Survey of Watermarking Algorithms For Medical Images

A.Umaamaheshvari#1, K.Thanuskodi*2

#Dept of ECE, SSEC, ANNA University
INDIA

2*Director
ACET,INDIA

Abstract— **Watermarking is a branch of information hiding which is used to hide proprietary information in digital media like photographs, digital music, or digital video. And also which has seen a lot of research interest recently. The Medical images are also much important in the field of medicine ,all these medical images are need to be stored for future reference of the patients and their hospital findings hence, the medical image need to undergo the process of compression before storing it. In this paper we present a detailed survey of different existing watermarking algorithms and techniques for medical images. We classify the techniques based on different domains in which data is embedded and to be extracted. Here we limit the survey to medical images only.**

Key words:—Watermarking, Embedding, Extraction, FFT, DWT and Medical images.

I. INTRODUCTION

Digital watermarking is the process of embedding information into a digital signal which may be used to verify its authenticity or the identity of its owners, in the same manner as paper bearing a watermark for visible identification [1]. In digital watermarking, the signal may be audio, pictures, or video. If the signal is copied, then the information also is carried in the copy. A signal may carry several different watermarks at the same time.

In visible digital watermarking, the information is visible in the picture or video. Typically, the information is text or a logo, which identifies the owner of the media. The image on the right has a visible watermark. When a television broadcaster adds its logo to the corner of transmitted video, this also is a visible watermark.

In invisible digital watermarking, information is added as digital data to audio, picture, or video, but it cannot be perceived as such (although it may be possible to detect that some amount of information is hidden in the signal). The watermark may be intended for widespread use and thus, is made easy to retrieve or, it may be a form of steganography, where a party communicates a secret message embedded in the digital signal. In either case, as in visible watermarking, the objective is to attach ownership or other descriptive information to the signal in a way that is difficult to remove [2]. It also is possible to use hidden embedded information as a means of covert communication between individuals.

One application of watermarking is in copyright protection systems, which are intended to prevent or deter unauthorized copying of digital media. In this use, a copy device retrieves the watermark from the signal before making a copy; the device makes a decision whether to copy or not, depending on the contents of the watermark. Another application is in source tracing [3]. A watermark is embedded into a digital signal at each point of distribution. If a copy of the work is found later, then the watermark may be retrieved from the copy and the source of the distribution is known. This technique reportedly has been used to detect the source of illegally copied movies. Annotation of digital photographs with descriptive information is another application of invisible watermarking. While some file formats for digital media may contain additional information called metadata, digital watermarking is distinctive in that the data is carried right in the signal.

The information to be embedded in a signal is called a digital watermark, although in some contexts the phrase digital watermark means the difference between the watermarked signal and the cover signal. The signal where the watermark is to be embedded is called the host signal. In digital watermarking life-cycle phases, a watermarking system is usually divided into three distinct steps, embedding, attack, and detection. In embedding, an algorithm accepts the host and the data to be embedded, and produces a watermarked signal[4].

Then the watermarked digital signal is transmitted or stored, usually transmitted to another person. If this person makes a modification, this is called an attack. While the modification may not be malicious, the term attack arises from copyright protection application, where pirates attempt to remove the digital watermark through modification. There are many possible modifications, for example, lossy compression of the data (in which resolution is diminished), cropping an image or video, or intentionally adding noise.

Detection (often called extraction) is an algorithm which is applied to the attacked signal to attempt to extract the watermark from it. If the signal was unmodified during transmission, then the watermark still is present and it may be extracted. In robust digital watermarking applications, the extraction algorithm should be able to produce the watermark correctly, even if the modifications were strong. In fragile digital watermarking, the extraction algorithm should fail if any change is made to the signal.

II. WATERMARKING ALGORITHMS

A. Need for Watermarking

We enunciate the need for watermarking database relations to deter data piracy, identify the characteristics of relational data that pose unique challenges for watermarking, and delineate desirable properties of a watermarking system for relational data. We then present an effective watermarking technique geared for relational data. This technique ensures that some bit positions of some of the attributes of some of the tuples contain specific values. The specific bit locations and values are algorithmically determined under the control of a secret key known only to the owner of the data. This bitcpattern constitutes the watermark [5],[6]. There are several benefits to watermarking photos, including:

- Discourage thieves. It makes it very difficult for somebody to take credit for your work when your name is plastered across a photo, hopefully discouraging them from even attempting to try.
- Copyright. Although you don't need a watermark on your image for it to be copyrighted, doing so will remind people who the photo belongs to.
- Free advertising. Having your information on your photos will help you get recognized. If somebody loves your photo, perhaps would like a copy, they know who you are.
- Sense of satisfaction. It is so easy to share, copy, and save anything that is published on the Internet. As well, photo sharing websites are as popular as ever. If you plan to post your photos on the Internet, having a watermark on it will give you a sense of satisfaction when you see your photo published for the world to see, branding your name.

B. The watermarking algorithms

In this survey we are evaluating and studying the following algorithms for watermarking of medical images, which are very are very useful for doing research in the area of watermarking.

- A Block-Based Watermarking Method
- A Feature-Based Watermarking Method
- A Watermarking technique based on spectrum analysis and pseudorandom sequences
- A Steerable pyramid transform Based Watermarking Method
- A Discrete Fourier transform–based watermarking method
- A Discrete Wavelet transform based watermarking

The rest of this paper is organized as follows. A brief review of the Block-Based Watermarking Method is given in Section III. In Section IV, Feature-Based Watermarking is constructed. Section V details the Watermarking technique based on spectrum analysis and pseudorandom sequences with embedding and detection. Section VI explains the transform domain watermarking algorithms such as Steerable pyramid transform, Wavelet transform and Discrete Fourier transform. Section VII concludes this survey.

III. A BLOCK-BASED WATERMARKING METHOD

In this block-based method, a blind watermarking method based on discrete wavelet transform (DWT) using maximum wavelet coefficient quantization is proposed. The wavelet coefficients are grouped into different block size with each block being randomly selected from different subbands. The watermark is embedded in the local maximum coefficient which can effectively resist attacks. A host image of size I_W by I_H is transformed into wavelet coefficients using the *L*-level discrete wavelet transform (DWT). With L-level decomposition, we have 3×*L*+1 subbands. According to the characteristics of this scan order, we embed the watermark bits into the LH_L and HL_L subbands [7].

A. Watermark Embedding

A binary watermark *W* of size *Nw* (<= *BlocksN*) bits will be embedded. We represent each watermark bit as 1 or 0. Now, we use a pseudorandom function to shuffle *Nw* bits, with different seeds. According to the watermark bits embedded later, we select *Nw* non-overlapping blocks from *BlockQue* and compute the average local maximum coefficient of all *Nw* blocks using Equation

$$Mean_{embed} = \frac{1}{N_w}\sum_{i=1}^{N_w} M_i$$

Where

$$M_i = \begin{cases} max_i, \text{if } i^{\text{th}} \text{ watermark bit is 1,} \\ max_i \times T_1, \text{ otherwise.} \end{cases} \quad \text{--- (1)}$$

$Mean_{embed}$ denotes the average value of the local maximum wavelet coefficients in all *Nw* blocks; *maxi* is the local maximum wavelet coefficient of the *i*th block. The value of $max_i \times T1$ will be explained later

Hence we compute the average coefficient value *avgi* of the *i*th block excluding the local maximum wavelet coefficient *maxi*. The later value will be referred to in order to quantize the local maximum wavelet coefficient. Hence we quantize max*i* with a reference value αi which is represented as

$$\alpha_i = Maximum\left\{ |avg_i|, \left|Mean_{embed} \times T_q\right| \right\} \quad \text{--- (2)}$$

Finally, if a block is embedded with a watermark bit whose value is 1, the max*i* is quantized as

$$max_i^{new} = max_i + \alpha_i$$

Where

$$\alpha_i = max_i \times (1 - T_1) \quad \text{----- (3)}$$

$$max_i^{new} = max_i \times T_1 \quad \text{----- (4)}$$

B. Watermark Extraction

$$\alpha_i' = Maximum\{ |avg_i'|, |Mean_{block}| + \sigma_1 + \sigma_2 \} \quad \text{----- (5)}$$

The watermark can be obtained by

$$watermark\ bit = \begin{cases} 1, & if\ (max_i' - \alpha_i') \geq sec_i' \\ 0, & otherwise. \end{cases} \quad \text{----- (6)}$$

Then the block is embedded with a watermark bit 1. Otherwise, the block is embedded with a watermark bit 0 [7]. By using the above 5, 6 equations on the remaining N_w-1 blocks, the watermark image can be extracted. This method proposes a blind watermarking algorithm based on maximum wavelet coefficient quantization for copyright protection. In order to achieve the secrecy of embedding watermark, we use variable blocks size and embed a watermark bit using different subbands which are selected randomly from two subbands.

IV. A FEATURE-BASED WATERMARKING METHOD

This method presents a robust digital image watermarking scheme using feature point detection and watermark template match. A scale interactive model based filter is used to extract the feature points of original image, based on which a watermark template is constructed and embedded adaptively into the local region of these points. Watermark decision is made by computing the statistical correlation between the watermark and the embedded region. Because the proposed feature detection is robust against JPEG compression, filtering, noise addition and geometric distortions, the proposed watermarking scheme can achieve good performance against these attacks [8].

A. Watermark Embedding

For the proposed watermark embedding, as a whole, each payload watermark element in W is embedded in the local region of the corresponding feature point in the original image. The proposed procedure is shown in Fig. 1 and can be described in detail as follows. Suppose that the watermark element $W(\vec{x})$ is embedded into the local region of the feature point $\vec{x}$. Firstly, in order to achieve local content dependent watermark embedding, the noise visibility function (NVF) proposed is used to improve the robustness and imperceptibility, which is defined by

$$\alpha(\vec{x}) = 1 - \frac{1}{1 + \theta\sigma_l^2(\vec{x})} \quad \text{----- (7)}$$

where $\sigma_l^2(\vec{x})$ is an unbiased estimation of the local variance over a square window with width l centered at $\vec{x}$, and

$$\theta = \frac{D}{\max_{(\vec{x})} \sigma_l^2(\vec{x})} \quad \text{----- (8)}$$

where $\max_{(\vec{x})}\sigma_l^2(\vec{x})$ is the maximum local variance. Finally, the watermark element $W(\vec{x})$ is embedded in the host image as

$$I_w(\vec{x}+\vec{r}) = I(\vec{x}+\vec{r}) + \alpha(\vec{x}+\vec{r})W(\vec{x}+\vec{r}) \quad \text{----- (9)}$$

Where r is a coordinate parameter which iterates over the square window region with width 3 centered. Once each watermark element is embedded into the neighborhood region of the corresponding feature point as the same manner described above, the watermarked image Iw is obtained [8].

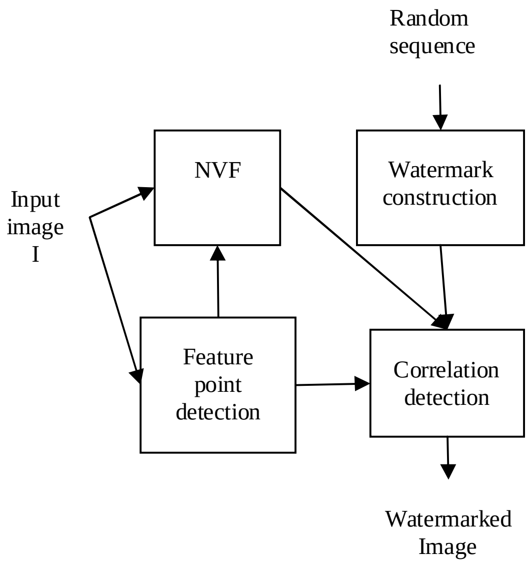

Fig. 1. The watermark embedding process

B. Watermark Extraction

The watermark detection process illustrated in Fig. 2 can be divided into two steps, one is image recovering, the other is watermark correlation. As the input possibly watermarked image may be attacked, the extracted feature points are not corresponding with the watermark element in W exactly. Maybe some points cannot be detected and some new points appear, especially after geometric distortions. So the first step for watermark detection is to recovering the input image into its original shape.

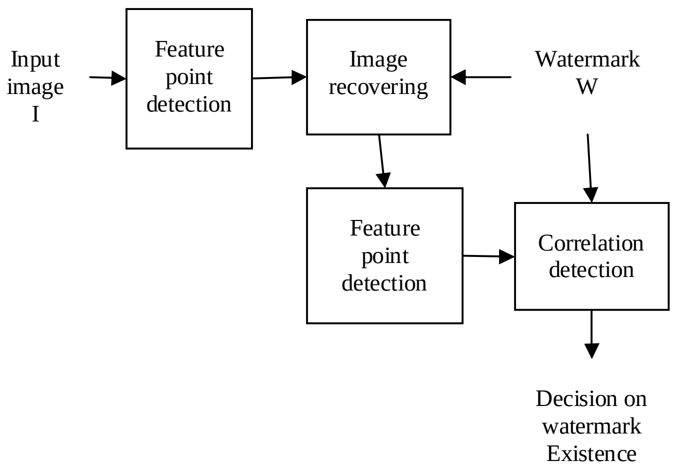

Fig. 2. The watermark detection process

After the input image is recovered, the feature points can be re-extracted. Since the image has been processed and slight distortions may be unavoidable, the extracted feature points may be not corresponding with the watermark elements exactly. If the distance between a watermark element and a extracted feature point is less than a threshold e, they are deemed to be corresponding. In our experiments, the threshold e is set to 2. Because each watermark element is embedded in the neighborhood region of each feature point. The watermark element is still corresponding with a watermarked point; even the point is not the original corresponding feature point.

The key contributions of this method are

• Watermark as a template is introduced to recover the input image. Although template based watermarking has been introduced much into watermarking, watermark and template is separated in most applications.

• Image recovering is simple by using a linear transformation matrix, the computation complexity is decreased significantly.

V. A WATERMARKING TECHNIQUE BASED ON SPECTRUM ANALYSIS AND PSEUDORANDOM SEQUENCES

In this method a watermarking scheme is presented that embeds the watermark message in randomly chosen coefficients along a ring in the frequency domain using non maximal pseudorandom sequences. The proposed method determines the longest possible sequence that corresponds to each watermark bit for a given number of available coefficients. Furthermore, an extra parameter is introduced that controls the robustness versus security performance of the encoding process. This parameter defines the size of a subset of available coefficients in the transform domain which are used for watermark embedding [9].

The watermark is embedded in the form of a pseudorandom noise (PN) sequence. (PN) sequences are binary sequences that appear to be statistically random and have properties similar to random sequences generated by sampling a white noise process. (PN) sequences are generated by pseudorandom number generators using an initial seed (key).

A. Watermark Embedding

In order to accomplish image watermarking, a watermark *W* as well as a private key *K* are required. Key $K=\{K'_m, \hat{L}_{RR}, S_L\}$ consists of the number K_m' of registers in the (PN) sequence generator, the number $\hat{L}_{RR}$ of chosen coefficients and the seed S_L of the random number generator.

As already mentioned, due to the symmetry of the Fourier transform domain, the encoded watermark W_s is embedded twice in the ring *R* of magnitude coefficients. Let $R_{i=1,2}$ denote the two sets of coefficients where the encoded watermark W_s will be embedded, one on each semi-ring. The magnitude of these coefficients is modified as

$$M_w(u,v) = M(u,v) + g\, W_s$$

Where $M(u,v) \in R_{i=1,2}$ ------ (10)

The constant *g* is a factor that controls the strength of the embedded watermark. The watermarked image $I'(x, y)$ is obtained by applying the inverse Fourier transform

$$I'(x,y) = \frac{1}{N_x N_y} \sum_{x=0}^{N_x-1} \sum_{y=0}^{N_y-1} F'(u,v) e^{2\pi j (ux/N_x + vy/N_y)}$$

Where $F'(u,v) = M_w(u,v) e^{jP(u,v)}$ ----- (11)

B. Watermark Extraction

For the detection of the watermark the private key $K=\{K'_m, \hat{L}_{RR}, S_L\}$ is used and a two step process is applied: First the correlation between the marked (and possibly corrupted due to an attack) coefficients and the watermark itself is computed in order to detect the most probable offset position of the watermark inside each semi-ring. Second, the coefficients are divided into *d* length sequences and compared to the (PN) sequences used during the embedding process in order to extract the original watermark message.

In this method a watermarking scheme is presented that uses randomly chosen coefficients along a ring in the transform domain in order to embed a watermark message. The watermark is constructed using non maximal pseudorandom sequences so that each watermark bit is encoded by the longest possible pseudorandom sequence [10].

VI. TRANSFORM DOMAIN BASED WATERMARKING METHODS

A. A Steerable pyramid transforms Based Watermarking Method

This method proposes an image watermarking scheme based on steerable pyramid transform to embed invisible and robust watermark. We can summarize the basic principles of our method as follow: a host image is first transformed by the steerable pyramid transform. The different features are then extracted by thresolding the different subbands. The watermark sequence is inserted into disjoint blocks centered on the extracted feature points. The original host image is needed in watermark detection mainly for extracting the featured coefficients necessary for robust detection and determining the value of one bit of the watermark spread into a block [11].

a. The Steerable Pyramid Transform

Recursive multi-scale transforms are now a standard tool in signal and image processing. However, their main drawback is the lack of translation invariance especially in two-dimensional (2-D) signals. To overcome this problem, the steerable pyramid transform has been proposed by Freeman and Simoncelli. In this linear decomposition, an image is subdivided into a collection of subbands of various orientations. The scale tuning of the filters is constrained by a recursive system diagram. The bloc diagram of this decomposition at frequency domain is shown in Fig. 3 which presents three types of filters: low-pass (L_0), high-pass (H_0), and pass-bands (B_0... B_K). In fact, both low-pass and high-pass filters separate the image into low and high pass subbands respectively. Then, the low-pass subband is further decomposed into 1+Koriented subbands and a low-pass subband. The latter is then subsampled by a factor 2 and a new decomposition is performed until reaching the scale fixed by the user. Indeed, each successive level of the pyramid is constructed from the previous level's lowpass band [12].

b. Watermark Embedding

The general embedding method can be decomposed into different steps. First of all, the host image is transformed into steerable pyramid coefficients by using specific values of scales and directions determined by the user. Edges and high textured area must then be extracted. Indeed, with the steerable pyramid transform, edges and textures are usually well confined to larger magnitude coefficients in the different subbands. Consequently, high values are selected by using a threshold. The threshold value is set equal to the maximum of the considered subband divided by a factor 3. The next step is to find out 3x3 disjoint blocks included in thresholded edges. Then a watermark sequence is inserted in all these blocks. The number of bits that may be encoded equals the number of generated blocks and this in turn depends on the size of the image and on its homogeneity. Hence, more homogenous the image is, less the extracted feature are and vice versa. The redundancy in the code can be adequate for some applications such as for error detection and correction. Using this may introduce a high amount of redundancy for the tag information especially when the number of 3X3 blocks extracted from a subband is higher than the watermark's length. This redundancy can be achieved not only through each level of the pyramid but also in each subband. For embedding the information, each bit is spread into one block. All the values of the blocks are modified as follows :

$$X_{w,k} = X_k + \alpha W_k \quad \text{------ (12)}$$

Where $X_{w,k}$ is the watermarked coefficient and X_k is the original coefficient with the coordinate k in the spatial position. W_k is the determines the strength of the watermark. It is used to adjust the amount of added watermark energy corresponding watermark symbol, which takes two values -1 and 1. The weighting factor is a positive number which. The value of alpha is adjustable by the user to achieve a balance between robustness and fidelity of the resulting watermarked image. This factor also depends on the treated image. Doing this, the mean of each block may then be incremented to encode a '1' or decremented to encode a '0'. Finally, the inverse pyramid transform is then applied combining the different watermarked subbands to form the watermarked image.

c. Watermark Extraction

The detection process needs the original image for extracting the signature as well as the presence of the watermarked image. Original host image is needed in watermark detection mainly for extracting the featured coefficients necessary for robust detection and determining the value of one bit of the watermark spread into a block. The general extraction method can be decomposed into different steps. First of all, the host image and the watermarked one are transformed into the steerable pyramid coefficients with the same parameters as in the embedding stage. In order to localize the marked block, the same rule described latter is also available here. Then, the extraction of all signature occurrences is based on a comparison between the blocks of the two available images. Finally, we succeed to extract correctly the signature embedded by averaging all the occurrences.

This method embeds invisible and robust watermark into significant areas –around edges and in textured areas- of an image. The human visual system is less sensitive to distortions in these areas than in smooth ones. The watermark is added to each subband of a steerable pyramid decomposition.

Fig. 3. watermark of medical image

B. A Discrete Fourier transform–based watermarking method

In this method, first of all, the original images is split into the blocks and proceed DFT transform after that by using Arnold scrambling change water mark and produce pseudo-random sequence, result a image with watermark is produce. The watermark detection is achieved with image segmentation process, DFT transform process and relativity process. A watermarking algorithm based on image segmentation, is also use for improve the security of the watermark with DFT algorithm [13].

a. Watermark Embedding

The embedding Algorithm describe in the following five steps-

Step 1- First of all divide the original image, in which watermark is embedding, into the sub-blocks of 256*256

Step 2- After division process; transform the all image blocks into 8*8 matrixes by using DFT transform.

Step 3- Then use the Arnold Scrambling to change the binary watermark and generate two unrelated pseudo-random sequence.

Step 4- Some time during this whole process, there is a problem with amplitude is produce so in this step modify the corresponding value of amplitude spectrum.

Step 5- Now use the Discrete Fourier Transform to each image blocks to produce the image with watermark.

b. Watermark Extraction

The Extraction Algorithm describe in the following five steps-

Step 1-Firstly uses the image segmentation process to divide the image into 256*256 sub-blocks, which is embedded watermark.

Step 2- After division process, transform the all image blocks into 8*8 matrix by using DFT transform.

Step 3- In this step produce the two unrelated pseudo-random sequence.

Step 4- Here compare the watermark's amplitude spectrum and the pseudo-random sequence and calculate the relativity between both of them and then produce watermark matrix with the help of embedding rules.

Step 5- Now in this last step produce the extracted the watermark by using Arnold transform scrambling to watermark matrix.

In this paper, we proposed a novel approach of watermarking of an image based on DFT and on image segmentation.

C. A Discrete Wavelet transform based watermarking

Digital Watermarking is a technology which is used to identify the creator, owner, distributor of a given video or image by embedding copyright marks into the digital content, hence digital watermarking is a powerful tool used to check the copy right violation. In this paper a robust watermarking technique based on DWT (Discrete Wavelet Transform) is presented. In this technique the insertion and extraction of the watermark in the grayscale image is found to be simpler than other transform techniques [14].

a. Watermark Embedding

In this process firstly the gray scale host image is taken and 2D DWT (Discrete Wavelet Transform)is applied to the image which decomposes image into four components low frequency approximation, high frequency diagonal, low frequency horizontal ,low frequency vertical components. In the same manner DWT is also applied to the watermark image which is to be embedded in the host image. The wavelet used here is the wavelets of daubecheis. The technique used here for inserting the watermark is alpha blending. In this technique the decomposed components of the host image and the watermark which are obtained by applying DWT to both the images are multiplied by a scaling factor and are added. During the embedding process the size of the watermark should be smaller than the host image but the frame size of both the images should be made equal. Since the watermark embedded in this paper is perceptible in nature or visible, it is embedded in the low frequency approximation component of the host image.

According to the formula of the alpha blending the watermarked image is given by

WMI=k*(LL1) +q*(WM1) ------ (13)

WMI=Watermarked image
LL1=low frequency approximation of the original image
WM1=Watermark.
k, q-Scaling factors for the original image and watermark respectively

b. Watermark Extraction

In this process the steps applied in the embedding process are applied in the reverse manner. The Inverse discrete wavelet transform is applied is applied to the watermarked image [15]. Now the result obtained is subtracted from the watermarked image and in this way the host image is recovered. The watermark is recovered from the watermarked image by using the formula of the alpha blending.

RW=(WMI - k*LL1) ----- (14)

RW=Recovered watermark, LL1=Low frequency approximation of the original image,
WMI=Watermarked image

In this algorithm the watermark insertion and extraction was done using the DWT (Discrete Wavelet Transform) and IDWT(Inverse Discrete Wavelet Transform) respectively. In this method of watermarking we have used alpha blending technique

VII CONCLUSION

In this survey we presenting the various watermarking algorithms for medical images, such as A Block-Based Watermarking Method, A Feature-Based Watermarking Method, A Watermarking technique based on spectrum analysis and pseudorandom sequences, A Steerable pyramid transform Based Watermarking Method, A Discrete Fourier transform–based watermarking method and A Discrete Wavelet transform based watermarking. Thus this survey will helpful for those who doing research in the area of image processing particularly in watermarking. In this paper the watermark insertion that is embedding and extraction was presented using the different algorithms for improving the efficiency of the watermark of an image.

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Bibilography

A. Umaamaheshvari,born in Coimbatore District, Tamilnadu state,India in 1974, received the BE in Electrical and Electronics Engineering from Madras University, Chennai. ME in Applied Electronics in Anna University, Chennai and Currently doing Ph.D in Digital Image Processing from Anna University,Coimbatore . Her research interests lie in the area of Computer Networking and Image processing. Published few papers in International conferences and Journals