

# EMBEDDING AND EXTRACTION TECHNIQUES FOR MEDICAL IMAGES – ISSUES AND CHALLENGES

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## **ABSTRACT**

*New technologies in multimedia and communication fields have introduced new ways to transfer and save the medical image data through open networks, which has introduced new risks of inappropriate use of medical information. Medical images are highly sensitive hence secured transmission and reception of data is needed with minimal distortion. Medical image security plays an important role in the field of Telemedicine. Telemedicine has numerous applications in teleconsulting, teleradiology, telediagnosis, telesurgery and remote medical education. Our work is to analyze about the different embedding techniques that can be used for embedding the personal and diagnosed details of a person within the medical images without any visual discrepancy. Also to survey about the blind extraction algorithm utilizing genetic algorithm for optimization of the key parameters.*

## **KEYWORDS**

Robustness, Fidelity, Joint Watermarking, Embedding algorithm, Genetic algorithm

## **1. INTRODUCTION**

In the new era medical images are produced from a variety of imaging equipments, such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT), etc. CT can clearly reflect the anatomical structure of bone tissues. SPECT can highlight the lesion of tissues and organs to provide information about blood flow and temperature of body parts. PET scanning can show blood flow, oxygen and glucose metabolism in the tissues of the brain. MRI can clearly reflect the anatomical structure of soft tissues, organs and blood vessels. These medical images can also be saved in a digital format.

Electronic Patient Record (EPR) is one of the digital format of saving the personal details of patient, details of diagnosis, hospital information along with the medical image for continual monitoring [1]. Telemedicine is the process by which electronic, visual and audio

communications are used to support practitioners at remote sites with diagnosis and consultation procedures, such as remote clinical examinations and medical image transfers. Telemedicine is legally regulated by laws and constraints regarding the access of data contained in Personal medical Files. The transmit of medical transcriptions through online provides efficient clinical interpretation without carrying the documents. The diagnosis needs confidentiality, availability, and reliability [2]. Confidentiality means that only the original users have access to the information. Availability, guarantees access to medical information. Reliability is based on integrity that the information has not been modified by unauthorized persons; and authentication intends that the information belongs indeed to the correct patient.

Hospital patient database management system is implemented in more hospitals nowadays which is designed to transform the manual way of maintaining and accessing patient medical files into electronic medical record (EMR) or Electronic Health Record (EHR) [3]. EMR is used to solve the problem of manual method. To protect this private information about a person against unauthorized viewers, we can use any one of the techniques for medical image data : Cryptography or Watermarking.

Cryptography is the technique of transforming information to more secured form. Digital encryption of medical images before transmission and storage is proposed as an easiest way to protect the patient information. Cryptography technique can be divided into symmetric encryption needs secret key and asymmetric encryption which needs private and public keys. An encryption technique [4] is used which is a blend of symmetric key encryption and steganography with a variable length key derived from the encrypted text itself to have better security. Chaotic systems [5] [6] can be used for medical images to achieve robust system and its implemented using Bit Recirculation Image Encryption (BRIE) to control the pseudo-random operations on each pixels. The traditional algorithms are not recommended for medical images because they are slow, hence we can associate the properties of traditional cryptography with the properties of a chaotic system. There are several chaotic algorithms which handle the medical image are Bit Recirculation Image Encryption, Circulation Encryption Algorithm, Chaotic Key-Based algorithm, Image Chaotique, Hierarchique Encryption. Visual cryptographic technique [7] can also be used for encrypting medical images which provides a more reliable system.

The cryptography systems have only limited techniques hence the tracker can easily predict the original image after some iterations .Hence we should choose a technique where the predictions of the data from the embedded data should be so difficult by the unauthorized users. Watermarking has found a niche role in secure sharing and handling of medical images. The watermarks are embedded into medical image for three purposes: hiding electronic patient's data, integrity verification and for authentication.

The watermarking techniques are divided into two basic categories as spatial domain watermarking and Frequency domain watermarking. In spatial domain the Least Significant Bit (LSB) of the image pixel is replaced with the watermark bit and in the Frequency domain the image is transformed to the frequency domain and then the frequency components are modified with the watermark bits.

The watermarking techniques can also be classified based on the watermarking robustness as Robust, Fragile and Semi-Fragile [8] [9]. Robust watermarks can resist non-malicious distortions and best suited for copyright protection Fragile watermarks can easily destroyed by all image

distortions and its suited for tamper detection and authentication. Semi-Fragile watermarks can be destroyed by certain types of distortions and resists minor changes and used for some special cases of authentication.

There are three watermark detection/extraction schemes: Non-blind, semi-blind, and blind. Both the original image and the secret key are needed for non-blind extraction. Semi-blind needs only the secret key and the watermark. Blind extraction system needs only the secret key. The digital watermark when it is hidden in the image it generally introduces some amount of imperceptible distortion in the image. In medical images, there is a region that is important for diagnosis called ROI (region of interest) and RONI (region of non-interest). Embedding data in ROI region should not cause any visual artifacts which affects the interpretation by medical doctors. So watermarking can be used in RONI of medical image [11]. To enhance confidentiality and authentication a dual watermarking scheme in which Caption watermarking for hiding patient's information in ROI and Signature watermarking hides the physician's digital signature in RONI.

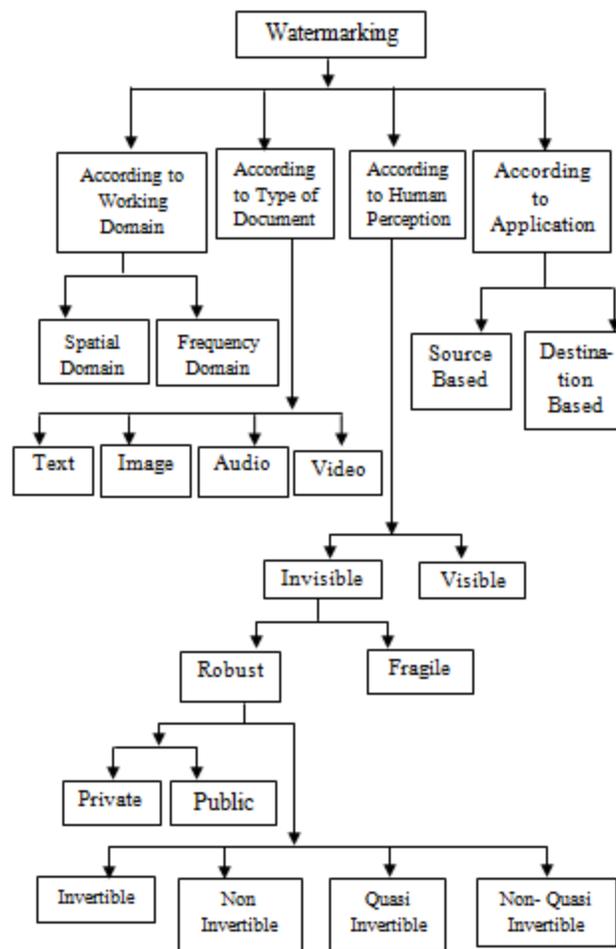


Fig 1. Classification of Watermarking

To achieve better performance in terms of perceptually, invisibility and robustness, an adaptive quantization parameters can be used for data hiding. The embedding strength is more or less proportional to the value of energy to have better robustness and transparency. The block wise embedding technique with the larger quantization parameters improve the robustness. Another dual watermarking method consists of an annotation part and a fragile part [11] in which Encrypted patient data is embedded in an annotation watermark, and tampering can be detected using a fragile watermark.

In order for physicians, hospitals, and patients to utilize the benefits of digital medical images, all communication must be compatible. When manufacturers use proprietary formats, the digital files can be read only with the manufacturer's equipments and communicating these files over multiple networks is not possible. As digital medical information evolved, the medical community demands for a standard method of transmitting medical images and their associated information. DICOM is a standard file format for transmission and storage of digital medical images which suits for hospital database management system [12] [13]. DICOM defines the network and media interchange services allowing consistency so that EHR records are available to all who need them.

Header in DICOM image format stores patient's information such as patient identification number, name, sex, and age. Insurance companies, hospitals and patients may want to change this data for various reasons. After embedding the data, watermarked medical image can still conform to the DICOM format. Pixel data can be compressed using a compression standard and the DICOM Grayscale Display Function Standard improves image quality. The DICOM Presentation State Storage Service Class ensures presentation consistency since the physician interpreting an image may adjust magnification, window width, and window center or apply various image processing enhancements. DICOM has a key role in virtually every medical profession that uses images, including cardiology, dentistry, endoscopy, mammography, ophthalmology, orthopedics, pathology, pediatrics, radiation therapy, radiology, and surgery as well as veterinary medical imaging. DICOM continuously updates the standards per year.

## **2. RELATED WORKS**

### **2.1. Watermarking Techniques:**

#### **a. Spatial Domain Techniques:**

In Spatial domain the watermark is directly embedded by modifying the pixels of the original image without any transformation of the image. This technique is often fragile and applied in the pixel domain and has less complex computation thus consumes less time for archiving and retrieval. The least significant bit (LSB) technique is used to embed information [14] in a cover image. The LSB technique of a cover image is described by changing pixels by bits of the secret message. An embedding scheme which randomly hides messages in the LSB of any/all component of the chosen pixel using polynomial [15]. If polynomial is used, hacker needs to predict more than one number i.e. all coefficients of polynomial has to be decoded correctly and probability of finding all right coefficients is less compared to predicting single bit. Watermarking can be done by embedding watermark into sub images with LSB technique. The watermark can be embedded into specifics blocks[16] of the host image where the selection of blocks are based on entropy value which gives a high PSNR value.

### b. Frequency Domain Techniques:

Transformation of an image is needed to get more information about the image and to reduce the computational complexity. Even though this technique takes more time and more complex than spatial domain technique the embedded watermarked data cannot be identified easily as the previous technique. In transform domain the watermark is embedded after performing transformations such as, Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT), and Discrete Wavelet Transform (DWT), Contourlet Transform etc. The watermark is embedded in the transform coefficients. When compared to spatial domain these techniques offer high security and are robust to attacks. In frequency domain watermarking the values of selected frequencies can be altered. Since high frequencies will be lost by compression or scaling, the watermark signal is applied to lower frequencies, or better yet, applied adaptively to frequencies containing important elements of the original picture.

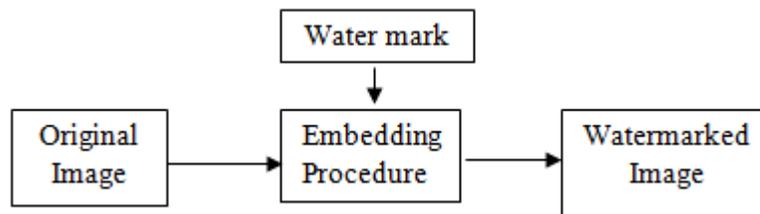


Fig 2. Embedding Process

DFT is the basic transform used for data and images. DCT is a fast transformation technique provides excellent energy compaction for highly correlated data and most of the information (dc-coefficient) is in the first pixel. DWT gives both the frequency and location in time and it is suited for Time-varying signals. The Contourlet Transform has the main feature of capturing two dimensional singularities. With an intention to increase the robustness a reversible technique based on wavelet transform is proposed by Lingling An et al. [17]. SQH with k-means clustering is used to resist unintentional attacks and EPWM is used to balance invisibility and robustness.

A new approach of Lifting Wavelet Method (LWT) is capable of maintaining the structural index and provides a better performance than the DWT method. The Daubechies wavelet family performs better than the other wavelet types. A dual security approach can be employed for medical image security where the medical image is considered as watermark and is watermarked inside a natural image. This approach is to wean way the potential attacker by disguising the medical image as a natural image. To enhance the security the watermarked image can be encrypted using encryption algorithms. The water marking can be implemented using Lifted Wavelet Transforms (LWT) and Singular Value Decomposition (SVD) technique [18]. The features of Lifting Wavelet Transforms (LWT) along with Discrete Wavelet Transforms (DWT) and Singular Value Decomposition (SVD) [19] can be used to provide a robust and imperceptible watermark. Contourlet Transform provides a multi resolution and directional expansion of images using Pyramidal Directional Filter Bank (PDFB). The LP decomposes the image into frequency band to obtain singular points. The DFB decomposes each LP detail band to capture directionality.

### C. Joint Watermarking:

Joint watermarking combines the watermarking of the encrypted data in medical images in order to provide more security utilizing the benefits of cryptography and watermarking techniques.

Joint Medical image watermarking is to encapsulate vital data inside an image in energy packed areas, which is optimized with respect to image quality and to provide a second level security by incorporation of state of the art cryptographic standard. Rajendra Acharya et al [20] has proposed the technique of watermarking by interleaving encrypted patient information with medical images during JPEG compression, to reduce storage and transmission overheads. A novel method for watermarking by SVD based blind watermarking method and ciphering color in ages, based on the joint use of a key-dependent wavelet transform, Fibonacci-Haar wavelet transform domain to increase its security with a secure cryptographic scheme by Federica Battisti et al [21]. Gouenou Coatrieux et al [22] has proposed a new technique of knowledge digest which gives a synthetic description of the image content, a digest that can be used for retrieving similar images with either the same findings or differential diagnoses. A secure version of a classical trellis coded quantization watermarking where the trellis path generated from the discrete key and the message was given by Sofiane Braci et al [23]. The spread transform can represent a second or alternative security level for watermarking systems which makes message hard to read for unauthorised user. The access control model in order to enhance the protection of medical images was given by Wei Pan et al [24] in distributed healthcare infrastructures. Mohammad-Saleh Nambakhsha et al [25] has used digital watermarking framework using electrocardiograph (ECG) and demographic text data as double watermarks. The watermarks are embedded in selected texture regions of a PET image using multi-resolution wavelet decomposition.

A secure watermarking system using Arnold scrambling and 2-D Cellular Automata Transform (CAT) was given by Xiao-Wei Li et al. [26]. CAT-based watermarking system can simultaneously improve security, robustness and image quality of the watermarked image. Dalel Bouslimia, B et al [27] has proposed a joint encryption/watermarking algorithm in which it combines the RC4 stream cipher and two substitutive watermarking modulations: the Least Significant Bit Method and the Quantization Index Modulation which improves the peak signal to noise ratio. Dalel Bouslimi et al [28] a joint encryption/watermarking system based on an approach which combines a substitutive watermarking algorithm, the quantization index modulation, with an encryption algorithm: a stream cipher algorithm (e.g., the RC4) or a block cipher algorithm (e.g., the AES in cipher block chaining (CBC) mode of operation). The algorithm of discrete wavelet transform and Hankel transform combined is developed to achieve the integrity authentication of color image contents through embedding watermarking by M.V.S.S.Babu et al [29]. Vinay Pandey et al [30] has used steganography by medical image of any other as cover image and embedded encrypted image as secret image with the private key. It also apply two shares encryption algorithm for encryption of embedded image. To achieve integrity service Mohamed M. Abd-Eldayem et al [31] has proposed a hash value based encryption. To provide confidentiality and authentication services: the compressed R-S-Vector, the hash value and patient ID are concatenated to form a watermark then this watermark is encrypted using AES encryption technique. Hung-I Hsiao et al [32] has used chaotic amplitude phase frequency model (APFM) nonlinear adaptive filter for medical image security using is proposed. We set nine parameters, simulated time interval, and initial values for APFM nonlinear adaptive filter to generate chaotic orbits. Lamri Laouamer et al [33] has proposed a new approach for generating symmetric keys for image encryption / decryption, whereby the medical images (area of interest) use an informed process based on a technique that has been demonstrated on textual analysis called N-grams. Watermarking is performed by using a new nontensor product wavelet filter banks designed by A. Kannammal et al [34], which have the ability to reveal singularities in different directions. Natural image is taken as the original image

and the medical image is taken as a watermark image. The proposed algorithm has the ability to withstand different attacks like noise, rotation, contrast, and brightness attacks.

A Joint FED watermarking system is proposed by . P. Viswanathan et al [35] for addressing the issues of teleradiology. The system combines a region based substitution dual watermarking algorithm using spatial fusion, stream cipher algorithm using symmetric key, and fingerprint verification algorithm using invariants. Medical information, is embedded into the regions of interest (ROI) in medical images with a high capacity difference-histogrambased reversible data-hiding scheme. After that, the watermarked medical images are encrypted with hyperchaotic systems proposed by Shun Zhange et al [36]. V. Amutha et al [37] has proposed a substitutive watermarking algorithm combined with an encryption algorithm, advanced encryption standard (AES) in counter mode.

### 3. BLIND WATERMARKING

It is a Zero-Knowledge watermarking algorithm which does need the original image for the detection process. Wei-Hung Lin A [38] has proposed a blind watermarking algorithm based on maximum wavelet coefficient quantization for copyright protection. The watermark is embedded in the local maximum coefficient which can effectively resist attacks, either non-geometry or geometry attacks. The watermark can effectively resist common image processing attacks, especially by JPEG compression (with a quality factor greater than 20) and Gaussian noise with a variation of less than 2. Xinge You [39] proposed a new method for constructing nontensor product wavelet filter banks and applied them into watermarking scheme design. The proposed wavelet filter banks make the watermarking scheme more flexible because more subbands and coefficients are suitable for watermark embedding. The algorithm is robust against various attacks particularly Gaussian noising attack.

Singular value decomposition (SVD) based image watermarking technique was proposed by Deepa Mathew K [40]. SVD uses non fixed orthogonal bases. The result of SVD gives good accuracy, good robustness and good imperceptibility. Swanirbhar Majumder [41] has used singular value decomposition (SVD) with the unconventional transform called Contourlet transform (CT). Here the combination of pyramidal and directional filter bank (PDFB) has been used in Contourlet transform. An effective watermarking algorithm based on the chaotic maps was proposed by Jila Ayubi [42]. The chaotic maps are employed to generate a key space with the length of  $10^{40}$  numbers to increase the degree of security. Mutation operator has been used to encrypt the watermark. This algorithm can preserve the hidden information against geometric and non geometric attacks. Surya Pratab Singh [43] has used a 3rd level of DWT (Discrete Wavelet transform) and before embedding the watermark image is passed through chaotic encryption process for its security, Other important thing is that in this watermark is embedded in the form of DCT (Discrete Cosine Transform) with special coefficient shifting algorithm to minimize the impact on main image. Yinglan Fang [44] has proposed an improved blind watermarking algorithm based on two-dimensional discrete wavelet transform. Before embedded watermark, the watermarking image is pretreated by using Arnold scrambling to improve its security. This algorithm had better concealment and improved the robustness and efficiency. A new blind watermarking algorithm technique based on DCT and DWT using middle frequency band of DCT and 2- levels DWT by Farhed aseed [45]. Using ARNOLD transformation the robustness and security of watermark image is increased. Nidhi Bisla [46] has used the watermarking technique of DWT and hybrid DWT-SVD. In case of DWT, decomposition of the original

image is done to embed the watermark and in case of hybrid DWT-SVD firstly image is decomposed according to DWT and then watermark is embedded in singular values obtained by applying SVD. Sudeb Das [47] has proposed a blind, fragile and Region of Interest (ROI) lossless medical image watermarking (MIW) technique, providing an all-in-one solution tool to various medical data distribution and management issues like security, content authentication, safe archiving, controlled access retrieval, and captioning.

A novel image encryption technique was given by J.B.Lima A [48] which involves two steps, where the finite field cosine transform is recursively applied to blocks of a given image. In the first step, the image blocks to be transformed result from the regular partition of subimages of the original image. The transformed subimages are regrouped and an intermediate image is constructed. In the second step, a secret-key determines the positions of the intermediate image blocks to be transformed. N. Venkatram [49] has highlights the extension of dwt-svd based image watermarking to medical images. For medical images 2D lifting wavelet transform (LWT) is used instead of dyadic 2D discrete wavelet transform. Even after attacks LWT-SVD method gives satisfactory quality both visually and mathematically. B. Jagadeesh [50] has used a novel digital image watermarking algorithm based on artificial neural networks. As neural networks are good at pattern recognition, they can be used as a medium to store the frequency domain components of the image and these can be used at the extraction of watermark. It gives better PSNR value and it is robust to many image processing attacks like compression, resizing & filtering.

#### 4. GENETIC ALGORITHM

Genetic algorithms are adaptive algorithms for finding the global optimum solution for an optimization problem. It is also called as an optimization algorithm, meaning they are used to find the optimal solution(s) to a given computational problem that maximizes or minimizes a particular function. These algorithms are far more powerful and efficient than random search and exhaustive search algorithms, yet require no extra information about the given problem. This feature allows them to find solutions to problems that other optimization methods cannot handle due to a lack of continuity, derivatives, linearity, or other features. GAs applying the principles of survival of the fittest, selection, reproduction, crossover (recombining), and mutation on these individuals to get, hopefully, a new better individuals (new solutions). There are two basic genetic algorithms operators which are crossover and mutation. These two operators are work together to explore and exploit the search space by creating new variants in the chromosomes. Researchers used Genetic Algorithm to optimize the watermarking requirements.

Hamed Modaghegh et al [51] used a new adjustable watermarking method based on singular value decomposition is presented so that SVD parameters are adjusted by using the GA considering image complexity and attack resistance. Veysel Aslantaset al [52] has used intelligent optimization algorithms for correcting the rounding errors caused by the transformation process. K. Ramanjaneyulu et al [53] has proposed a novel method for oblivious and robust image watermarking scheme using Multiple Descriptions Coding (MDC) and Quantization Index Modulation (QIM). Proposed scheme is characterized with Blocked Discrete Hadamard Transform (DHT) parameters and Genetic Algorithm (GA) is used for parameter optimization. The performance improvement is achieved over the existing methods in terms of Peak Signal to Noise Ratio (PSNR) and Normalized Cross correlation (NCC). The tradeoff between the transparency and robustness is considered as an optimization problem and is solved by applying

Genetic Algorithm proposed by P.Surekha et al [54]. The amplification factor and robustness against attacks. For the Colour image, the image is decomposed into their colour components viz, R, G and B. One of these matrices are divided into odd and even banks of 8X8 each, such that pixel values present in the odd positions will go to the odd bank and similarly even bank. The data to be embedded is embedded into one of the banks say odd bank. The embedding position of the data to be watermarked into the image is found out using Genetic Algorithm given by Abduljabbar Shaamala et al [55] and in [57] he gives the effect of embedding data in frequency domain on the robustness in genetic watermarking.

D. Venkatesan et al [56] has used a center of mass selection operator based Genetic Algorithm, to investigate the variation of maximum fitness based on the higher PSNR value of watermarked image, against embedding strength, number of genes, various payload of digital watermark. Azman Yasin et al [58] has given a study of comparison between two existing methods: Dual Intermediate Significant Bit (DISB) and Genetic Algorithm (GA). GA is used in determining the minimum fitness value in which the fittest is the absolute value between the pixel and chromosome. It produces a high quality watermarked image, but there is a big difference in the processing time, so the DISB method is faster than the GA method. In particular, IR is one of the key steps in medical imaging, with applications ranging from computer assisted diagnosis to computer aided therapy and surgery. IR can be formulated as an optimization problem on a real coded genetic algorithm with a more appropriate design given by Andrea Valsecchi [59].

## 5. ATTACKS AND EMBEDDING CAPACITY

When the images are transmitted there is the possibility of attack either intentionally or unintentionally. This may degrade the quality of the image and affect the performance of the system. Hence the watermarking system should be robust enough to survive the attacks. In order to evaluate the robustness and effectiveness of our watermarking method, it is necessary to investigate the influence of different attacks on image as innocent Attacks and Malicious attacks [60]. A watermarking technique in wavelet domain for the EHR data is based on energy band selection [61] [62] and in reference to the bit location in the reference image. Virtually all lossless embedding techniques increase the file size of the embedded image. The lossless embedding methods that preserve the file size of images in the RLE encoded BMP and the JPEG formats. A reversible method can be used to embed information without increasing its size.

## 6. PROSPECTS & APPLICATIONS

Digital image watermarking has numerous applications in variety of fields such as Copyright Protection, Content Archiving, Meta data Insertion, Tamper Detection, Digital Fingerprinting. Depending on the medical application area (health, administrative, teaching, research ...) the trade-offs among robustness, invisibility and capacity varies. The image segmentation is applied to select only the required portion of medical image. RONI approaches will leave intact the diagnostic information, but they can be applied only if a RONI exists. Furthermore, the capacity is dependent upon the RONI area size. Neural networks can be used to implement an automated system of creating maximum-strength watermarks. Artificial intelligence techniques can be used for watermarking to have better robustness against many image processing attacks like rotation, sharpening, image contrast attacks. Fuzzy-Neuro system to offer combined advantages of both Artificial Neural Networks and Fuzzy Logic.

## 7. CONCLUSION

A review of various watermarking embedding techniques have been done which suits for medical images with higher embedding capacity and higher imperceptibility with which it can withstand against attacks as well. Since no compromise can be made on the fidelity criteria of the medical images appropriate transforms for medical image could be identified and incorporated to bring an optimal embedding of diagnosed data in medical images. Analysis of various detection algorithm also has been done for medical images which was optimized using suitable genetic algorithm. There was always been a tradeoff between robustness, capacity and imperceptibility hence the embedding and detection algorithm has to suit for the need of data retrieval and archiving.

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