`_{low}$ *(k)* ,k=0,1……..L

Denotes number of pixels of intensity value k

Divide the histogram bins as groups, each group consist of two adjacent bins (bin1 and bin2) and their population is b1` and b2` respectively.

Step 4: Watermark embedding range is done by selecting Lgroups with most number of pixels as watermarked groups.

Step 5: Watermark is detected by computing the ratio between b1` and b2` of each group, one inserted bit is extracted in reference to the following equation,

w`(i) = 1, if b1` / b2` ≥ 1

w`(i) = 0, otherwise

The process is repeated until all bits of watermark are extracted and the extracted watermark is represented as
W`= w`(i) | i=0,1,2…….L

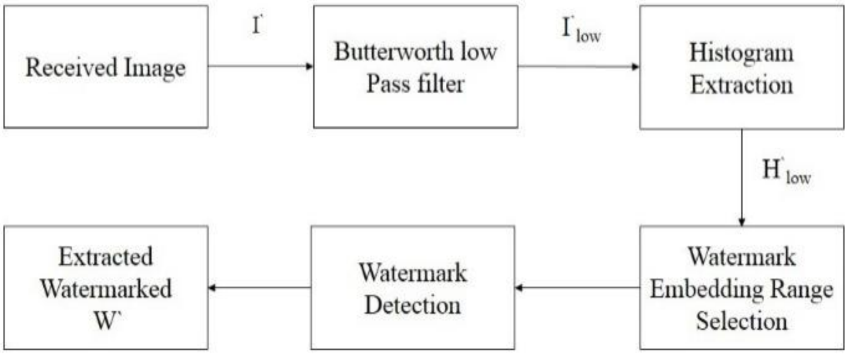


Fig.5. Block Diagram of Watermarking Extraction Process [15]

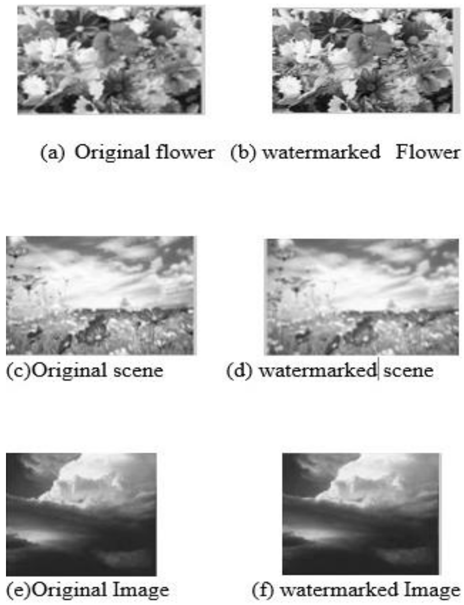


Fig 6. Flower, Scene & Image and their watermarked counterparts

VII. PERFORMANCE ANALYSIS

In order to evaluate the proposed watermarking method, Flower, Scene and image are taken as Test images shown in Fig.1. The perceptual quality of watermarked images is measured by PSNR (Peak Signal to Noise Ratio). In this, all images have PSNR of above 45 DB. As, PSNR of 40 dB indicates good perceptual quality[16]. Therefore, Quality of images is good.

In the proposed watermarking algorithm, watermark is only inserted in the low-frequency component, so the high-frequency component is not altered.

PSNR is defined as:

$PSNR=20*\log_{10}(Max/MSE)$

Where Max-maximum pixel value of the Image

MSE-mean squared error.

Table I Quality of the Proposed Method

PSNR (DB)	
Scene	50.0619
Flower	50.7432
Image	49.3076

From Fig.6. There is no any evidenced difference seenbetween the original images and the watermarked images, this point proves that this algorithm has better hidden property.

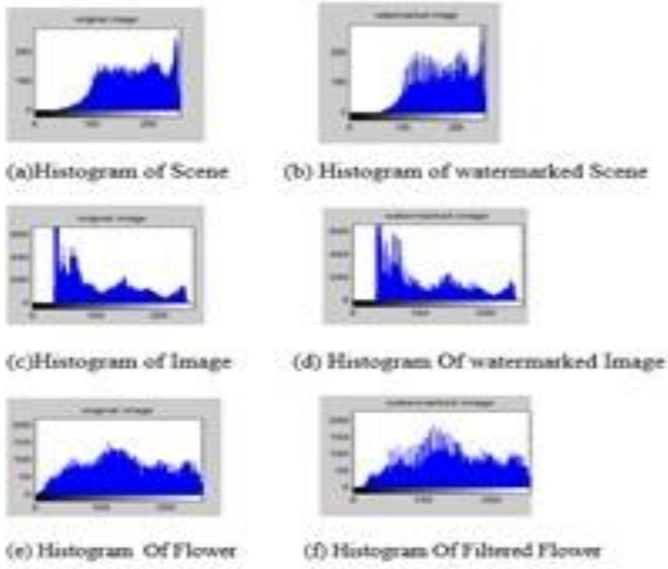


Fig7. Histogram of Original and Watermarked Test Images

From Fig.7, It is observed that the watermarked Images do not lose the original images information, but the difference observed is in the form of "interstices" between histograms of watermarked images and histogram of original image. Because watermark embedding introduces change only in adjacent bin. In other way, the number of samples of a certain bin is increased or decreased in relation to the original histogram.

VIII. CONCLUSION

This proposed robust image watermarking scheme by using the property of the histogram shape to be independent of the pixel location, mathematically invariant to the scaling. Embedding of watermark is done in low frequency component of Butterworth low pass filter. Watermark is extracted without knowledge of original image. The experimental result show that proposed algorithm achieve good quality which is tested by PSNR. The proposed algorithm is robust against different geometric attack rotation, scaling, translation etc. and got good results. It is tested against BER (Bit error rate) and in future research, consideration is to enhance the security of the watermarking scheme by using different cryptographic algorithms. It can be applied to pseudo color image processing.

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