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A CLASSICAL REVIEW ON ADVANCED DIGITAL IMAGE WATERMARKING TECHNIQUES

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ABSTRACT:

The world has become a global village in digital era due to advances in internet and communication technology. Presently, creation, copy and transmission of image data via internet and mobile phone are very common practices. The access, sharing, replication and manipulation of medical images have become daily needs. Image data distributed can be copied repeatedly without errors putting the rights of owners at risk. Even though encrypted for distribution, images can be unprotected after decryption. Deployment of information and communication technology infrastructure is bringing revolution to health industry. Consequently, worldwide e-health technology and associated standards demand strong security of medical image data. Digital image data security is achieved by different ways.Digital image watermarking provides copyright protection and authentication by hiding ownership information in image data. This paper presents motivation along with vast number of application area of digital image watermarking. The paper mainly focuses on classical review of variety of advanced image watermarking techniques. The paper recommends transform domain image watermarking for strong provision of imperceptibility, robustness and security. This study also draws some significant conclusions based on classical review of advanced image watermarking techniques.

KEYWORDS: Watermarking, PSNR, Fingerprinting, MMS, Shift-variant, EVM, Compression.

I. INTRODUCTION:

Digital image watermarking protects the rights of their owners in variety of ways including copyright identification, user identification or fingerprinting (FP), authenticity determination, automated monitoring and copyright protection. Digital fingerprinting is used to trace out unauthorized user and identify the copyright violator. This is achieved by embedding a fingerprint in each copy to be distributed so that authorized user can be identified.With advances in communication technology and due to widespread use of internet and mobile phones, image data security is essentially required in many applications areas [1][2].

Image copyright communication for digital rights management (DRM) and protection strongly demands it. Multimedia Message Service (MMS) are commonly used to send images through mobile phones where security is required. Central Bureau Investigations (CBI) and other crime investigation agencies need to transmit either grey scale or color criminal images to distant officesvia internet or cell phones. Such image data demands high safety and confidentiality. 'Secured Voting System' is heart of democratic countries worldwide. E-voting systems are better options for Electronic Voting Machines (EVM) for implementation of free and fair voting system which is also cost effective as it saves extra financial burden caused economy system of a given country.Biometric based watermarking techniques can be efficiently used for e-voting systems used in parliament, president and municipal elections. Biometric based watermarking techniques can be efficiently used for e-voting systems used in parliamentary, presidential or municipal. Distance education is growing rapidly nationwide or worldwide. Due to shortage of highly qualified skillful human resources in rural and backward areas intelligent technologies for distant learning with student-teacher interaction is required with secured transmission of image data. Here, digital image watermarking can provide solution.

Many Android based application in mobile phones are written using Java Programming language. Since mobile phones are capable of running Java programs, even simple program can extract hidden messages from innocent images. Hence, watermarking techniques are equally used for all types of mobile based image data security. Secured image databases required by health insurance companies and car insurance companies during decision making process of accidental cases and allowances of damaged vehicles. The banking services including multinational companies require for maintaining secure image databases and their transmission, secured passport IDs require secured authentication for customer-image data during transmission to and from central administrative offices. The generalized approaches and analysis used for image data can be easily applied for other media such as audios and videos .

In telemedicine for number healthcare applications like teleradiology, telepathy, telecare, telesurgery, teleneurology medical images needproper safetyand

confidentiality because patient diagnosis by specialists is based on information containedin medicalimages. Many times patient who is criticallyill or seriously injured in accident need to be treated locally by effective and secured communicationof EPR (Electronic Patient Report) data between remote hospitals and distant specialty hospitals. Clinical Decision Support System (CDCS) extract knowledge from electronic medical records (EMR) and provide input to the doctors those do exact diagnosis. The transmission of medical images from remote hospitals to specialist hospital located at distant geographical locations is common practice now a day. Sensitive medical images need 'a priori' and 'a posteriori'protection. Hence,secure, robust and high capacity watermarking techniques is demand of healthcare industry. A medical image contains Region of Interest (ROI) and Region of Non Interest (RONI). ROI is sensitive region of medical image using which doctors do exact diagnosis and decide treatment according. So, ROI should not be disturbed while embedding watermark. Hence, ROI based watermarking of digital images need to be handled carefully.

II. IMAGE QUALITY METRICS:

Imperceptibility, robustness, payload and security are four attributes those determine quality of image watermarking scheme**.**

A. IMPERCEPTIBILITY OR PERCEPTUAL TRANSPARENCY:

The imperceptibility is also called as perceptual transparency or fidelity. Addition of watermark in a cover image is as good as addition of noise to it. Hence, the imperceptibility of watermarked image is degraded during watermark embedding process. Imperceptibility of the watermarked image is measured in term of various attributes like difference based measures such as Peak signal to noise ratio(PSNR) which is determined in terms of mean square error(MSE). MSE, PSNR are pixel difference based measures which compute the distortion between two images based on their pixel wise difference. Better PSNR shows better quality of watermarked image.

B. ROBUSTNESS:

Watermark must be capable for survival against both intentional and unintentional attacks. Robustness is detecting reliability of given watermarking technique in presence of channel noise or intentional attacks. It measures immunity of watermark against attempts to various image modification and manipulation like noise addition, noise filtering, rotation, scaling, collision attacks, resizing, cropping, compression. Robustness depends on various factor like watermark information hiding capacity, visibility and strength. It is measured in terms of similarity between original watermark and extracted watermark. i.e. 'correlation factor'.

C. CAPACITY:

It is measure of number of bits those can be embedded in a cover image. A good quality watermarking technique should have maximum embedding capacity. Transparency and robustness to image processing conflict with each other under high payload scenario. The high capacity watermark embedding can be achieved by compromising either perceptual quality or robustness of watermarking technique. Thus, it is the fundamental problem to achieve suitable tradeoff between fidelity and robustness.

D. SECURITY:

It is the ability of preserving owner's rightful information. The watermarking technique should be complex enough to break. It measures resistance of watermark in case attacker attempts to various image like rotation, scaling, noise addition, noise filtering, resizing, cropping, collision attacks, compression. Robustness depends on different factor such as watermark hiding capacity, strength and visibility. It is measured in terms of correlation between original watermark and extracted watermark. i.e. 'correlation factor'.

III. CLASSICAL REVIEW:

The numbers of watermarking techniques have been proposed by researchers for grey scale, color and medical images. According to embedding domain watermarking techniques are categorized as spatial domain and transform domain.

A. SPATIAL DOMAIN TECHNIQUES:

Least Significant Bit (LSB) based techniques are examples of spatial domain techniques which are less secured, having low watermark information hiding capacity, results less perceptual quality of watermarked image and can be detected easily. Mohammed, Ghassan N et al.[2] proposed Dual Intermediate Significant Bit (DISB) model to achieve robustness against possible attacks as well as perceptual quality of the watermarked images.The two bits are embedded into all pixels of the cover image and other six bits are altered such that they will directly assimilate the original pixel. The resultant watermarked image quality is improved with compared with LSB after embedding two bits.In transform domain techniques, watermark is inserted into transformed coefficients of image. It gives better watermark information hiding capacity and also provides better robustness against watermarking attacks. The frequency domain methods are widely applied compared to spatial domain methods.

B. VISIBLE WATERMARKING TECHNIQUES:

Tsung-Yuan Liu et al.[3] presented lossless visible watermarking method of cover image. This method embeds 440x330 size watermarks with 88,424 nontransparent pixels and average capacity of 33.7% of watermark coverage. But visible watermarking schemes are used only for limited application areas.

C. BLIND WATERMARKING TECHNIQUES:

A blind watermarking techniques do not require cover image during extraction process. Md. Iqbal H. Sarker et al.[4] presented Hadamard transform and best first search based blind watermarking technique to achieve robustness against compression, rotation, cropping, noise addition and noise filtering attacks. Jiasong Wu et al.[5], also presented watermarking technique for Sliding Window based Sequency-Ordered Complex Hadamard Transform. The technique is proved faster than only FFT or the sliding DFT based methods. Feature based classification technique for blind Steganalysis technique is proposed by Wen-Nung Lie et al.[6]. Here, two statistical properties in the spatial and DCT domains are proposed blindly to determine the presence of hidden messages in image. The neural classifier based on two extracted features namely gradient energy and statistical variance of the Laplacian parameters are proposed to achieve blind steganography. FabrizioGuerrini et al.[7] presented blind watermarking scheme based on quantization index modulation(QIM). The scheme is robust against tone mapping operators. This scheme is specifically presented for High dynamic range (HDR) images which allow accurate rendering of wide range of luminance values.

D. SPREAD SPECTRUM BASED TECHNIQUES:

Fan Zhang et al.[8] presented spread spectrum watermarking scheme based on perceptual quality metrics. This method is proposed as an optimization to search watermark to minimize distortion of watermarked image and maximize correlation between watermark and spread spectrum carrier with fast implementation. Spread Spectrum Watermarking Scheme is presented by Minoru Kuribayashi et al.[9] for fingerprint application.

E. QUANTIZATION BASED TECHNIQUES:

Mohsen Zareian et al.[10] proposed modulation based quantization watermarking with adaptively selected quantization step size. This method found robust for AWGN attack, JPEG attack, filtering attack, salt-pepper noise attack and rotation attack. Quantization based watermarking is also presented by Xiangui Kang et al.[11] which is robust to JPEG, noise addition, histogram equalization, color reduction and Gamma correction attacks.

F. COLOR TRANSFORMATION BASED TECHNIQUES:

Soo-Chang Pei et al.[12] presented reversible color transformsfor red-green-blue(RGB) and KarhunenLoeve average (KLA), RGB-IV1V2, RGB-XYZ, RGB-UVW, RGB-YIQ, RGB-DCT, RGB-YCbCr, RGB-YUV, RcGcBc and RGB-RsGsBs with reduced implementation complexity.

A perceptually tuned method for color images is presented by Chun-Hsien Chou et al. [13] hiding watermark into 3 color channels and host image without resulting perceivable distortion. The method is based on CIEDE 200 color difference equation and Just Noticeable Difference (JND) model. Paulo ViniciusKoerich Borges et al.[14] proposed transparent color modulation for text data hiding using print scan(PS) channel model. DWT based color image watermarking in YCbCr color space is presented by Shang-Lin Hsieh et al.[15] and YIQ color space technique is presented by Guangmin Sun et al.[16].

G. REVERSIBLE WATERMARKING TECHNIQUES:

Reversible watermarking is special data hiding technique where watermark with original image are completely recovered. Such techniques are used in applications like medical and military where media do not allow any loss. Hao-Tang Chan et al.[17] presented reversible fragile transform domain method based on digital hologram. Here the reversibility is achieved using Hadamard transform. A. Umamageswari et al.[18] proposed reversible watermarking technique in compression domain. Lingling An et al.[19] presented robust reversible watermarking(RRW) using wavelet domain statistical histogram shifting and clustering(WSQH-SC) pixel wise masking to balance robustness and invisibility.

Ioan-CatalinDragoi et al.[20] presented local prediction based watermarking technique with four horizontal and vertical grouping of four pixels. Sunil Lee et al.[21] proposed reversible watermarking method using integer to integer wavelet transform. The mean squared distortion between original and watermarked images with given payload is minimized by adaptively embedding watermark in a cover image.

H. HISTOGRAM BASED TECHNIQUES:

Histogram based schemes are also presented for reversible watermarking. PasunuriNagarju et al.[22] presented histogram bin shifting based reversible watermarking for grey scale images. In range of pixels of 0-255, from histogram, zero point (pixel value with frequency zero) and peak point (pixel value with frequency maximum) are effectively shifted for data embedding. GouenouCoatrieux et al.[23] proposed scheme using dynamic histogram shifting which dynamically uses local specificities of local contents.

I. E-HEALTH CARE BASED MEDICAL WATERMARKING TECHNIQUES:

E-health technology and related telemedicine applications including telepathy, telecare, teleradiology, telesurgery and teleneurology demand high confidentiality and safety of Electronic Patient Records (EPR). Medical image with region of interest (ROI) is need to be treated carefully because doctors do exact diagnosis based on information provided by ROI based medical images. Kumar M et al.[24] proposed reversible image watermarking method for medical where both payload and the patient information are encrypted using symmetric key encryption algorithm. GouenouCoatrieux et al.[25] proposed scheme using non-significant region watermarking with signatures extracted from different pixel blocks of interest. This method uses set of three signatures are used for confidentiality. DalelBouslimi et al.[26] presented method using joint encryption/watermarking to verify reliability of medical images. This method guarantees priori and posteriori protection of medical images.

M. Kamran et al.[27] proposed e-health technology related scheme of Electronic Medical Records(EMR) system that is processed by Clinical Decision Support System(CDSS). This information preserving scheme is robust to insertion, deletion and alteration attacks. A novel scheme using integration of multiple cryptographic mechanisms and key management scheme is proposed by Chien-Ding Lee et al.[28] to track malicious staff members using watermarked clue. C. Vinoth Kumar et al.[29] proposed high embedding capacity reversible technique for medical images. The cover image is hierarchically divided into smaller blocks and further histogram shifting mechanism is applied for data hiding.

J. WATERMARKING USING SPECIAL PROPERTIES OF SINGLE TRANSFORM:

Discrete Wavelet Transform (DWT) is very similar to Human Visual System (HVS). It allows multi-resolution decomposition of image and exact reconstruction of decomposed image. Hence DWT has become researchers focus. Roland Kwitt et al.[30] presented DWT based spread spectrum blind watermarking.Discrete Cosine Transform(DCT) has 'energy compaction property'. Most of visually significant information of natural images is concentrated in few coefficients of DCT. Spatio-Temporal Just Noticeable distortion (JND) based scheme for grey scale image in DCT domain is presented by Zhenyu Wei et al.[31]. This JND based scheme incorporates spatial contrast sensitivity function (CSF), luminance effect, contrast masking effect and Gamma correction in DCT domain. Experimental results show that the Spatio-Temporal JND model is consistent with HVS. Tsz Kin Tsui et al.[32] presented Fourier transform based color image watermarking scheme consistent with our Human Visual System. This scheme embeds watermark into all (luminance and chrominance) components of color images. The logic is based on fact that addition and subtraction of two colors produce other colors.

MatthieuUrvoy et al.[33] developed watermarking technique in Fourier domain which is robust against geometrical distortions. The watermark embedding is done within Fourier domain by substitution of both the magnitude (energy) and the phase (information). Peng LUO et al.[34] proposed color image watermarking technique using non sampled contourlet transform (NSCT) with HVS masking technique to obtain high robustness and transparency. Lihong Cui et al.[35] presented multi-wavelet based adaptive scheme based on Just Perceptual Weighting(JPW) model. This model includes various masking effects of HVS perception by considering eye sensitivity to change in noise depending on spatial frequency, texture and luminance of image sub bands. Chalamala S.R et al. [36] proposed new lightweight and robust method image watermarking based on contourlet transform compared its performance with a wavelet transform based method. The fixed size block of sub band coefficients are obtained using contourlet transform and watermark bit is embedded into one of the Eigenvalues of that fixed size block. The authors proved that watermarking techniques using contourlettransfom are more robust than watermarking techniques using wavelet transform under several attacks but wavelet based techniques give better perpetual transparency than contourlet based techniques.

K. WATERMARKING BASED ON COMPOSITION OF TWO TRANSFORMS:

Some researchers combined spatial properties of transforms giving composition of multiple transforms. The combined DCT-DWT based technique is proposed by KetaRaval et al.[37]. The composite DWT-DCT based technique is proposed by Saied AmirgholipourKasmani et al.[38] in which binary watermarked image is embedded in selected sub bands of three level transformed of host image. Each of DWT sub band is selected and it's DCT transform of is computed. Finally, Pseudorandom Number (PN) sequences of watermark bits are generated and thosePN sequencesare embedded in coefficients of related DCT middle frequencies. Singular value decomposition (SVD) gives good stability.Small modifications in singular values do not cause many variations. Hence, some of researchers have combined good properties of DWT and SVD. Hailiang Shi et al.[39] combined DWT and SVD transforms for rotation, scaling and translation(RST) invariant scheme. The scheme is found robust for variety of RST attacks. Priyanka Singh et al.[40] used combined

DWT-SVD based technique in YUV and YIQ color spaces. The technique is tested with cover images of 512x512 sizefor checking perceptual transparency and robustness. The method demonstrated better performance of Y color space. Chih-Chin Lai et al. [41] used DWT and SVD hybridization for achieving robustness against geometric attacks, noising attacks, denoising attacks, format compression attacks and other image processing attacks. Redundant Discrete Wavelet Transform (RDWT) is variation of DWT to overcome shift-variant limitation of DWT which occurs due to down sampling process after each level of filtering that causes significant change in wavelet coefficient. Samira Lagzian et al.[42] presented RDWT-SVD based method that embeds data in all LL,LH,HL and HH sub bands of DWT. The scheme found robust against rotation attack, Gaussian noise, salt & pepper attack, speckle noise attack, median filtering attack and histogram equalization attack.The composition of DWT-DFT isused by Xiangui Kang et al.[43] for achieving robustness against different affine transforms and compression attacks.

L. WATERMARKING BASED ON COMPOSITION OF TWO TRANSFORMS:

The composition of three transforms is also used by some of researchers. SivavenkateswaraRao. V et al.[44] combined DWT,DCT and SVD for optimization of robustness and fidelity. The scheme is tested for attacks including Gaussian noise(σ=0.01), rescaling (512-1024-512), histogram equalization, gamma correction (0.7), low pass filtering, JPEG Compression (quality factor: 80), contrast adjustment (20) and false positive problem checking.

M. OPTIMIZATION BASED WATERMARKING TECHNIQUES:

It is challenging issue to achieve robustness and imperceptibility i.e. fidelity under high payload scenario maintaining security of underlying watermarking technique. Some researchers proposed optimization based solutions. DCT-Singular Value Decomposition (SVD) based genetic algorithm(GA) technique by Chih-Chin Lai et al.[45], wavelet based GA method by K.Ramanjaneyulu et al.[46], quantization with DWT-SVD non-dominated Sorting Genetic Algorithm-II proposed by Jiann-Shu Lee et al.[47] are example GA based techniques proposed used for optimization of robustness and fidelity. Particle swarm optimization effectively explores solution space for optimal feature subset as per criteria specified as per requirement of the application. The particle swarm optimization with feature based robust image watermarking using DWT-SVD is proposed by Chih-Chin Lai et al.[48] . SulagnaLaha et al.[49] proposed robust invisible digital watermarking technique using Particle Swarm Optimization (PSO) with SVD. Image watermarking system demands strongly techniques so that underlying system should be unbreakable.

N. WATERMARKING TECHNIQUES USING EFFECTIVE SCRAMBLING METHODS:

Many researchers have used variety of scrambling methods to provide security. Watermark scrambling methods are used to convert image into unrecognizable patterns so that extracted watermark cannot be recognized directly. Fibonacci transform, Fibonacci Q transform, Arnold transform, modified Arnold transform, Lucas transform, Fibonacci-Lucas transform with their comparative sustainability against robustness is presented by Minati Mishra et al.[50], grey code transformation, affine modular transformation are also proposed by EhsanNezhadarya et al.[51].An excellent style manual for science writers is [7].

IV. DISCCUSSIONS AND CONCLUSIONS:

Based on the classical review presented here, some significant conclusions are drawn here:

- The highly secured, strongly robust with high payload watermarking techniques for grey scale, color and medical images are required in majority application areas of image processing.
- The spatial domain image watermarking techniques are simple for implementation but support less watermark information hiding capacity, poor perceptual transparency and poor correlation between original and extracted watermark.
- Transform domain methods insert watermark in transformed coefficients of cover mage. They have better watermark hiding capacity and better robustness compared to spatial domain watermarking methods.
- DWT has multi-resolution property and it is most popular transform preferred for image watermarking. As per international standard organization (ISO) norms, JPEG2000image compression standard has replaced DCT by DWT. Hence majority of researchers are focusing on DWT for implementation of watermarking frameworks.
- In spread Spectrum communication, a narrow band signal is transmitted over larger bandwidth such that signal energy present in any frequency is undetectable. Spreading the watermark through spread spectrum of image ensures large measure of security. But spread spectrum based watermarking methods have low watermark information hiding capacity.
- Many researchers working in watermarking field have tried to prove that watermarking techniques using

composition of two or three transforms give better performance than single transform.

- The most of the existing image watermarking methods have failed to achieve imperceptibility and robustness simultaneously. These quality parameters conflict each other under high watermark embedding capacity.
- The GA based optimization techniques are presented by some researchers to optimize perceptual transparency and robustness by embedding high payload. But slow execution speed is limitation of GA based methods as it searches optimizes solution in large space.
- The watermark scrambling methods are used to convert image into unrecognizable patterns so that extracted watermark cannot be recognized directly. Hence the scrambling methods are effectively used by many researchers for security provision.

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