Design and Implementation of Transform Domain Watermarking Techniques for Color Image Authentication

Abstract submitted for the Degree of Doctor of Philosophy (Engineering) in the Department of Computer Science and Engineering, Faculty of Engineering, Technology and Management, University of Kalyani

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The rapid advancement of communication system enables easier transmission of materials such as text, image, audio and video over the public network. The private information might be destroyed, tampered, copied or altered by the impostor in the unrestricted domain. In effect, important information such as secret message, corporate data etc. are to be protected from any such illegal manipulation or malicious attacks. Therefore, security has becomes as much as important in today’s world. Information hiding is the art of fabricating secret information into the cover media by keeping the fidelity near equal to original one.

Two prominent areas of information hiding processes are steganography and watermarking respectively. Steganography reveals the mechanism of fabricating the secret messages into the carrier media in which the fabricated secret information is the object of communication. Digital watermarking also fabricate secret information into the digital media however, digital watermarking focuses mainly on the copy-right protection and authentication of digital content. The digital watermarking can further be classified into fragile, semi-fragile and robust categories. The major application of fragile watermarking is authentication and integrity verification of digital images, wherein the fabricated watermark is expected to be destroyed when the attacks are mounted on the host media. Cryptographic techniques such as message digest or digital signature can also be used for authentication. Semi-fragile watermarking techniques aim at detecting malicious alterations on an image, while allowing tolerable manipulations such as lossy-compression. A digital watermark is said to be robust, if it resists certain class of transformations. Robust watermarking may be used in copy-right protection applications to carry copy and no access control information. For a “fragile” image authentication, a single bit error in the hidden watermark leads to a totally different authenticator, however, for a “semi-fragile” image authentication the authenticator does not altered at all. Due to the high sensitivity against malicious attacks, “fragile” watermarking is one of the suggestive solutions to verify the authenticity however, “semi-fragile” watermarking based authentication reveal the sensitive nature to content modification and serious image quality distortion. The latter one is ideally independent on the logical content-based, non-variant relation among image pixels. Watermark can be inserted into a cover media in two different domains: Spatial and Transform.

The basic characteristics of watermarking are robustness imperceptibility and payload. The payload is nothing but the measure of the embedded information into the cover media. Imperceptibility concerns the visual inability to detect the secret information, and robustness refers to the ability to resist visual/geometrical attacks. However, there is a tradeoff among these characteristics. Spatial-domain techniques are implemented easily but suffer from the lack of security and robustness against image processing attacks such as filtering, blurring, noise addition and compression etc. On the contrary, transform domain techniques offer improved security and high robustness against such attacks. However, proposed watermarking schemes are basically designed for authentication purpose and hence, the payload and imperceptibility is considered as the primary issues.

It is seen that most of the existing watermarking techniques are applicable for gray-scale images. On the contrary, embedding in color images could be an effective choice since the use of color images as cover media ensured better transparency and higher payload. In addition, it has been observed that the major application of watermarking is copy-right protection. In contrast, very few of the researches have chosen watermarking as a solution of authentication. Watermarking based on Slant Transform (ST), Contourlet Transformation (CT) and Discrete Cosine Transformation (DCT) used selective components for secret bits insertion which effects high robustness, low payload and significant quality distortion. The trade-off between payload and image quality can be maintained by choosing the block size as 2 x 2 or 1 x 2 which in turn provides the payload values in the range [0.5 – 3 bpB] with acceptable quality distortion in the output watermarked images. It is seen that DCT based watermarking scheme deals with fractional coefficients which ensures floating-point calculation and makes an operation slower. It could be avoided by introducing such transforms which ensured real transformed matrices as output with respect to real pixel matrices as input. Most of the watermarking schemes in transform domain suffer from overflow and underflow which could be avoided by using pixel adjustment process prior to embedding. Sometimes, an additional re-adjustment operation may also be incorporated to avoid overflow and underflow situations. The re-computed pixel components become non-negative and fall into the range [0, 255].

The main objectives of this thesis are:

- To introduce color image based authentication which will ensure the integrity and authenticity of color images.
- To investigate the limitations of existing watermarking schemes and to overcome the limitations in terms of image quality and payload.
- To design and develop new schemes to improve the enhancement of watermarked images quality.

- To enhance the security of embedded information by fabricating the watermark in transform domain.
- To enhance payload by maintaining the tradeoff between quality and payload.
- To improve the quality based on genetic algorithm based optimization/quality enhancement scheme.
- To avoid overflow and underflow conditions
- To ensure only real valued calculations

In this thesis, fragile watermarking techniques have been proposed for color image authentication based on Discrete Hartley Transform (DHT), Legendre Transform (LT), Binomial Transform (BT), Stirling Transform (ST) and group of linear transformations for dihedral group of order 4 (G-lets D4), respectively. The techniques are namely, the watermarking based on Discrete Hartley Transform (WDHT), watermarking based on Legendre Transform (WLT), watermarking based on Binomial Transform (WBT), watermarking based on Stirling Transform (WST) and watermarking based on G-lets D4 domain (WGD4) respectively. Two novel techniques corresponding to each transform has been proposed for 2 x 2 and 1 x 2 sub-blocks. In addition, the quality enhancement (QE) and Genetic Algorithm based optimization (GAO) have also been elaborated to enlighten the post-embedding quality improvement over the above mentioned watermarking techniques.

Watermarking based on Discrete Hartley Transform (WDHT): The Discrete Hartley Transform (DHT) based watermarking is classified into two major sections: 2 x 2 block based watermark fabrication using two dimensional Discrete Hartley Transform (2D-DHT) or more specifically Separable Discrete Hartley Transform (SDHT) and 1 x 2 block based watermark fabrication using one dimensional Discrete Hartley Transform (1D-DHT). The carrier image is decomposed into non-overlapping blocks which in succession are converted into transform domain based on Discrete Hartley Transform (DHT). The pre-embedding pixel adjustment ensures the non-occurrence of overflow and underflow situations. Secret information is fabricated into the transformed components to achieve variable payload (0.5 – 3 bpB) with minimum degradation in fidelity. Inverse Discrete Hartley Transform (IDHT) is applied on each block of embedded components to re-compute the pixel components in spatial domain. However, carrying out the process repeatedly, the watermarked image is produced. The recipient extract the fabricated secret information based on the reverse operation and the authenticity of the secret information is verified through a pair of message digests.

Watermarking based on Legendre Transform (WLT): Two novel fragile watermarking techniques for 2 x 2 and 1 x 2 blocks have been outlined in Legendre Transform (LT) domain. Both schemes achieved payload variation in the range of 0.5 to 3 bpB by keeping the quality of the watermarked image as well perceptible; though, its primary concern is to authenticate color images. The carrier image is decomposed into sub-image blocks which are in turn transformed through Legendre Transform (LT). Watermark (along with a message digest) bits are fabricated into the transformed components in variable proportion to achieve variable payload and considerable quality distortion in the watermarked image. Applying Inverse Legendre Transform (ILT) on embedded blocks, the pixel components are generated in spatial domain. The recipient retrieves the watermark (as well as the message digest) through extraction operation and another message digest is re-computed to verify the authenticity. No overflow or underflow situations are arises during embedding process since a pre-embedding pixel adjustment as well as a post-embedding re-adjustment has already been incorporated.

Watermarking based on Binomial Transform (WBT): To verify the authenticity of color images, Binomial Transform (BT) based fragile watermarking has been proposed using specifications comprising of 2 x 2 and 1 x 2 blocks respectively. Binomial Transform (BT), which is basically a self-inverse symmetric transformation, converts the non-overlapping blocks of the carrier image into transform domain. Also, the pixel components are adjusted prior to embedding to avoid overflow and underflow situations. Secret bits (along with a message digest) are concealed into the transformed components based on a predefined embedding rule to achieve variable payload by allowing a considerable quality distortion. Embedded blocks are re-transformed into the spatial domain through inverse Binomial Transform (IBT) which in succession generates the watermarked image. On embedding, if the problem of overflow and underflow is re-occurred for some exceptional components, then a delicate re-adjustment operation is performed. The recipient retrieves the secret bits through the reverse operation and re-computes another message digest which is compared against the extracted message digest for authentication.

Watermarking based on Stirling Transform (WST): The objective of Stirling Transform (ST) based fragile watermarking schemes is to verify the authenticity of color images by fabricating varying number of secret bits within perceptible quality of degradation. The cover image is decomposed either into 2 x 2 or 1 x 2 non-overlapping blocks which in turn are transformed through Stirling Transform (ST). However, the overflow and underflow problems are managed by applying a pre-embedding pixel adjustment process. Watermark and the message digest (obtained from the watermark) are embedded into the transformed components. The pixel components are re-computed from each block of embedded components by applying inverse Stirling Transform (IST). The 1 x 2 block based scheme further uses Arnold's cat map for scrambling of watermark pixel components to enhance the security. As Stirling Transform (ST) is highly sensitive against a small modification, the overflow and underflow may occur in rare case; however, it can be managed by a re-adjustment process of embedded components. The decoder extracts the hidden watermark and the message digest. Message digest is also re-computed from the extracted watermark which in turn is compared with the extracted message digest to verify the authenticity.

Watermarking based on G-lets D4 domain (WGD4): A group of linear transformations projected on a discrete signal is termed as G-lets in the context of group theory. G-lets are constructed for the dihedral group of order n (i.e., D_n) that can deal with two types of transformations: reflection and rotation. The authentication of color image is carried out based on the fragile watermarking schemes based on group of linear transformations for dihedral group of order 4 (G-lets D4). The dihedral group of order 4 i.e., D_4 is considered as the symmetry group of the square in which the vertices are on the unit circle formed at angles 0, π /2, π, and 3π /2. The watermarking based on group of linear transformations for dihedral group of order 4 (G-lets D4) is applicable for 2 x 2 as well as 1 x 2 blocks. The carrier image has been decomposed into non-overlapping blocks and then each block is converted into the transform domain by applying forward transform in G-lets D4 domain. The message digest obtained from the watermark, size of the watermark and the content of the watermark are embedded into the transformed components in varying proportion. The pixel components are re-computed from each block of embedded components by applying inverse transform in G-lets D4 domain. The recipient extracts the fabricated message digest, size and content of the watermark. Another message digest is computed from the extracted watermark which in turn is compared against the extracted message digest to verify the authenticity.

Quality Enhancement (QE): As a consequence of the incorporation of the Quality enhancement technique, the degradation of image quality has been significantly reduced for watermarking techniques discussed so far. The enhancement scheme is categorized as adaptive quality enhancement and EMD based quality enhancement, respectively. The adaptive quality enhancement phase is introduced in between the fabrication and the inverse transform phases of the corresponding watermarking process. However, the EMD based quality enhancement is introduced only in the 1 x 2 block based watermarking in WGD4 domain before the actual embedding is made. It finds the suitable pair of components from a set of pairs which offers minimum changes in the pixel components on embedding.

Genetic Algorithm based Optimization (GAO): The effectiveness of a watermarking scheme is evaluated based on the characteristics such as imperceptibility, payload, robustness and bit error rate. A digital watermark is called “fragile” if it fails to be detectable after a bit modification. Fragile watermarking is an excellent choice of authenticating digital media wherein, the imperceptibility and payload plays the primary role. In general, increasing payload might reduce the imperceptibility and robustness whereas, decreasing payload might enhance the imperceptibility and robustness. As the characteristics are conflicting among themselves, the watermarking is considered to be an optimization problem. In this pretext, Genetic Algorithm (GA) has been used to solve the optimization problem. Therefore, the distortion of the watermarked images followed by GA optimization is minimized superbly over the proposed watermarking schemes prior to optimization.

Performance of the obtained watermarked images through the above mentioned watermarking schemes is measured in terms of widely acceptable features such as payload, quality, robustness and imperceptibility, respectively. As the research work is based on fragile watermarking, the major emphasis has been given on payload and quality. In general, the quality of watermarked images with respect to the original cover images is measured in terms of peak signal to noise ratio (PSNR), mean squared error (MSE), image fidelity (IF), structural similarity index (SSIM), universal image quality index (UIQ), standard deviation (SD) and standard deviation error (SDE), respectively. Simulation results is made at variable payload (0.5 – 3 bpB) for twenty different benchmark (BMP) images of dimension 512 × 512 such as, (i) Lena, (ii) Baboon, (iii) Pepper, (iv) Airplane, (v) Sailboat, (vi) Earth, (vii) San Diego, (viii) Splash, (ix) Oakland, (x) Foster City, (xi) Anhinga, (xii) Athens, (xiii) Bardowl, (xiv) Barnfall, (xv) Butrfly, (xvi) Bobcat, (xvii) Bodie, (xviii) Bluheron, (xix) Colomtn and (xx) Desert, respectively. However, comparative analysis is made for five cover images such as Lena, Baboon, Pepper, Airplane and Sailboat as these are widely used in existing schemes. The notational representation of quality enhanced (QE) and optimized (GAO) watermarking such as for the 2 x 2 block based WDHT scheme are as follows: WDHT_2x2_QE and WDHT_2x2_GAO etc.

Figure 1 illustrates the investigation of image quality for WDHT_2x2_QE, WDHT_2x2, DPTHDI and DGTDHS, respectively.

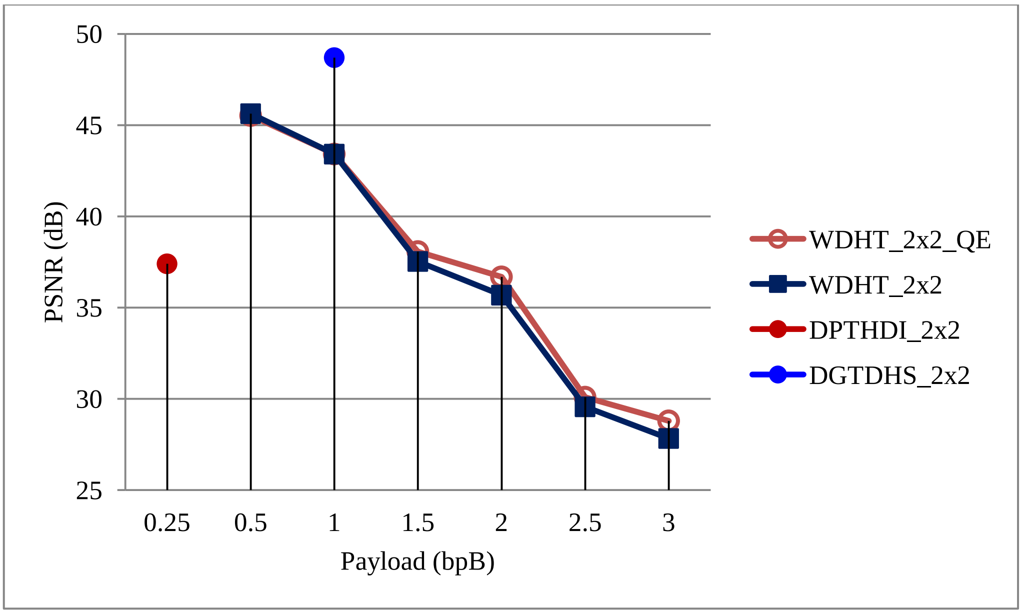

Figure 1. Graphical representation of variation of average PSNR (dB) with respect to payload for WDHT_2x2_QE, WDHT_2x2 and Varsaki et al.'s (DPTHDI and DGTDHS) schemes

Figure 2 illustrates the variation of average PSNR values for WDHT_1x2_QE, WDHT_1x2, WDHT_2x2_QE, DPTHDI and DGTDHS respectively.

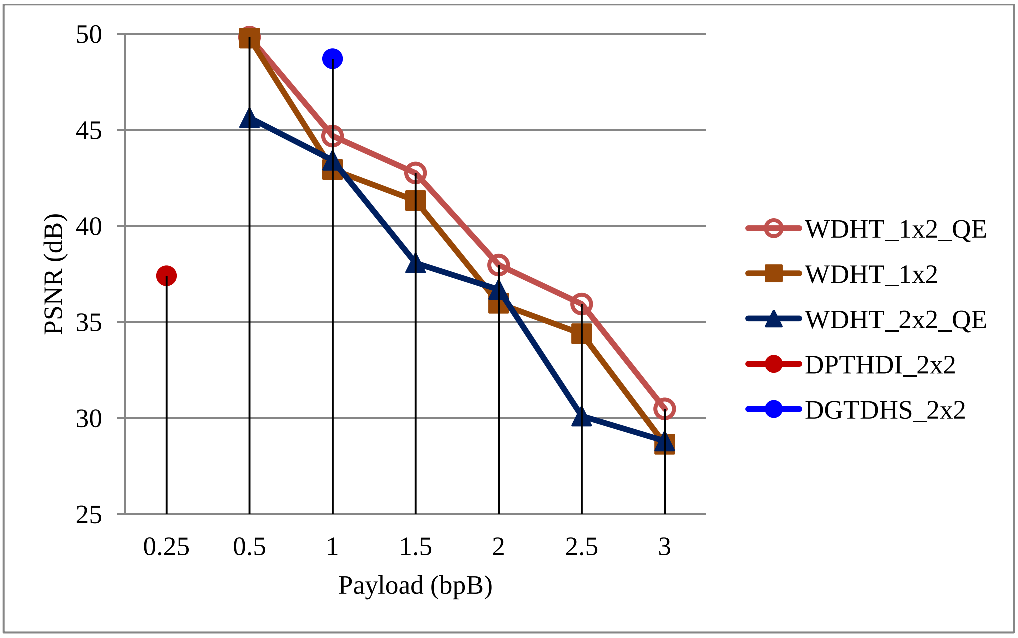

Figure 2. Graphical representation of variation of average PSNR (dB) with respect to payload for WDHT_1x2_QE, WDHT_1x2, WDHT_2x2_QE and Varsaki et al.'s (DPTHDI and DGTDHS) schemes

Figure 3 depicts the comparison of average PSNR for WDHT_2x2_GAO and WDHT_2x2 against the fixed payload based schemes (DPTHDI and DGTDHS).

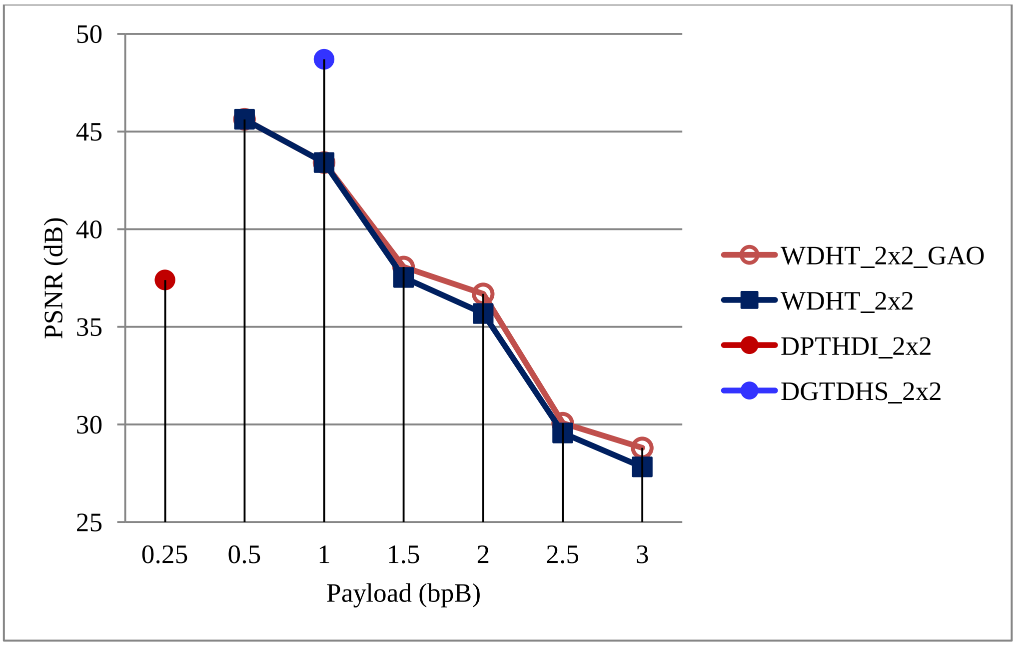

Figure 3. Graphical representation of variation of average PSNR (dB) with respect to payload for WDHT_2x2_GAO, WDHT_2x2 and Varsaki et al.'s (DPTHDI and DGTDHS) schemes

Figure 4 represents the variation of average PSNR for WDHT_1x2_GAO, WDHT_1x2 and WDHT_2x2_GAO, DPTHDI and DGTDHS with respect to 0.5 – 3 bpB of payload.

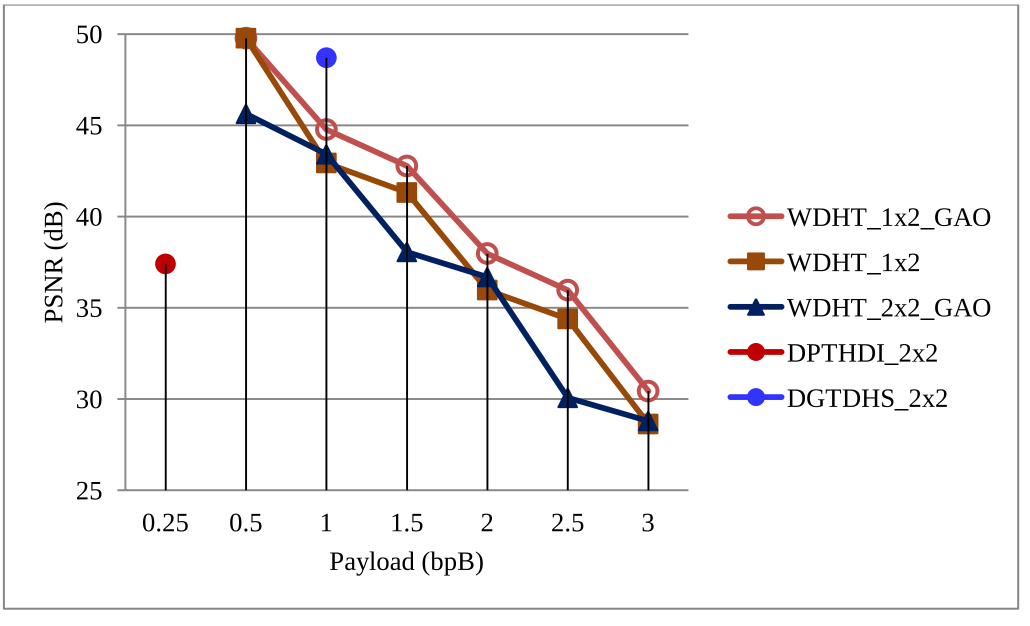

Figure 4. Graphical representation of variation of average PSNR (dB) with respect to payload for WDHT_1x2_GAO,WDHT_1x2, WDHT_2x2_GAO and Varsaki et al.'s (DPTHDI and DGTDHS) schemes

Similarly, the graphical analysis can also be made for rest of the transform domain based watermarking schemes.

To summarize the performance of the watermarking techniques without enhancement or optimization (WDHT_2x2, WDHT_1x2, WLT_2x2, WLT_1x2, WBT_2x2, WBT_1x2, WST_2x2, WST_1x2, WGD4_2x2 and WGD4_1x2), a graphical analysis is made (figure 5) against the existing schemes (DPTHDI, Lin et al.'s method, Yang et al.'s method and DGTDHS) to investigate the visual clarity (in terms of PSNR) of the watermarked images.

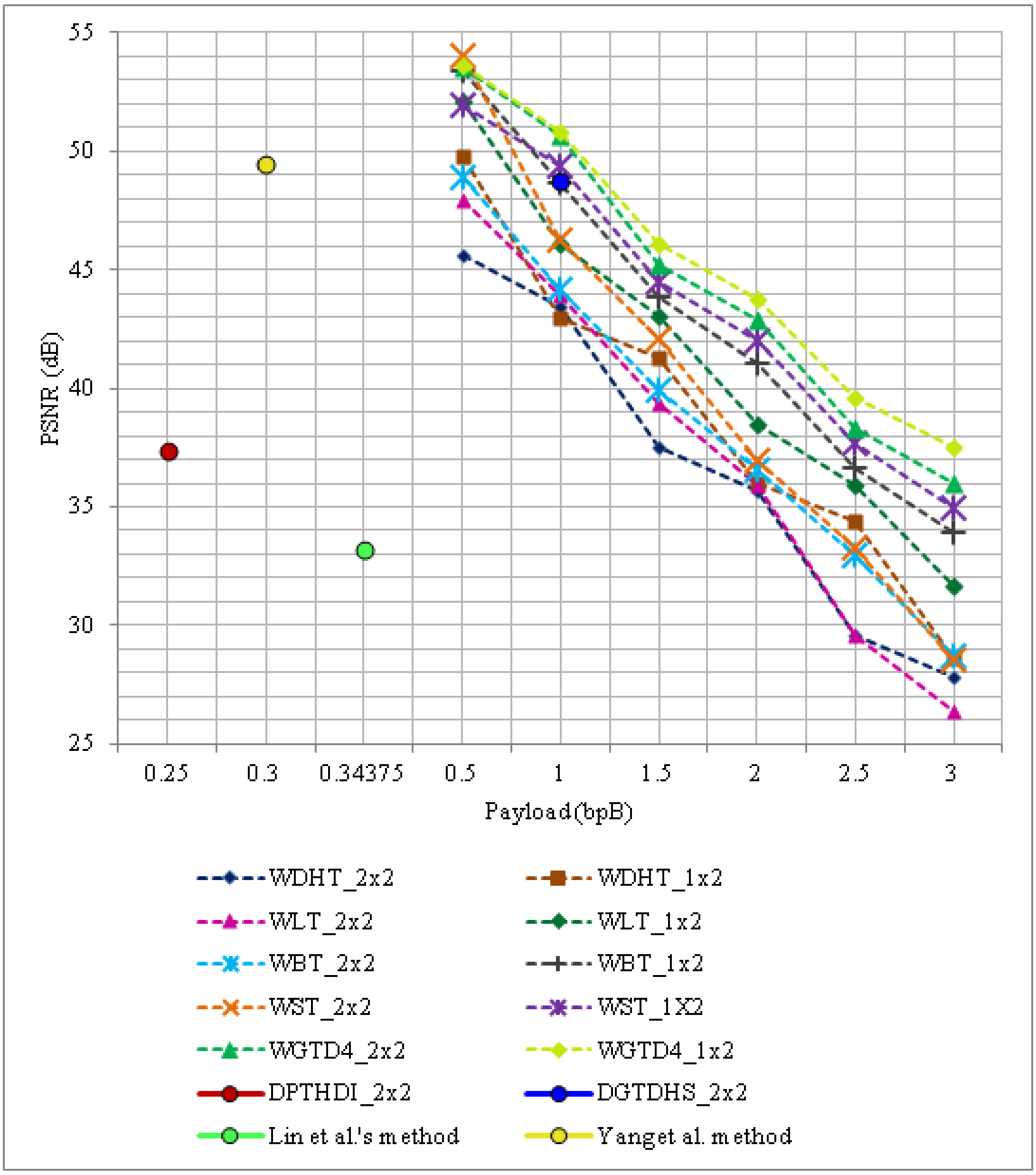

Figure 5. Comparative analysis of PSNR (dB) with respect to payload (bpB) among WDHT_2x2, WDHT_1x2, WLT_2x2, WLT_1x2, WBT_2x2, WBT_1x2, WST_2x2, WST_1x2, WGD4_2x2, WGD4_1x2, Varsaki et al.'s DPTHDI, Lin et al.'s, Yang et al.'s and Varsaki et al.'s DGTDHS schemes

In figure 6, the WDHT_2x2_QE, WDHT_1x2_QE, WLT_2x2_QE, WLT_1x2_QE, WBT_2x2_QE, WBT_1x2_QE, WST_2x2_QE, WST_1x2_QE, WGD4_2x2_QE and

WGD4_1x2_QE has been investigated for the payload range [0.5, 3 bpB]. These schemes are compared with Varsaki et al.'s DPTHDI, Lin et al.'s method, Yang et al.'s method and Varsaki et al.'s DGTDHS respectively. The quality enhancement is investigated in terms of average PSNR for the proposed watermarking schemes for 0.5 to 3 bpB. Lines representing the schemes overlap each other up to 2 bpB; afterward, the average PSNR is improved in a linear fashion with each scheme giving better result than the immediate preceding scheme in the order: WDHT_2X2_QE, WLT_2X2_QE, WST_2X2_QE, WBT_2X2_QE, WDHT_1X2_QE, WLT_1X2_QE, WBT_1X2_QE, WST_1X2_QE, WGD4_1X2_QE and WGD4_2X2_QE respectively.

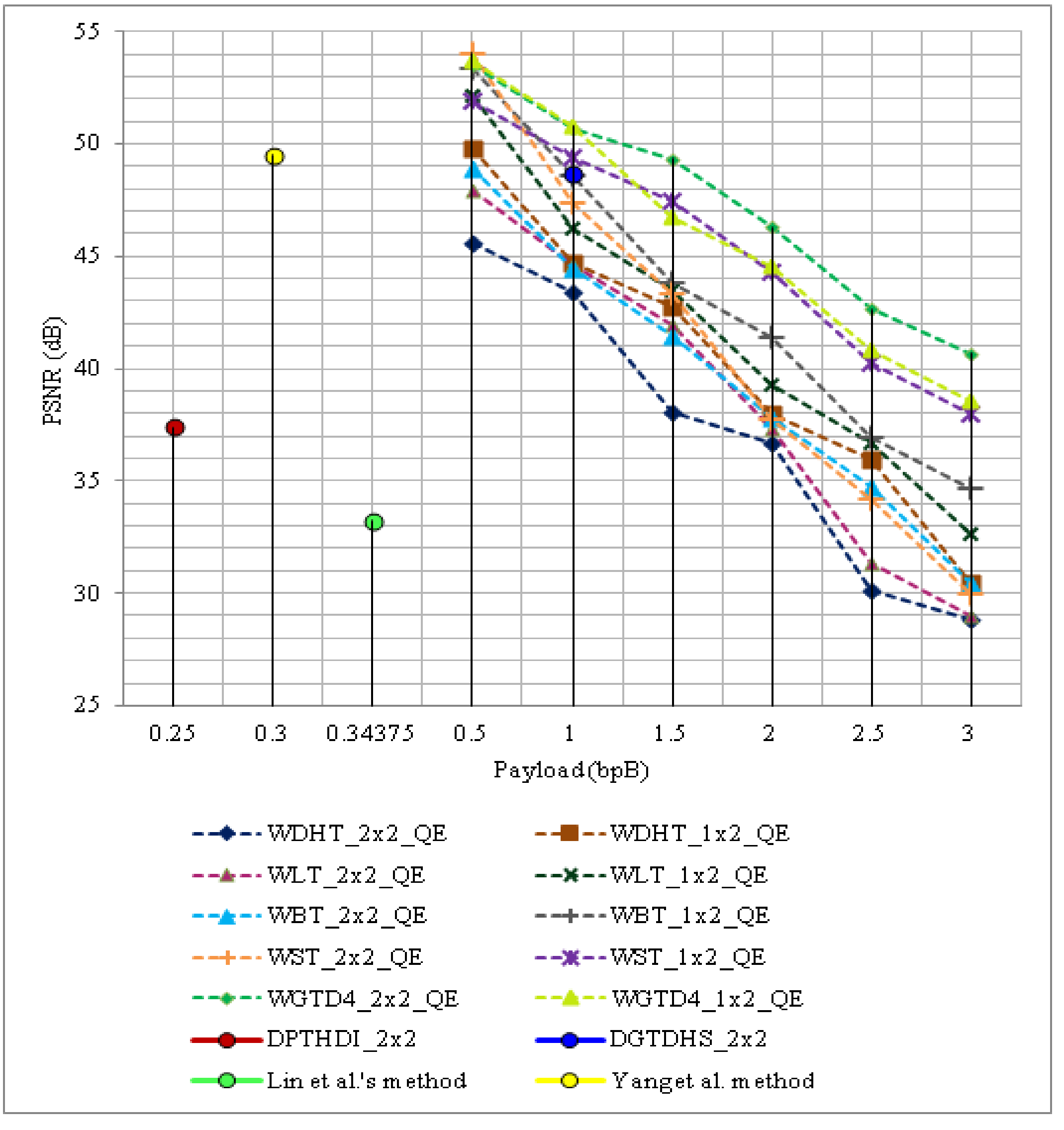

Figure 6. Comparative analysis of PSNR (dB) with respect to payload (bpB) among WDHT_2x2_QE, WDHT_1x2_QE, WLT_2x2_QE, WLT_1x2_QE, WBT_2x2_QE, WBT_1x2_QE, WST_2x2_QE, WST_1x2_QE, WGD4_2x2_QE, WGD4_1x2_QE, Varsaki et al.'s DPTHDI, Lin et al.'s, Yang et al.'s and Varsaki et al.'s DGTDHS schemes

In figure 7, the quality of the optimized schemes such as WDHT_2x2_GAO, WDHT_1x2_GAO, WLT_2x2_GAO, WLT_1x2_GAO, WBT_2x2_GAO, WBT_1x2_GAO, WST_2x2_GAO, WST_1x2_GAO and WGD4_2x2_GAO are analyzed with respect to increasing payload for the range [0.5 – 3 bpB] and are compared against the fixed payload based existing schemes (Varsaki et al.'s DPTHDI, Lin et al.'s method, Yang et al.'s method and Varsaki et al.'s DGTDHS) respectively. The new arrangements according to the performance is represented as per the following order: WDHT_2X2_GAO, WLT_2X2_GAO, WST_2X2_GAO, WBT_2X2_GAO, WDHT_1X2_GAO, WLT_1X2_GAO, WST_1X2_GAO, WBT_1X2_GAO and WGD4_2X2_GAO, respectively.

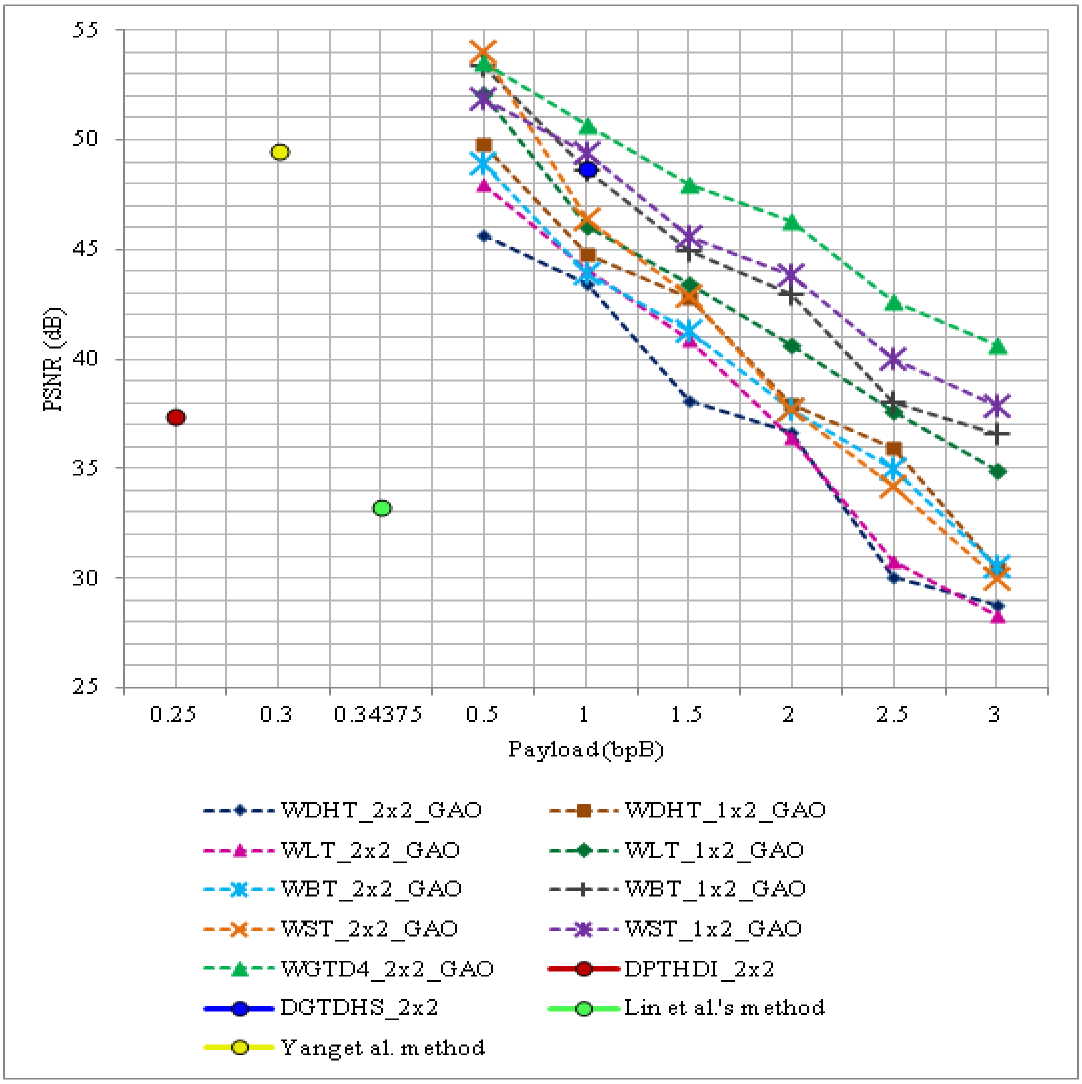

Figure 7. Comparative analysis of PSNR (dB) with respect to payload (bpB) among WDHT_2x2_GAO, WDHT_1x2_GAO, WLT_2x2_GAO, WLT_1x2_GAO, WBT_2x2_GAO, WBT_1x2_GAO, WST_2x2_GAO, WST_1x2_GAO, WGD4_2x2_GAO, Varsaki et al.'s DPTHDI, Lin et al.'s, Yang et al.'s and Varsaki et al.'s DGTDHS schemes

In figure 8, a comparative analysis has also been made among the proposed watermarking schemes prior to quality enhancement/optimization, the quality enhanced watermarking schemes (QE) and the GA optimization based watermarking (GAO) schemes in terms of predictive PSNR with respect to 0.5, 1, 1.5, 2, 2.5 and 3 bpB of payloads respectively. It is observed from the graph that the QE and GAO based schemes does not affect the fidelity up to 1 bpB of payload. But, as the payload increases, the QE and GAO based schemes giving better results in terms of average PSNR than the proposed watermarking schemes without quality enhancement/optimization. Consequently, the distortions of the watermarked images are minimized tremendously.

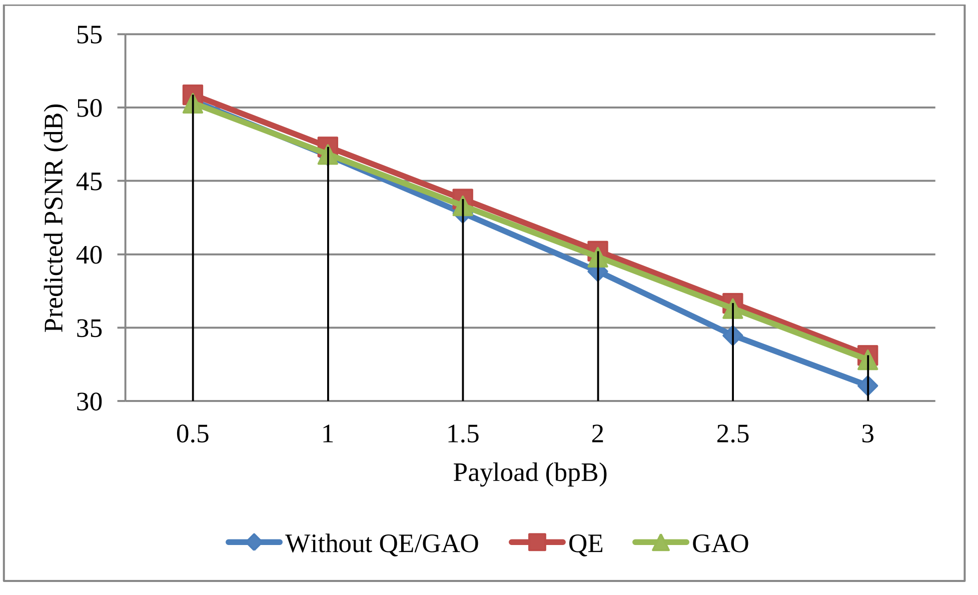

Figure 8. Comparative analysis of predictive PSNR among the watermarking based on quality enhancement (QE), GA based optimization (GAO) and the schemes without quality enhancement (QE) / GA based optimization (GAO)

In this thesis, the major achievement is designing and implementation of fragile watermarking schemes for color image authentication. A set of methods have been proposed, implemented and tested in the thesis to deal with watermark embedding in transform domain. In proposed schemes, color images as the cover ensured better transparency and high payload because the watermark information are fabricated separately into the red, green and blue channels. Unlike Discrete Cosine Transform (DCT), above mentioned transforms produces real transformed matrix from real pixel matrix which ensured less computation time and faster execution over floating-point calculations. To minimize the distortion of the watermarked images quality, Quality Enhancement (QE) and Genetic Algorithm (GA) has been utilized which improves the performance of the watermarking techniques significantly.

List of Publications

Journals

1. Ghosal S.K., Mandal J.K., "Authentication based on Fragile Watermarking in Stirling Transform Domain (AFWSTD)", Security and Communication Networks, Wiley Online Library, 2015 (Impact Factor: 0.72) (ACCEPTED).
2. Ghosal S.K., Mandal J.K., "Binomial transform based fragile watermarking for image authentication", Journal of Information Security and Applications, Elsevier B.V., 19(4-5), pp. 272-281, 2014.
3. Ghosal, S.K, Mandal J.K, "Color Image Authentication based on Two-Dimensional Separable Discrete Hartley Transform (CIA2D-SDHT)", Association for the Advancement of Modelling and Simulation Techniques in Enterprises (AMSE) Journals – 2014-Series: Advances B, 57(1), pp. 68-87, 2014.
4. Ghosal, S.K, Mandal J.K, "A Fragile Watermarking based on Legendre Transform for Color Images (FWLTCI)", Signal & Image Processing : An International Journal (SIPIJ), DOI: 10.5121/sipij.2013.4410, ISSN : 0976 - 710X (Online) ; 2229 - 3922 (print), 4(4), pp. 119-127, August 2013.
5. Ghosal, S.K, Mandal J.K, "Binomial Transform based Image Authentication (BTIA)", International Journal of Multimedia & Its Applications (IJMA), DOI: 10.5121/ijma.2013.5405, ISSN: 0975 - 5578[Online]; 0975 - 5934 [Print], 5(4), pp. 67-74, August 2013, 2013.
6. Mandal J.K, Ghosal, S.K, "A Fragile Watermarking based on Separable Discrete Hartley Transform for Color Image Authentication (FWSDHTCIA)", Signal & Image Processing : An International Journal (SIPIJ), DOI : 10.5121/sipij.2012.3603, ISSN : 0976 - 710X (Online) ; 2229 - 3922 (print), 3(6), pp. 23-33, 2012.
7. Mandal J.K, Ghosal, S.K, "A Two Dimensional Discrete Fourier Transform Based Secret Data Embedding for Color Image Authentication (2D-DFTSDECIA)", Signal & Image Processing : An International Journal (SIPIJ), DOI : 10.5121/sipij.2012.3608, ISSN : 0976 - 710X (Online) ; 2229 - 3922 (print), 3(6), pp 87-97, 2012.

Book Chapters

8. Ghosal S.K., "Genetic Algorithm based Optimization of Fragile Watermarking in Discrete Hartley Transform Domain", (Handbook of Research on Natural Computing for Optimization Problems, Advances in Computational Intelligence and Robotics (ACIR), IGI Global, 701 E. Chocolate Ave., Hershey, PA 17033, USA) (ACCEPTED).

International Conferences

9. Ghosal, S.K, Mandal J.K, "Stirling Transform based Color Image Authentication (STCIA)", Proceedings of International Conference on Computational Intelligence: Modeling, Techniques and Applications (CIMTA- 2013), Procedia Technology, Elsevier B.V., ISSN: 2212-0173, Vol. 10, pp. 95-104, Kalyani, 2013.

10. Mandal, J. K., Ghosal S. K., "Legendre Transformation based Color Image Authentication (LTCIA)", Proceedings of Computer Science & Information Technology (CS & IT), DOI : 10.5121/csit.2013.3630, ISSN : 2231 - 5403, AIRCC, Feb.18-20, 2013, pp. 265–272, Bangalore, 2013.

11. Mandal, J. K., Ghosal S. K., "A Fragile Watermarking based on Binomial Transform in Color Images", SIPP- 2013, Proceedings of Computer Science & Information Technology (CS & IT), DOI : 10.5121/csit.2013.3632, ISSN : 2231 - 5403, AIRCC, Feb.18-20, 2013, pp. 281–288, Bangalore, 2013

12. Mandal J.K, Ghosal, S.K, "Separable Discrete Hartley Transform based Invisible Watermarking for Color Image Authentication (SDHTIWCIA)", Second International Conference on Digital Image Processing and Pattern Recognition (DPPR-2012), Advances in Intelligent and Soft Computing, Springer Berlin Heidelberg, DOI: 10.1007/978-3-642-30111-7_73, Vol. 177, pp. 763-772, Chennai, 2012.

13. Mandal J.K, Ghosal, S.K, "A Novel DFT Based Information Embedding for Color Image Authentication (DFTIECIA)", Third International Conference on Communication Security and Information Assurance (CSIA 2012), Advances in Computing and Information Technology Advances in Intelligent Systems and Computing, Springer Berlin Heidelberg, DOI: 10.1007/978-3-642-31552-7_78, Vol. 177, pp. 767-776, Delhi, 2012.

Other Publications

14. Mandal J.K, Ghosal, S.K, "A High Payload Steganographic Technique for Color Images (HPST)", International Conference on Information's System Design and Intelligent Applications, ISBN- 978-981-07-1158-0, pp. 65-70, Vizag, 2012.
15. Sudipta Kr Ghosal, "A New Pair Wise Bit Based Data Hiding Approach on 24 Bit Color Image using Steganographic Technique", International Conference on Scientific Paradigm Shift in Information Technology & Management (SPSITM 2011) in collaboration with IEEE, Kolkata, 2011.
16. Ghosal Sudipta Kr, Mukherjee Saswati, "An Enhanced Secure and Comprehensive Data Hiding Approach Using 24 Bit Color Images", International Conference on Advanced Computing & Communication (ICACC 2010), pp. 61-65, Kerala, 2010.
17. Mandal J.K, Ghosal, S.K, "Separable Discrete Hartley Transform based Embedding for Color Image Authentication (SDHTECIA)", Second National Conference on Computing and Systems (NACCS-2012), ISBN-978-93-80813-18-9, pp. 178-183, Burdwan, 2012.
18. Sudipta Kr Ghosal, Saswati Mukherjee, Matangini Chattopadhyay, "A Novel Approach: Data Hiding and Security of Multimedia Content using Steganography", National Conference on Emerging Trends in Computer Science and Information Technology 2010 (ETCSIT 2010) ,pp. 133-137, Nashik, 2010.
19. Sudipta Kr Ghosal, Arnab Nath, Saswati Mukherjee, Arunashish Acharya, " A New Data Hiding Application Tool on ASP.NET Framework using Steganography", UGC Sponsored National Conference on Image Processing 2010 (NCIMP 2010), ISBN-978-81-8424-574-5, pp. 249-252, Gandhigram,2010.
20. Sudipta Kr Ghosal, Arnab Nath, Saswati Mukherjee, Arunashish Acharya," A New Approach: Data Hiding and Security of Multimedia Content using Steganography", UGC Sponsored National Conference on Image Processing 2010 (NCIMP 2010), ISBN-978-81-8424-574-5, pp. 253-256, Gandhigram, 2010.
21. Arnab Nath, Sudipta Kr Ghosal, Saswati Mukherjee, Arunashish Acharya," An Efficient Approach of Watermarking to Protect Multimedia Content", UGC Sponsored National Conference on Image Processing 2010 (NCIMP 2010), ISBN-978-81-8424-574-5, pp. 259-264, Gandhigram, 2010.

22. Ghosal Sudipta Kr, Dutta Chowdhury Souvik, "A DCT based Watermarking on Grayscale Images against Copy-right Infringement (DCTWGICI)", JIS Educational initiative sponsored one day National seminar on Intellectual Property Rights and Patent Laws", Kolkata, 2012.

List of Papers Presented

International Conferences

1. Ghosal, S.K, Mandal J.K, “Stirling Transform based Color Image Authentication (STCIA)”, Proceedings of International Conference on Computational Intelligence: Modeling, Techniques and Applications (CIMTA- 2013), Procedia Technology, ELSEVIER, ISSN: 2212-0173, Kalyani, 2013.
2. Mandal, J. K., Ghosal S. K., “Legendre Transformation based Color Image Authentication(LTCIA)”, Proceedings of Computer Science & Information Technology (CS & IT), DOI : 10.5121/csit.2013.3630, ISSN : 2231 - 5403, AIRCC, Feb.18-20, 2013, pp. 265–272, Bangalore, 2013.
3. Mandal, J. K., Ghosal S. K., “A Fragile Watermarking based on Binomial Transform in Color Images”,SIPP- 2013, Proceedings of Computer Science & Information Technology (CS & IT), DOI : 10.5121/csit.2013.3632, ISSN : 2231 - 5403, AIRCC, Feb.18-20, 2013, pp. 281–288, Bangalore, 2013
4. Mandal J.K, Ghosal, S.K, “A Novel DFT Based Information Embedding for Color Image Authentication (DFTIECIA)”, Third International Conference on Communication Security and Information Assurance (CSIA 2012), Advances in Computing and Information Technology Advances in Intelligent Systems and Computing, 2013, Volume 177, 767-776, DOI: 10.1007/978-3-642-31552-7_78, Delhi, 2012.
5. Mandal J.K, Ghosal, S.K, “A High Payload Steganographic Technique for Color Images (HPST)”, International Conference on Information’s System Design and Intelligent Applications 2012, ISBN- 978-981-07-1158-0, Vizag, 2012.
6. Sudipta Kr Ghosal, “A New Pair Wise Bit Based Data Hiding Approach on 24 Bit Color Image using Steganographic Technique”, International Conference on Scientific Paradigm Shift in Information Technology & Management (SPSITM 2011) in collaboration with IEEE, Kolkata, 2011.

National Conferences

9. Mandal J.K, Ghosal, S.K, "Separable Discrete Hartley Transform based Embedding for Color Image Authentication (SDHTECIA)", Second National Conference on Computing and Systems (NACCS-2012), page no. 178-183,ISBN-978-93-80813-18-9, Burdwan, 2012.
10. Sudipta Kr Ghosal, Saswati Mukherjee, Matangini Chattopadhyay, "A Novel Approach: Data Hiding and Security of Multimedia Content using Steganography", National Conference on Emerging Trends in Computer Science and Information Technology 2010 (ETCSIT 2010), pp. 133-137, Nashik, 2010.

Publication Indexing Database

The lists of publications relevant to the thesis work are indexed / abstracted in the following databases which are mentioned in the following table serially.

Publication Serial No.	*Database*
1	SCIE, SCOPUS, DBLP, Web of Knowledge (Thomson Reuters), Web of Science (Thomson Reuters), COMPENDEX (Elsevier), Computer & Information Systems Abstracts (ProQuest),CSA Technology Research Database (ProQuest), Current Contents: Engineering, Computing & Technology (Thomson Reuters), INSPEC (IET), PASCAL Database (INIST/CNRS) etc.
2	SCOPUS, DBLP, Engineering Index, INFONA, Zentralblatt Math, Elsevier B. V., Google Scholar etc.
3	SCOPUS, EBSCO, IEEE-INSPECT, Elsevier B. V., Institute for Scientific Information etc.
4	EBSCO, Scribd, CiteSeer, Pubget, Google Scholar, DOAJ, ProQuest etc.
5	EBSCO, Scribd, CiteSeer, Pubget, Google Scholar, DOAJ, ProQuest etc.
6	EBSCO, Scribd, CiteSeer, Pubget, Google Scholar, DOAJ, ProQuest etc.
7	EBSCO, Scribd, CiteSeer, Pubget, Google Scholar, DOAJ, ProQuest etc.
8	Thomson Reuters Book Citation Index, DBLP Computer Science Bibliography, ERIC - Education Resources Information Center, and ACM Digital Library, and CrossReflinking network
9	SCOPUS, DBLP, INFONA, Elsevier B. V., Google Scholar etc.
10	Open J-Gate, ArXiv.org, EBSCO, Scribd, CiteSeer, Google Scholar etc.
11	Open J-Gate, ArXiv.org, EBSCO, Scribd, CiteSeer, Google Scholar etc.
12	SCOPUS, ISI Proceedings, EI-Compendex, DBLP, Google Scholar and Springerlink etc.
13	SCOPUS, ISI Proceedings, DBLP. Ulrich's, EI-Compendex, Zentralblatt Math, MetaPress, Springerlink etc.

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