STUDY OF CONTEMPORARY DIGITAL WATERMARKING TECHNIQUES

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Abstract

Digital watermarking is a concept of embedding authentication information. It uses an algorithm for inserting a watermark to protect the copyright of media. It became very important in various application areas like video, audio, text, image etc... A number of watermark techniques have been proposed by many authors in the last several years. However, there is a need to have enough analysis and comparative study on these techniques. This paper has discussed the conventional watermark techniques from various points of view. Currently watermark techniques based on the transform domain are more popular than those of the spatial domain.

Keywords: *Digital Watermarking, Transform techniques, Spread Spectrum Techniques*

1. Introduction

Digital contents are spreading rapidly in the world via the internet. It is possible to produce a number of copies of the same data with the original data without any limitation. The growth of internetwork has increased the need for the protection of digital media. Digital media includes text, digital audio, images, video and software. Many approaches are available for protecting digital content, like encryption, authentication and time stamping. Techniques are needed to prevent the copying, forgery and unauthorized distribution of images and video. Without such methods, placing images on a public network puts the owners at risk of theft and undetected alteration. 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 image. Then the watermarked digital image is transmitted or stored on Internet. If a person makes a modification and displays in his web site then that is called an attack. While the modification may not be malicious, the term attack arises from copyright protection application, where third parties may attempt to remove the digital watermark through modification. Detection or extraction is an algorithm which is applied to the attacked image to attempt to extract the watermark from it. Digital Watermarking can be used for a wide range of applications like Copyright protection, Fingerprinting, Broadcast Monitoring, Covert Communication, Tampering detection. It serves to identify the manufacturer and thus authenticate the product, Media serialization and tracking, Asset control and management, also provides Filtering/ classifications and Authentication/ integrity.

Digital watermarking offers advantages such as Privacy prevention for multimedia data, Creates a persistent identity to enable content to be managed more effectively and help enable new business models, greater security and broader consumer choice. Readable by computers/devices while remaining imperceptible to humans. Enables content identification or rights enforcement in digital or analog content distribution. Communicates copyright information and associated rights. It enables interoperability across different content management systems/devices and Offers copyright stakeholder's persistent content identification and authentication, also Provide appropriate trade-off between imperceptivity and robustness against deformation due to common audio manipulations and synchronization attacks. The key advantage is that it is adaptable to all media types, platforms, and distribution and transmission methods, Auto complimentary codes also provide beneficiaries. The disadvantages of digital watermarking are that a subscriber cannot significantly alter some files without sacrificing the quality or utility of the data, Obscures image, Easy to remove with the assistance of image-editing software, limited protection and also time consuming.

The rest of the paper organized as follows. Section 2 explains the watermark classification. Various watermark techniques were discussed in section 3.

2. Classification

Digital watermarking techniques can be classified based on their Robustness, Perceptibility and capacity. A watermark is called fragile if it fails to be detected after the slightest modification. Fragile watermarks are commonly used for integrity proof. A watermark is also called semi-fragile if it resists benign transformations but fails detection after malignant transformations. Semi-fragile watermarks are commonly used to detect malignant

transformations. A watermark is called robust if it resists a designated class of transformations. Robust watermarks are commonly used in copyright applications and copy protection applications. A watermark is called imperceptible if the original cover signal and the marked signal are perceptually indistinguishable un watermarked content or its presence in the marked signal is noticeable, but non-intrusive and also it is easy to create robust watermarks or imperceptible watermarks, but the creation of robust and imperceptible watermarks has proven to be quite challenging. The length of the embedded message m determines two different main classes of watermarking schemes. First, the message is conceptually zero-bit long and the system is designed in order to detect Italic only the presence or the absence of the watermark in the marked object. Second, the message m is a n-bit long stream. This kind of schemes is usually referred to as multiple bit watermarking or non zero-bit watermarking schemes. The main working domains for embedding a digital watermark into a signal are Time and spatial domain, frequency domain and wavelet domain.

2.1 Time and Space Domain

In the time or space domain, enhancement of the input signal through filtering is the most acceptable processing approach. A number of filter applications, like linear filter, causal filter, time-invariant filter, stable filter and finite impulse response filter(FIR), used under this process technique. A filter may also be described as a difference equation, a collection of zeroes and poles. The output of a linear digital filter to any given input may be calculated by convolving the input signal with the impulse response.

2.2 Frequency Domain

To analyze the signal properties the frequency domain analysis is used. This allows to study the spectrum to determine which frequencies are present in the input signal and which are missing. Signals are converted from time or space domain to the frequency domain the transform techniques like Fourier Transform (FT), Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Discrete Hadamard Transform (DHT), Walsh Hadamard Transform (WHT), Discrete Cosine Transform (DCT) etc... These transform techniques converts the signal information to a magnitude and phase component of each frequency. The transformation of signal is converted to the power spectrum, which is the magnitude of each frequency component squared. In addition to frequency information, phase information is also obtained. In some applications, how the phase varies with frequency can be a significant consideration. Filtering, particularly in non-real time work can also be achieved by converting to the frequency domain, applying the filter and then converting back to the time domain. Frequency domain analysis is also called spectrum or spectral analysis.

2.3 Wavelet Domain

In numerical analysis and functional analysis, a Discrete Wavelet Transform (DWT) is a wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution. it captures both frequency *and* location information (location in time). The first DWT was invented by the [63]. The Dual-Tree Complex Wavelet Transform (CWT) is relatively recent enhancement to the DWT. Other forms of DWT include the non or un decimated wavelet transform, the Newland transform, the Complex wavelet transform and Wavelet packet transform.

3. Watermarking Techniques

Many watermarking algorithms were developed based on spread spectrum methodologies, quantization and amplitude modulation techniques. If the marked signal is obtained by an additive modification then this watermarking method is referred as Spread-spectrum. If the marked signal is obtained by quantization then this watermarking method is referred as quantization type. If the marked signal is embedded by additive method then this watermarking method is referred as amplitude modulation.

In [1], Chung-Chi Tsai have proposed a practical content based video copy detection scheme which is employed as an efficient and effective content matching approach to determine whether an investigated video is a duplicated copy and may infringe the copyright. In this watermarking scheme, the key frames of videos are first retrieved and the methods of Vector Quantization (VQ) and SVD were applied to extract the spatial features of these Frames. After locating the visually similar key-frame pairs by the matched VQ code words, the shot lengths were used as the temporal features for further matching to achieve a more accurate result. In [2]N.F. Maxemchuk and S. Low have changed line space and character space to embed information in textual images for bulk electronic publications. This is a major impediment to electronic publishing. Illegal redistribution can be discouraged by placing unique marks in each copy and registering the copy with the original recipient. If an illegal copy is discovered, the original recipient can be identified. In [3],E. Koch and J. Zhao have discussed a set of novel steganographic methods to secretly embed robust labels into image data for identifying image copyright holder and original distributor in digital networked environment. The embedded label is undetectable, irremovable and unalterable. Furthermore it can survive processing which

does not seriously reduce the quality of the image, such as lossy image compression, low pass filtering and image format conversions. In [4], Prasad et al. have discussed a watermarking method based on complete complementary code(CCC) and fast walsh Hadamard transform technique. In this they have generated unique code by applying CCC technique on the given watermark. The obtained unique code can then be embedded to transformed matrix of the original image. This method has shown acceptable results on various compression techniques. In [5], J. M. Shieh et al. have presented a robust watermarking approach for hiding grayscale watermarks into digital images. The proposed method embeds the singular values (SVs) of the original image into the watermark to attain the lossless objective. In addition to the guarantee of the quality of extracted watermark image, the security of the referenced watermark is further strengthened by applying chaos permutation on it in advance. The proposed scheme leads to satisfactory robustness to various attacks and is compared to other well-known grayscale watermarking methods to reveal its efficiency for practical applications.

In [6], Bai Ying Lei et al. have proposed a new, blind and robust audio watermarking scheme based on Sigular Value Decomposition (SVD) and DCT with the synchronization code technique. 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. In [7], Liu Ping Feng , et al. have proposed a blind watermark algorithm which is the combination of DWT and DCT. The watermark is scrambled by Arnold and embedded in a spread spectrum pattern using pseudo random. The block-based DCT transform of DWT LL sub-band is computed and the pseudo random sequence of the watermark bits are embedded in the mid frequency coefficients of the corresponding DCT blocks. Using DWT prior to DCT will provide better imperceptibility and higher robustness against signal processing attacks. In [8], Hui-Yu Huang et al. have proposed a video watermarking method which is based on a pseudo-3-D DCT and quantization index modulation (QIM). The secret key, which is used for extraction which is done blindly, is created by embedding the watermark into the quantization regions from the successive raw frames in the uncompressed domain and recording the relative information. In [9], Amit Phadikar et al. have presented digital watermarking algorithm for the purpose of copyright protection and integrity verification of image database by using QIM, where by using quad tree decomposition and image database on a single entity. To embed a watermark, a set of features are extracted from the host media and is quantized to the nearest code of the quantizer corresponding to the watermark.

In [10], Dawen Xu have proposed a content based authentication watermarking scheme for H.264/AVC video. Considering the new feature of H.264/AVC, the content-based authentication code for spatial tampering is firstly generated using the reliable features extracted from video frame blocks. The authentication code, which can detect malicious manipulations but allow recompression, is embedded into the DCT coefficients in diagonal positions using a novel modulation method. Experimental results show that the proposed scheme can discriminate the malicious tampering from the mild signal processing. The tampered location can also be approximately determined according to the glide window and the predefined threshold. In [11], Qi-yuan Sua and Hua-Qiang Yuan have proposed an algorithm to watermark the digital audio using both DWT and DCT. This watermarking algorithm guarantees the reliability and origin source endorsement of the multimedia file without mortifying its overall quality.

In [12], Jagdish C. Patra et al. have proposed , a novel Chinese Remainder Theorem (CRT) based technique for digital watermarking, this provides copyright protection and authentication of multimedia data, in the DCT domain, which is robust to several common attacks. The proposed scheme is able to achieve a Tamper Assessment Function (TAF) value of less than 10% when the watermarked image undergoes JPEG compression between a range of 50 to 70%, whereas, the spatial CRT-based scheme produce TAF value of more than 35% and the SVD-based scheme produces TAF value between 10 to 40% depending on the host image, for the same range of compression. In [13], Ray-Shine Run, Shi-Jinn Horng, Jui-Lin Lai, Tzong-Wang Kao, Rong-Jian Chen proposed a method to protect the copyright of multimedia documents. In [14], Dianwu Gao et al. have proposed a an algorithm based on union chaos technology and the DCT theory, the design have realized one kind based on the air zone image watermark algorithm. The experiment and the analysis indicated that, this algorithm realizes quite simply, also the invisibility is good, moreover resistance cutting and JPEG compression ability is strong, the algorithm time order of complexity is low, the encryption effect is good, the security is high. In [15], Min Wu proposed a method for block-based image according to smoothness and successive degrees, calculated the priority of edge points, and then embedded the disrupted watermark information in the location of these pixels with high priority.

In [16], Roland Hu et al. has provided a measure of distortions that each DCT coefficient can resist based on the human visual system. In [17], Didi Rosiyadi et al. have proposed efficient copyright protection scheme for e-government document images. They used the hybrid DCT-

SVD watermarking scheme based on GA to find the optimization scaling factor of the watermark image for e-government document image. In [18], Qiuping Guo Bin He Yuqian Wu proposed a challenge to identify whether the paper archive is credible. This method improves a DCT-based binary image digital watermarking algorithm. This algorithm not only applies to text, but also to other binary images. In [46], H.Lu et al. have presented an algorithm which will blur the original binary text for pre-processing, and secret information was embedded into the DC component of DCT domain. In [19], Pengfei Wang and Yewang Chen have proposed a watermarking process which is carried out during JPEG quantization process. Each 8×8 DCT block is subdivided into 4 groups based on logistic system in order to obtain the watermarked JPEG image, all of the groups are check coded by the check bits. The tamper probability is determined by checking DCT groups. In [20], Reza Mortezaei and Mohsen Ebrahimi Moghaddam have proposed a robust lossless watermarking method, which is anticipated based on applying fuzzy integral to find similarity between DCT coefficients of original image and watermark. The experimental results confirmed that the proposed method was robust against various attacks and the extracted watermark was visually similar to original one.

In [21], Chunlin Song et al. have proposed a novel watermarking technique in which watermark data is embedded on different regions of the host image using a combination of DWT and SVD techniques. To facilitate this, the technique utilizes dual watermarking technologies and embeds parts of the watermark images into selected regions in the host image. In [22], P.karthigai kumar and anumol,k.baskaran have proposed a design to overcome the disadvantages like larger area and high power consumption. The algorithm used in it is prototyped in virtex-6 FPGA. The results show that proposed design can operate at maximum frequency of 344 MHz in Vertex 6 FPGA by consuming only 1.1 % of available device. In[51], Karthigaikumar et al have implemented a low power robust invisible watermarking processor. The algorithm occupies 457 slices with less power. The algorithm is implemented both in FPGA and ASIC. In [52], Mansorary et al have introduced FPGA implementation of Fragile watermarking algorithm and obtained 1112 slices at 350 MHz frequency in vertex 6 FPGA and 2103 slices in vertex 4 with the frequency of 260 MHz. In [23], LI Hui-fang et al. have proposed that the DWT is selected to achieve the embedding and distilling of image digital watermarking on the basis of the characteristics of image digital watermarking as well as its processing procedure.In [24], Saeed Rastegar et al. have proposed a hybrid robust digital watermarking algorithm based on finite Radon transform (FRAT) and SVD is simulated. This procedure has used the middle frequency of HL3 and LH3 extracted by DWT. In [25], Qi-yuan Sua and Hua-Qiang Yuan have proposed an algorithm that is used in watermarking the digital audio using both DWT and DCT. This watermarking algorithm guarantees the reliability and origin source endorsement of the multimedia file without mortifying its overall quality. The multi-resolution of DWT and the de-correlation capability and energy aggregation of DCT are used.

In [26], Hung-Hsu Tsai et al. have proposed a novel blind watermarking scheme for image copyright protection by using the DWT based on SVD and SVR, additionally the particle swarm optimization (PSO) is further utilized to optimize the scheme where the watermark bit can be computed using the watermarked coefficient and its corresponding estimate coefficient. In [27], Gaurav Bhatnagar and Balasubramanian Raman proposed a new semi-blind reference watermarking scheme based on DWT and SVD for copyright protection and authenticity. Watermark is embedded into reference image by modifying the singular values of the watermark. After decomposing the host image into four sub-bands, they applied SVD to each sub-band and embedded singular values of the watermark into the sub-bands. In [53], Li et al. proposed a hybrid DWT-SVD domain watermarking scheme considering human visual system properties. After decomposing the host image into four sub-bands, they applied SVD to each sub-band and embedded singular values of the watermark into the sub-bands. In [54], Joo et al. have introduced robust reference watermarking scheme in which they have embedded watermarking into low frequency. For this purpose, host image is decomposed by the means of DWT. Suppose the coarsest level of decomposition is n, then LLn is selected and again 1-level DWT is applied on it. In [28], Ray-Shine Run et al. have proposed two methods to improve the reliability and robustness. To improve the reliability, for the first method, the principal components of the watermark are embedded into the host image in DCT and for the second method, those are embedded into the host image in DWT. To improve the robustness, the PSO is used for finding the suitable scaling factors.

In [29], Mohamed Ouhsain and A.Ben Hamza proposed approach is to decompose an image into four wavelet sub-bands and then apply NMF to the blocks of each sub-band, followed by an Eigen decomposition distortion step, a robust image watermarking scheme for copyright protection using Discrete Wavelet Transform (DWT) and Nonnegative Matrix Factorization (NMF). In [30], Min-Jen Tsai proposed a novel visible watermarking algorithm based on the content and contrast aware (COCOA) technique with the consideration of Human Visual System (HVS) model. The COCOA visible watermarking utilizes the global and local characteristics of the host and

watermark images in the DWT domain. The embedding energy of watermark and the perceptual translucence, the utilization of contrast–sensitive function, noise visible function of perceptual model, and the basis function amplitudes of DWT coefficients are fine-tuned, for the best quality of perceptual translucence and noise reduction of the COCOA algorithm. In [31], Lijing Zhang and Aihua Li have proposed a digital image watermarking algorithm in which the original image is transformed by DWT and SVD and the watermarking image is processed by Arnold transform and SVD. In [32], Liu Ping Feng et al. have proposed a blind watermarking algorithm based on DWT and DCT, in which the watermark is scrambled by Arnold and embedded in a spread spectrum pattern using pseudo random. The block-based DCT transform of DWT LL sub-band is computed and the pseudo random sequence of the watermark bits are embedded in the mid frequency coefficients of the corresponding DCT blocks.

In [33], Rakhi Dubolia et al. have discussed PSNR comparison of algorithms of DCT and DWT at different threshold value for different images. In [34], Ms. Kapre Bhagyashri S and Mrs. Joshi M.Y. proposed a new SVD and DWT based technique for hiding watermark in full frequency band color images. In [35], R. Reyes et al. have presented a public video watermarking algorithm, whose robustness depends on the embedding energy, which is limited due to degradation of video sequence caused by the same watermark signal. This algorithm embeds a perceptually recognizable binary pattern, such as owner's logotype to increase the security of the proposed scheme. In [36], Sartid Vongpraphip and Mahasak Ketcham proposed a new robust audio watermarking scheme which deals with DWT and SVD. Adaptive Tabu Search (ATS) have been used as mathematical tools for embedding data into an audio signal. In [37], Chih-Chin Lal and Cheng-Chih Tsai proposed a hybrid image-watermarking technique based on DWT and SVD, where the watermark is embedded on the singular values of the cover image's DWT sub bands. Experimental results of the proposed technique have shown both the significant improvement in imperceptibility and the robustness under attacks. In [38], Chen Wenjuan and Yang Hongmei proposed a digital watermarking embedding algorithm using DWT based on SVD. The algorithm can well withstand various geometrical attacks as rotation, scaling, cropping and translation. In [39], Feng Wenge Liu Lei has proposed a zero-bit watermarking algorithm based on SVD and DWT. The host image is firstly performed by DWT, and then divided into non-overlap blocks. SVD factorization is performed on each block. Watermarks are generated by comprising the singular value of different block. The zero-bit watermarking technique uses the feature of images to generate watermarks to be authenticator of the digital multimedia, and makes host media without any distortion. Zero-bit watermarking, as a special technique in digital watermarking, uses the feature of images to generate watermarks as authenticator.

In [40], Feng Shi et al. have proposed a digital watermarking algorithm based on DWT generally embedded in high frequency watermarks. The algorithm has difficulty to deal with some offensive algorithms, such as collusion attacks, cheating attacks. In [41], Marzieh Amini et al. have proposed a new halftone image watermarking based on DWT combined with SVD technique. Halftoning is the process of representing grayscale images using just black and white i.e. binary levels. The original image is an error diffusion halftone image which is decomposed into 2-level wavelet transform in the second level of wavelet transform, the sub band with the midst variance intensity is selected as a place for inserting the watermark. In extraction process, detector response is computed to obtain the original watermark, error diffusion based methods achieve good visual quality and reasonable computational complexity. In [42], Musa S. Al-Yaman et al. proposed a digital audio watermarking algorithm based on DWT and SVD techniques along with utilizing biometric features. In [43], Morteza Makhloghi et al. proposed a method for the embedding by modifying the specific bits of the singular values of the transformed host image with the bits of the watermark image's singular values. Although, the spatial domain watermarking methods are simpler, these methods are not robust against different geometric and non geometric attacks. In [44], Li De, Jihah Nah and JongWeon Kim proposed Forensic watermarking, which is used to trace the illegal distribution. For high capacity off axis hologram is developed and it is embedded into sub band of DWT domain so that we can reduce signal interference, they improved the algorithm safety and detection performance by using SVD for the signal embedded hologram. In [45], Grace C.-W.Ting et al. proposed a semi-blind watermarking scheme based on SVD. The have developed robust watermarking schemes so that the watermarked image should survive signal processing operations and also intentional tampering and therefore the watermark should still be recoverable from it even after that. In [47], Chih-Chin Lai proposed a watermarking scheme which is based on SVD and a tiny genetic algorithm (Tiny-GA). The Tiny-GA offers a systematic way to consider the improvements of the scaling factors that are used to control the strength of the embedded watermark, with this scheme; the embedded watermark can successfully survive after attacked by image-processing operations.

In [48], Gaurav Bhatnagar proposed a technique, which is to first scale up the size of host image equal to the size of watermark using chaotic map and Hessenberg decomposition followed by the redundant wavelet

transform. SVD is used to embed gray scale watermark in the low frequency sub-band at the finest level. Also the paper has discussed a reliable watermark extraction scheme is developed for extracting both the watermarks. In [50], Gaurav Bhatnagar et al. have proposed a Watermarking algorithm for image authentication using fractional wavelet packet transform (FRWPT) via singular value decomposition (SVD). The proposed algorithm is based on embedding in the singular values of the host image, where the watermark is added to the transform coefficients. Also a reliable watermark extraction algorithm is developed for the extraction of watermark from the distorted image. In [56], Na Maet al. have proposed DWT, Walsh and SV combination of digital watermarking algorithms. The energy in which Haar wavelet decomposition of the characteristics in the low-frequency coefficients and by Walsh transformation, block and calculate the adaptive embedding strength, greatly improved watermark in the human visual transparency, then using anti-geometric distortion of the SV decomposition. Experiments show that the algorithm is a crop, scale, translation ,noise, (JPEG) compression, median filtering, image processing has good robustness, in rotation 45°of the extracted watermark image processing may be effective but the quality is not high. In [57], Rajlaxmi Chouhan et al. have proposed a non-blind watermark extraction technique for robust extraction of a grayscale watermark based on dynamic stochastic resonance (DSR)technique. SVD is used for carrying watermarking embedding. In [59], Amnach Khawneet al. have presented a study of image watermarking using robust SVD in L1-norm sub-space. The watermarked image attacked by noise is greatly degraded. This results in the effects of transparency and robustness of the watermarked image. The L1 regression algorithm calculates eigen-vector. The L1 regression coefficients can be determined by estimating the elements of the left eigenvector with regression of each column of each block of attacked image. In [60], Wang Hui-Qin and Zhao Min proposed scheme for copyright protection and content authentication of digital color image based on SVD in DWT Domain. In this technique firstly, the blue component of the original color image is decomposed with DWT, then, the low-frequency coefficients are transformed by block-SVD and then and a binary watermark scrambled by logistic chaotic is embedded by quantizing the singular values of primitive image. Also the watermark extraction procedure was discussed without the original image.

In [61], Iman Omidvar Tehrani and Subariah Ibrahim have proposed a watermarking algorithm to protect images against illegal duplications. In the method U component is explored for embedding the watermark. In SVD based watermarking, first the original image matrix decomposes into three matrices using SVD transformation then the watermark can be embedded in one or in the combination of three matrices. In [58], Gaurav Bhatnagar and Q.M. Jonathan Wu have proposed a novel reference watermarking scheme based on Gyrator transform. In this method the original image is segmented into non-overlapping blocks using zigzag scan followed by the reference image formation considering the spatial frequency of the blocks. The Reference image is then transformed in the Gyrator domain. Modifying the singular values of reference image in Gyrator domain with the singular values of watermark image is done for embedding the watermark. In [55], WANG Jing-pei et al. have proposed an image watermarking algorithm based on SVD. Instead of using randomly Gaussian sequence as watermark, a meaningful text message modulated by media hash sequence is used as watermark.The problem of protocol attack can be solved by this method. In [49], Chen Wenjuan and Yang Hongmei have proposed a digital watermarking embedding algorithm using DWT based on SVD using locality and multi scale of wavelet transform and stability of SVD in to consideration. This method remains to be an improvement in embedding watermark adaptively. In [62],Shenchen ZHAO has presented a new technique of image digital watermarking technique based on DWT. This technique has combined a pre-transformation in time domain with DWT. This paper exploits orthogonal matrix to multiply each matrix block of the host image, and then, embeds the watermark information into the DWT domain of the processed host image.

4. Conclusion

A number of contemporary digital watermarking techniques exist to support copy right protection for Internet users. This paper has discussed the importance of these watermarking methods for understanding them and a help for new researchers in related areas. We classified these works based on the inserted media category, the perceptivity, the robustness, the inserting watermark type, the processing method and the necessary data for the watermark extraction. Most of the researches handled the watermark techniques on image media. Spatial domain and transform domain watermark techniques are the most concern areas for embedding watermark in to the media. In terms of processing domain, transform domain has been used rather than the spatial domain in most of the techniques. Especially DCT-based approach has been widely used among the transform domain approaches, however, currently wavelet-based approach which has the multi-resolution characteristic, is getting its popularity day by day. With the broad spreading of internet, audio and video based services such as MP3 and VOD are also being widely used. Therefore, proper audio and video

watermarking techniques are also required to study intensively.

Acknowledgments
First and Second Authors would like to convey regards to Dr. M.V.N.K. Prasad for guiding in their research work. They also convey their regards to the Chairman and Principal, Geethanjali College of Engineering and Technology, for supporting in all aspects.

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