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A Secure Semi-Fragile Watermarking Method for Image security Based on Wavelet Packet Decomposition and Singular Value Decomposition

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Abstract:
In this approach a secure semi fragile watermarking technique based on Wavelet Packet Decomposition and Singular Value Decomposition is proposed. We are using Haar DWT as mother wavelet. In this approach we first perform Haar DWT on the cover image to obtain LL, LH, HL and HH frequency sub-bands then we select LH and HL frequency sub-bands to obtain detail and approximation coefficient of cover image and watermark image. The watermark image is embedded into the original image using LH and HL frequency sub-bands. Singular Value Decomposition (SVD) is used to modify the singular values of the coefficient of cover image and watermark image. PNSR and similarity index are chosen to measure quality of this approach. Experiments are carried out with 512*512 and 256*256 image sizes. Experimental result shows that the proposed scheme is robust and secure. Moreover there is no visible difference between watermark image and extracted watermark.

I INTRODUCTION

1.1 What Is Digital Image Processing?

An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y, and the amplitude values of f are all finite, discrete quantities, we call the image a digital image. The field of digital image processing refers to processing digital images by means of a digital computer. Note that a digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements, peels, and pixels. Pixel is the term most widely used to denote the elements of a digital image. Vision is the most advanced of our senses, so it is not surprising that images play the single most important role in human perception. However, unlike humans, who are limited to the visual band of the Electro-magnetic (EM) spectrum, imaging machines cover almost the entire EM spectrum, ranging from gamma to radio waves. They can operate on images generated by sources that humans are not accustomed to associating with images. These include ultra-sound, electron microscopy, and computer-generated images. Thus, digital image processing encompasses a wide and varied field of applications. There is no general agreement among authors regarding where image processing stops and other related areas, such as image analysis and computer vision, start. Sometimes a distinction is made by defining image processing as a discipline in which both the input and output of a process are images. We believe this to be a limiting and somewhat artificial boundary. For example, under this definition, even the trivial task of computing the average intensity of an image (which yields a single number) would not be considered an image processing operation.

On the other hand, there are fields such as computer vision whose ultimate goal is to use computers to emulate human vision, including learning and being able to make inferences and take actions based on

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visual inputs. This area itself is a branch of artificial intelligence (AI) whose objective is to emulate human intelligence. The field of AI is in its earliest stages of infancy in terms of development, with progress having been much slower than originally anticipated. The area of image analysis (also called image understanding) is in between image processing and computer vision. There are no clear-cut boundaries in the continuum from image processing at one end to computer vision at the other. However, one useful paradigm is to consider three types of computerized processes in this continuum: low-, mid-, and high-level processes. Low level processes involve primitive operations such as image preprocessing to reduce noise, contrast enhancement, and image sharpening. A low-level process is characterized by the fact that both its inputs and outputs are images. Mid-level processing on images involves tasks such as segmentation (partitioning an image into regions or objects), description of those objects to reduce them to a form suitable for computer processing, and classification (recognition) of individual objects.

1.2 Components of an Image Processing System

As recently as the mid-1980s, numerous models of image processing systems being sold throughout the world were rather substantial peripheral devices that attached to equally substantial host computers. Late in the 1980s and early in the 1990s, the market shifted to image processing hardware in the form of single boards designed to be compatible with industry and hard buses and to fit into engineering workstation cabinets and personal computers. In addition to lowering costs, this market shift also served as a catalyst for a significant number of new companies whose specialty is the development of software written specifically for image processing. Although large-scale image processing systems still are being sold for massive imaging applications, such as processing of satellite images, the trend continues toward miniaturizing and blending of general-purpose small computers with specialized image processing hardware.

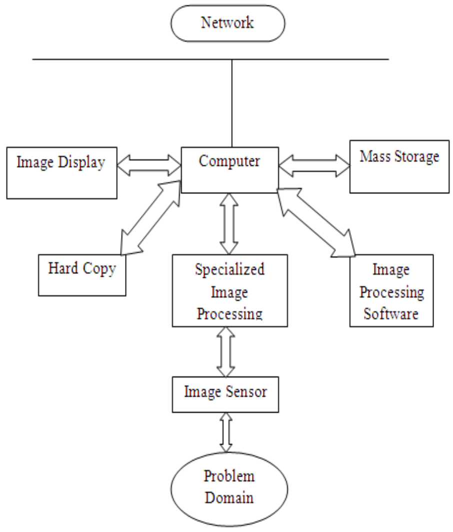

Fig 1.2.1 Basic Component Of Image Processing

Figure shows the basic components comprising a typical general purpose system used for digital image processing. The function of each component is discussed in the following paragraphs, starting with image sensing. With reference to sensing, two elements are required to acquire digital images. The first is a physical device that is sensitive to the energy radiated by the object we wish to image. The second, called a digitizer, is a device for converting the output of the physical sensing device into digital form. For instance, in a digital video camera, the sensors produce an electrical output proportional to light intensity. The digitizer converts these outputs to digital data. Specialized image processing hardware usually consists of the digitizer just mentioned, plus hardware that performs other primitive operations, such as an arithmetic logic unit (ALU), which performs arithmetic and logical operations in parallel on entire images. One example of how an ALU is used is in averaging images as quickly as they are digitized, for the purpose of noise reduction. This type of hardware sometimes is called a front-end subsystem, and its most distinguishing characteristic is speed. In other words, this unit performs functions that require fast data throughputs (e.g., digitizing and averaging video images at 30 frames) that the typical main computer cannot handle

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1.3 Image representation and its properties

We will use two principal ways to represent digital images. Assume that an image (x, y) is sampled so that the resulting digital image has M rows and N columns. The values of the coordinates (x, y) now become discrete quantities. For notational clarity and convenience, we shall use integer values for these discrete coordinates. Thus, the values of the coordinates at the origin are (x, y) = (0, 0). The next coordinate values along the first row of the image are represented as (x, y) = (0, 1). It is important to keep in mind that the notation (0, 1) is used to signify the second sample along the first row. It does not mean that these are the actual values of physical coordinates when the image was sampled. Figure shows the coordinate convention used.

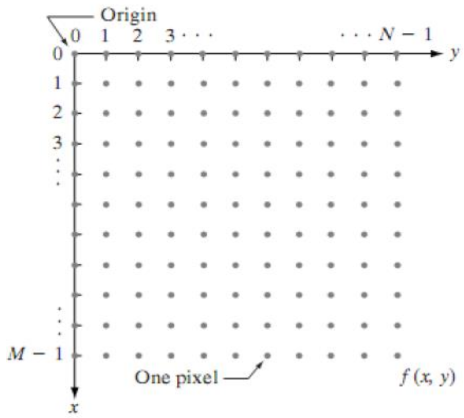

Fig 1.3.1 Image Representation

The notation introduced in the preceding paragraph allows us to write the complete M*N digital image in the following compact matrix form:

$$F(x, y) = \begin{bmatrix} F(0,0) & F(0,1) & \ldots\ldots & F(0, N\text{-}1) \\ F(1,0) & F(1,1) & \ldots\ldots & F(1, N\text{-}1) \\ F(M\text{-}1, 0) & F(M\text{-}1, 1) & \ldots\ldots & F(M\text{-}1, N\text{-}1) \end{bmatrix}$$

The right side of this equation is by definition a digital image. Each element of this matrix array is called an image element, picture element, pixel, or pixel

Geometric Transform:

Geometric image transformation functions use mathematical transformations to crop, pad, scale, rotate, transpose or otherwise alter an image array to produce a modified view of an image. The transformations described in this chapter are linear transformations. For a description of non-linear geometric transformations, When an image undergoes a geometric transformation, some or all of the pixels within the source image are relocated from their original spatial coordinates to a new position in the output image. When a relocated pixel does not map directly onto the centre of a pixel location, but falls somewhere in between the centers of pixel locations, the pixel's value is computed by sampling the values of the neighboring pixels. This resampling, also known as interpolation, affects the quality of the output image.

Cropping Images:

Cropping an image extracts a rectangular region of interest from the original image. This focuses the viewer's attention on a specific portion of the image and discards areas of the image that contain less useful information. Using image cropping in conjunction with image magnification allows you to zoom in on a specific portion of the image. This section describes how to exactly define the portion of the image you wish to extract to create a cropped image

Padding Images:

Image padding introduces new pixels around the edges of an image. The border provides space for annotations or acts as a boundary when using advanced filtering techniques. This exercise adds a 10-pixel border to left, right and bottom of the image and a 30-pixel border at the top allowing space for annotation. The diagonal lines in the following image represent the area that will be added to the original image. For an example of padding an image, complete the following steps.

Rotating Images:

The rotation operator performs a geometric transform which maps the position(x1, y1) of a picture element in an input image onto a position (x1,y1) in an output

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image by rotating it through a user-specified angle θ about an origin O . In most implementations, output locations (x2, y2) which are outside the boundary of the image are ignored. Rotation is most commonly used to improve the visual appearance of an image, although it can be useful as a pre-processor in applications where directional operators are involved.

Reflecting Images:

The reflection operator geometrically transforms an image such that image elements, i.e. pixel values, located at position (x1,y1) in an original image are reflected about a user-specified image axis or image point into a new position (x2,y2) in a corresponding output image. Reflection is mainly used as an aid to image visualization, but may be used as a pre-processing operator in much the same way as rotation.

II PROBLEM FORMULATION AND SOLUTION

2.1 Problem Statement

Security and capacity of watermark data are very important issues to be considered. A lot of research is going on to increase security and capacity. In this approach we are giving a new image watermarking method. This method increases the security and capacity of semi-fragile watermark. To increase capacity we are using wavelet transform with particle swarm optimization with provides high security and robustness. It is a blind watermarking method. Means original image is not required at the time of watermark recovery.

2.2 Justification Of Problem Statement

There are many watermarking techniques in spatial domain which embed one watermark in cover image. But, there exist very less no of technique for watermark in frequency or wavelet domain. Wavelet provide good security with robustness though working with wavelets is a complex process as compare to spatial domain method but security provided by wavelet transforms are far more greater than spatial domain methods (like DCT). So the problem we are trying to solve is not previously solved.

2.3 Why it is Worthwhile to Solve this Problem?

Watermarking is not a fully mature technology; lot of research is going on in this field, especially to increase security and capacity of watermark data. Most of researchers try to increase the watermark capacity by compromising image quality, because there is a tradeoff among data rate, security and imperceptibility. But with this approach we will be able to recover original cover image and watermark image without affecting the imperceptibility of the cover image.

So, it is worth to solve this problem, because by solving it we will get a watermarking technique that will increase the security of watermarks and will be capable of providing good compression ratio.

2.4 Problem Solution

In this approach we are giving a new image watermarking method. This method increases the security and capacity of semi-fragile watermark. To increase capacity the concept of wavelet is used. We are using Haar as a mother wavelet to perform wavelet packet decomposition and singular valued decomposition for matching the RGB components of original image to watermark image. It is a blind watermarking method. Spatial domain techniques are less robust, But robustness is much more important issue to be consider for watermark, because both unintentional and malicious attacks can alter the final watermarked image, which directly affect the security of watermark. So for embedding we used technique based on Haar Wavelet Transform, which is very robust against attacks.

2.4.1 Singular Value Decomposition (SVD)

SVD is a mathematical tool which decomposed a matrix into 3 matrices. Let A be an image of size M×N, then the SVD of A is given by A=USVT, where U and V are the orthogonal matrices. S is a diagonal matrix. The columns of U and V are known as left singular vector and right singular vector of A respectively and represents the geometrical properties of the image. The elements of S are known as singular values of A and are arranged in decreasing order. The elements of S show the brightness of the image A. The

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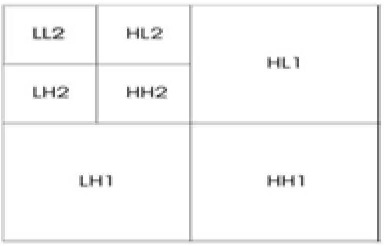
principal component can be found by multiplying U and S of the image. Most of the watermarking schemes use the concept of SVD because of two important properties, i.e. (a) Singular values do not change rapidly with the addition of small perturbation to the image. (b) Singular values represent algebraic image properties.

2.4.2 Wavelet Packet Decomposition (WPD)

Wavelet packet decomposition sometimes called wavelet packets. In wavelet packet decomposition signals is transited through more filters as compared to DWT. Wavelet packets form bases and are linear combination of wavelets. The bases keep the property of their parent wavelet like orthogonality, smoothness etc. A recursive algorithm is used to calculate the coefficient of linear combination. Each newly calculated coefficient form its own root of analysis tree. Wavelet packet decomposition decomposes both the coefficient i.e. detail and approximation coefficient. Wavelet packet decomposition will produce 2 coefficients for n level decomposition.



L - Low Frequency Sub bands
H- High Frequency Sub bands
1, 2 – Decomposition Levels

Fig.3.4.2.1 Wavelet transformation on images

2.4.3 Watermarking Embedding Algorithm

1. On the cover image perform 1-level Haar Discrete Wavelet Transform which will divide the cover image 'C' into four frequency band i.e. LL, LH, HL & HH.
2. Now, on LH and HL sub-bands perform Singular Value Decomposition i.e.

$$C_i = U_i S_i V_{iT} \quad , \quad i = 1, 2$$

3. Apply Haar Discrete Wavelet Transform on the watermark image which will decompose the watermark image into LL, LH, HL & HH.
4. Now, taking LH & HL decomposed part of watermark image.

$$W = W_1 + W_2$$

5. Singular values in HL and LH frequency sub-bands are modified by taking half of watermark image and then applying SVD to them i.e.

$$S_i + x{*}W_i = U_{iw} S_{iw} V_{iTw}$$

6. Now, to obtain modified DWT coefficient i.e. modified detailed coefficient and approximation coefficient of the cover image apply the given method i.e.

$$C_{*i} = U_i S_{iw} V_{iT} \quad , \quad i=1, 2$$

7. Now, perform inverse DWT and obtain watermarked image CW with the help of two modified DWT coefficient i.e. LH and HL and two unmodified DWT coefficient i.e. LL and HH.

2.4.4 Watermarking Extraction Algorithm

1. On the watermarked image C * W perform one-level Haar Discrete Wavelet Transform to obtain 4 sub-bands (i.e. LL, LH, HL and HH).
2. Now, on LH and HL sub-bands perform singular value decomposition i.e.

$$C_{*iw} = U_{*i} S_{*iw} V_{*iT} \quad , \quad i = 1, 2$$

3. Compute, $E_{*i} = U_{iw} S_{*iw} V_{iTw} \quad , \quad i = 1, 2$
4. Now from each sub-band extract half of the watermark image i.e.

$$W_{*i} = (E_{*i} - S_i) / x \quad , \quad i = 1, 2$$

5. To obtain the embedded watermark combine the result of step 4.

$$W_* = W_{*1} + W_{*2}$$

III RELATED WORK

3.1 Review of Related Work

1. Ahmed A.Mohammad [1]. In this paper, a new SVD-based digital watermarking scheme for ownership protection is proposed. The proposed algorithm solves the problem of false-positive detection. In addition, it enjoys all the advantages of SVD-based schemes. Instead of using a randomly generated Gaussian sequence, a meaningful text

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message is used. Thus, clarity of the extracted message determines the performance of the algorithm. Analytical and experimental developments show that the proposed algorithm is robust and secure. Comparisons with other algorithms indicate that the proposed algorithm is robust against most common attacks. In particular, the algorithm proved to be extremely robust against geometrical distortion attacks.

2. Balakrishnan Prabhakaran [2].For building generic copyright schemes for 3-D models, this paper presents a robust blind watermarking mechanism for 3-D point-sampled geometry. The basic idea is to find a cluster tree from clusters of 3-D points. Using the cluster tree, watermarks can be embedded and extracted by deriving an order among points at global (intra-cluster) and local levels (inter-cluster).

3. Bai Ying Lei [3].Singular value decomposition (SVD) is a new and important transform technique in robust digital watermarking due to its different properties from the traditional trans- forms such as Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). In this paper, blind and robust audio watermarking scheme based on SVD–DCT with the synchronization code technique is proposed. This technique embeds a binary watermark into the high-frequency band of the SVD–DCT block blindly. Chaotic sequence is adopted as the synchronization code and inserted into the host signal. Experimental results show that the proposed watermarking method is comparable to, if not, better than SVD based method and several selected typical audio watermarking methods, even in the presence of various common signal processing attacks.

4. Balasubramanian Raman [4]. In this paper, a discrete cosine transform based copyright protection scheme that does not require the original image for logo verification is proposed. Features of logistic map and discrete cosine transform are used to generate the verification map. Digital signature and timestamp are used to make copyright proving publicly verifiable. A combined cryptographic tools and digital watermarking, in order to enhance the security and reliability of copyright protection is proposed. In addition, chaotic map is used to generate a chaotic pattern image, which can be used as secret key to improve the security of proposed algorithm.

IV EXPERIMENTAL RESULTS

4.1 Experimental Results

In our experimental results three images of different sizes are used as cover images. These Images are shown below. We measure the quality of watermarked images in terms of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error). In ideal case PSNR should be infinite and MSE should be zero. But it is not possible for watermarked image. So, large PSNR and small MSE is desirable. To see that if the recovered watermark is identical to the one that is embedded we calculate only MSE. In this case it should be zero.

4.1.1 Watermark Embedding and Extraction Results

First we will see watermark embedding with three different image sizes. For this we are taking 512 * 512, 256 * 256 pixel size image. We will see the results in the below figures.

Watermark Embedding In Image Size 512 * 512

Fig 4.1.1 Original Host Image of Size 512*512

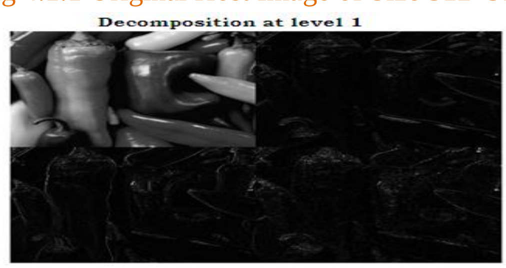

Fig 4.1.2 One-Level Decomposition of Original Image Using Haar DWT

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Fig 4.1.3 Watermark Image

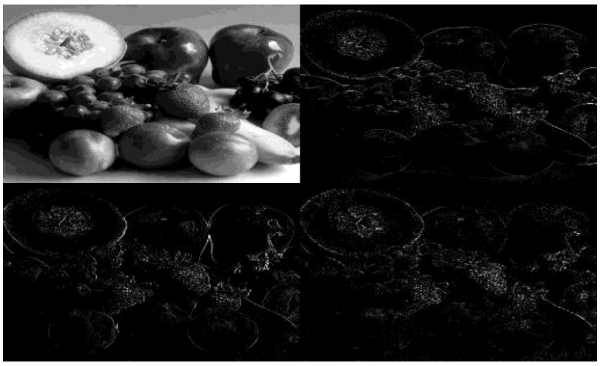

Fig 4.1.4 One-Level Decomposition of Watermark Image Using Haar DWT

Fig 4.1.8 Watermark Image

Fig 4.1.5 Watermarked Image

Watermark Extraction In Image Size 512 * 512

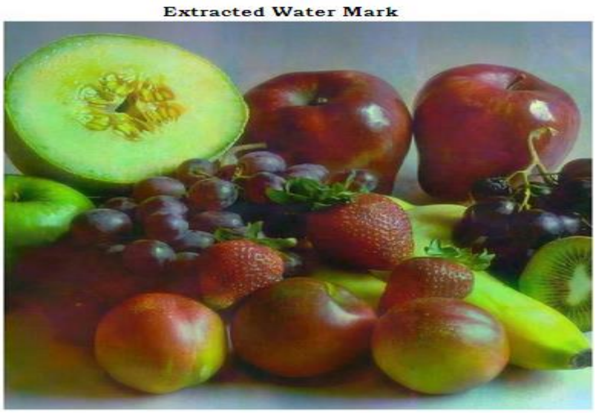

Fig 4.1.6 Extracted Watermark

Watermark Embedding In Image Size 256 * 256

Fig 4.1.7 Original Image Of Size 256 * 256

Fig 4.1.9 One-Level Decomposition of Original Image Using Haar DWT

Fig 4.1.10 One-Level Decomposition of Watermark Image Using Haar DWT

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Fig 4.1.11 Watermarked Image

Watermark Extraction In Image Size 256 * 256

Fig 4.1.12 Extracted Watermark

The below figure shows Peak Noise to Signal Ratio and Mean Square Error calculation results for watermark image and extracted watermark image.

Cover Image	Watermark	PNSR	MSE
Lena (512*512)	Flower (512*512)	18.5621	0.146
Vegetables (512*512)	Fruits (512*512)	18.5323	0.187
Cameraman (256*256)	Flag (256*256)	22.7092	0.281

Table No 4.1.1 PNSR and MSE calculation results

V. APPLICATION OF THE WORK

Watermarking is not a fully mature technology; lot of research is going on in this field, especially to increase security and capacity of watermark data. Most of researchers try to increase the watermark capacity by compromising image quality, because there is a tradeoff among data rate, security and imperceptibility. But with our scheme we will be able to recover original cover image and watermark image without affecting the imperceptibility of the cover image.

The proposed scheme is applicable to digital images. This approach provides increased security for semi-fragile watermark moreover the watermark is imperceptible, so no one can detect the presence of watermark. This approach provides high security as this is based on frequency domain method. In this approach we had applied this technique only to images of different size. This technique can be applied to audio and video with required modification. This scheme can be applied to:

- Forensic Research
- Military Forces
- Ownership Assertion
- Copy Prevention or Control
- Intelligence Bureau
- Industrial Area

Personal Use (if we want to send some secret image)

VI CONCLUSION AND FUTURE WORK

6.1 Conclusion

This approach presents a blind watermarking technique that uses frequency domain method i.e. Haar discrete wavelet Transform for decomposition (at level 1) with Singular value decomposition. For embedding watermark in Cover Image we used Haar DWT based technique and then for modifying the DWT coefficient value we use Singular Value Decomposition. As a test of the embedding, Peak noise to signal rations (PSNR) and similarity degree are chosen as detection indexes.

This algorithm provides high degree of similarity because there is no visible difference between watermark image and extracted watermark, but technically we could not recover exact watermark image because it is not possible. This is a blind watermarking technique so original image is not required at the time of watermark recovery. This algorithm provides good robustness. Though frequency domain methods are complex as compared to spatial domain method but they provide good robustness. This algorithm can be further applied to audio and video technology.

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6.2 Future Scope

Watermarking is an emerging research area for copyright protection and authentication of electronic documents and media. Most of the research is going on in this field, especially in the field of image watermarking. The reason might be that there are so many images available at Internet without any cost, which needs to be protected. The watermarking technique that is given in this thesis can be further improved to increase the hiding capacity of images without affecting the imperceptibility of the images. Moreover our technique can be enhanced by providing cryptographic technique so that increased security can be provided to watermark images.

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