DESIGN, IMPLEMENTATION AND COMPARATIVE ANALYSIS OF VARIOUSALGORITHMS FOR WATERMARKING

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Abstract

This research paper aims to tackle the obstacles related to data security in internet systems, with a specificfocus on safeguarding intellectual property. Watermarking is identified as a solution to this problem, which involves hiding data or identifying information within images, audio, video, and documents. However, the use of certain algorithms, such as DCT, can degrade the quality of the watermarked image. Through a literature review of more than 40 research papers, this research work presents a problem statement and objectives for improving watermarking techniques in the DCT domain. The report also provides a theoretical background, examines various findings, and analyzes the strengths and weaknesses of watermarking. In this study, a comprehensive investigation is conducted on the design and implementation of various watermarking techniques. The experimental results of each implementation aremeticulously presented, along with a comparative analysis among various algorithms for watermarking. The findings of this study provide valuable insights into the efficacy and practicality of watermarking techniques in the context of data security and intellectual property protection.

Keywords: Dct, Water Marking, Rgb, Dwt.

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1. Introduction

A comprehensive review of more than 40 research papers was conducted to explore the current challenges and opportunities in the field of Watermarking. Through the review process, a key issue was identified regarding image security using watermarking with DCT and filters. A thorough analysis of the literature was undertaken, which involved extracting common themes and trends from the research works, identifying their strengths and weaknesses, and identifying gaps to establish a clear problem statement and research objectives.

The following are the reviewed strengths of various research on digital watermarking algorithms:

- One algorithm that used the spread spectrum method to embed watermark in the DCT domain wasfound to be robust against image processing attacks. This was a blind watermarking algorithm. [3]
- Another blind watermarking algorithm, which modified AC coefficients in the DCT domain using theArnold transformation, was capable of resisting certain digital image attacks. [36]
- The use of both Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) in a digital watermarking algorithm made it resilient to different types of attacks. [15]
- The combination of spread-spectrum technology and block DCT in a dual-color image watermarking algorithm resulted in a highly secure, transparent, and robust solution. [38]
- An algorithm that took the average of the central frequency coefficients of block DCT coefficients ofan image was able to produce high-quality watermarked images. [17]
- Applying a joint digital watermarking and fingerprinting approach to colored digital images in thedouble DCT domain proved to be immune to various types of interference such as JPEG compression,
- Additive noise, and median filtering. The enhanced embedding capacity of the host image in the doubledomain approach contributed to the robustness of the technique. [13]
- DCT-based watermarking algorithm that was designed for copyright protection of digital images was able to survive various attacks, such as additive noise, rescaling, line removal, and JPEG compression. [35]

The following are the weaknesses observed in the reviewed research on digital watermarking algorithms:

- A digital watermarking algorithm that utilized both DCT and DWT was found to be ineffective forimage rotation. [15]
- Although robust to many attacks, a watermarking algorithm that utilized a combination of DWT and DCT was found to be vulnerable to geometric distortions such as rotation, translation, and scaling operations [4].
- One of the drawbacks of the dual-color image watermarking algorithm based on spread-spectrum technology and block DCT was that the quality of the extracted watermark image suffered from data loss resulting from image compression. [38]
- Various researchers have worked upon DCT and DWT techniques either separately or in combination to make the data secure, however the quality of image degraded.
- The researchers have rarely used combination of DCT/DWT and filter.
- Most of the researcher worked on either security or on quality but rarely the study has been carriedout taking both the parameters into consideration.

Table No: 1

Ref.No.	Input		DCT Method Name		Result	
	Format	Size	Hybrid	Basic	PSNR	NC
[1]	RGB	OI: 512*512 WI:512*512	DWT	NA	36.52	NA
[4]	RGB	OI: 24 bit WI: 24 bit	DWT	NA	35.39	NA
[5]	RGB	OI: 512*512 WI: 512*512	NA	Block DCT	Decreased PSNR	Less than 1
[6]	GrayScale	OI: 512*512	DWT	NA	35.6324 dB	More than 0.9

		WI: 64*64				
[13]	RGB	NA	DW & finger printing approach	DoubleDCT	58-73 dB	NA
[15]	Gray Scale	OI: 256*256 WI: 32*32	DWT	NA	50.0285 dB	0.9782
[16]	RGB	NA	Back Propagatio nAlgorithm	Blockwise DCT	39.9 dB	NA
[17]	bmp, jpg & png	OI: 256*256 WI:256*256	NA	BlockDCT	35-40	NA
[18]	RGB & Binary	OI: 512*512 WI: 64*64	NA	DCT	40.14	NA
[19]	Gray scale & binary	OI: 512*512 WI: 64*64	FCNN	NA	46.14 dB	NA
[25]	Png	OI: 512*512 WI: 64*64	Arnold2D CatMap	NA	40 dB	Between0.5& 0.9
[26]	RGB	OI: 512*512 WI: 256*256	NA	DCT	47-48	0.99
[27]	Grayscale	OI: 512*512 WI: 512*512	NA	DCT	44.35 dB	0.99
[30]	RGB	OI: 256*256 WI: 256*256	NA	DCT	21.581 dB	1
[32]	RGB	OI: 256*256 WI: 256*256	NA	DCT	14dB	NA
[33]	Gray scale & Binary	OI: 512*512 WI: 32*32	Chaotic System	Block wise DCT	NA	Close to 1
[35]	Bmp	OI: 512*512 WI: 32*32	NA	DCT	38-39 dB	NA
[36]	RGB	OI: 256*256 WI: 32*32	Arnold cat map	NA	35.1346 dB	1
[37]	Gray scale & Binary	OI:256*256 WI: 32*32	Arnold cat map	NA	31.8130 dB	1
[38]	24 bit	OI: 512*512 WI:64*64	Spread Spectrum	NA	41-42 dB	0.9711

Architectura

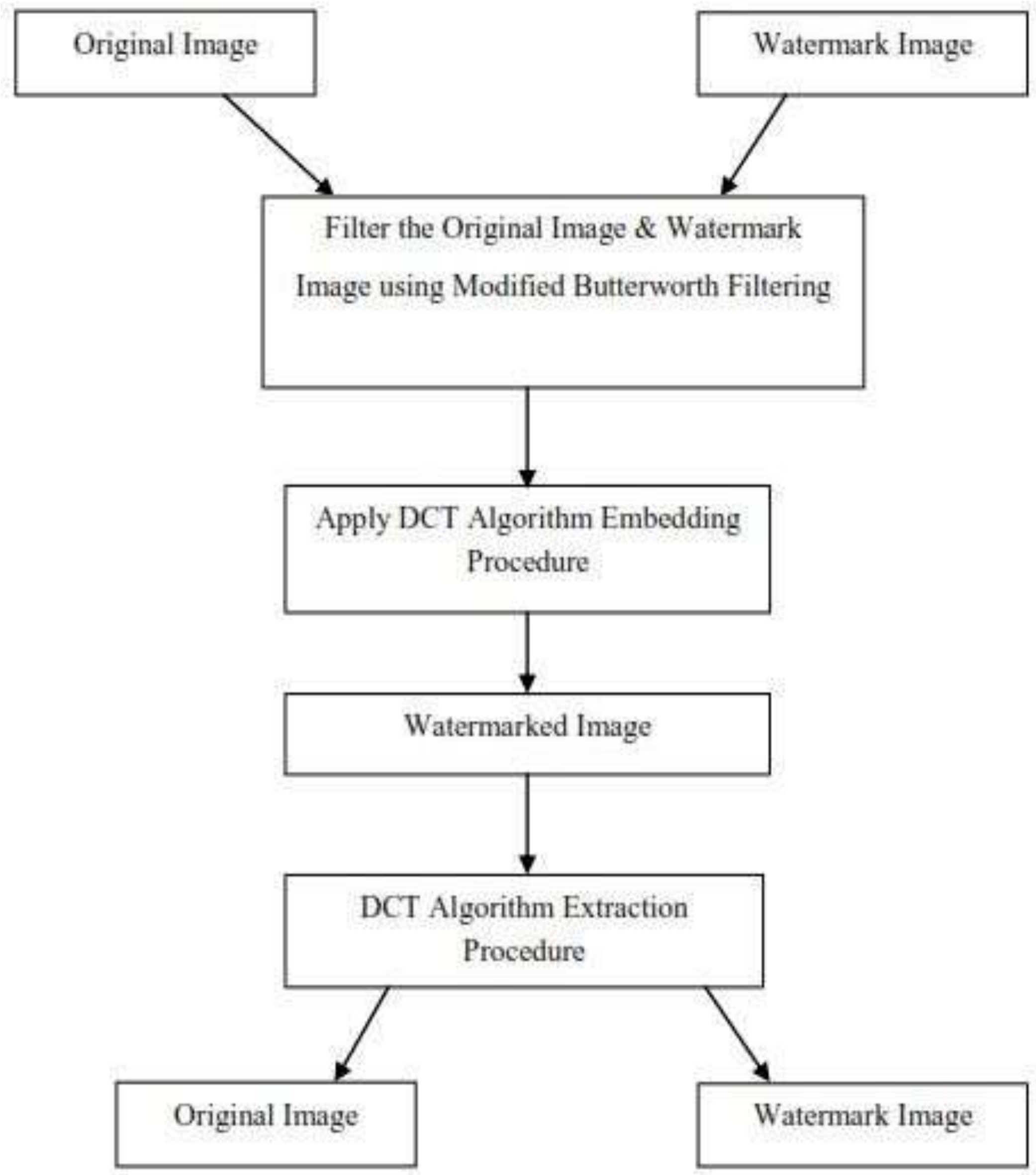


Fig. 1.1: Flow Diagram of work

Input Parameters: Following parameters are used for the experimentation

Original Image: A watermarking technique is used to secure the original image, also known as the cover image. Table 1.1 displays the properties of different original images used as input.

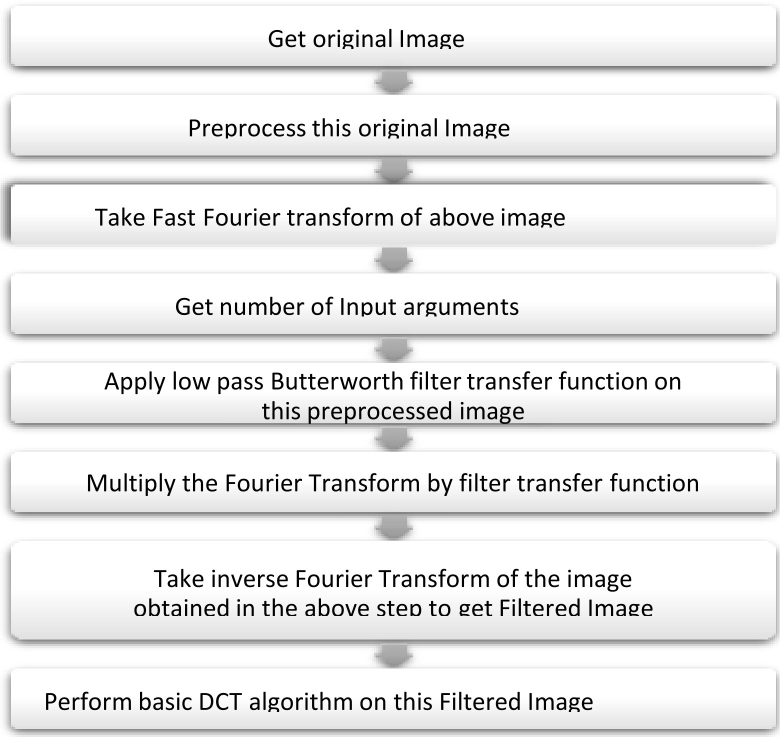
Watermark Image: The image that is embedded in a cover image is known as a watermark. This type of image can be used in any format. The table below displays the properties of different watermark images.

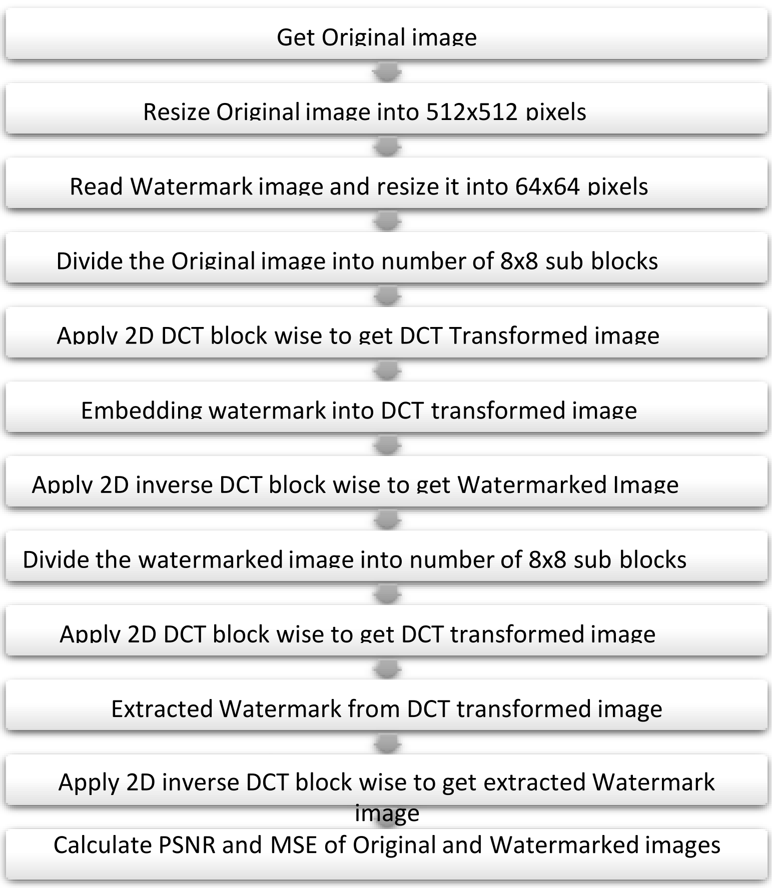
Table 1.2: Properties of Various Original Images

S. No	Original Images	Properties	
		Dimension(pixels)	Size(in KB)
1	girl.jpeg	204*204	5.35
2	car.png	280*168	35.7
3	guitar.png	280*328	59.5
4	canoe.tif	346*207	68
5	autumn.tif	345*206	208
6	land.bmp	1024*768	769
7	flag.bmp	124*124	45

S.No	Watermark Images	Properties	
		Dimension(pixels)	Size(in KB)
1	flowers.jpeg	300*168	12.8
2	kiwi.png	280*232	126
3	tree.png	280*420	195
4	scene.tif	350*258	966
5	cameraman.tif	256*256	63.7
6	forest.bmp	1024*768	769
7	marbles.bmp	1419*1001	4.06

Fig: Flowchart of DCT





Flowchart of DCT+Butterworth

Fig 1.2 Flowchart of Modified Butterworth

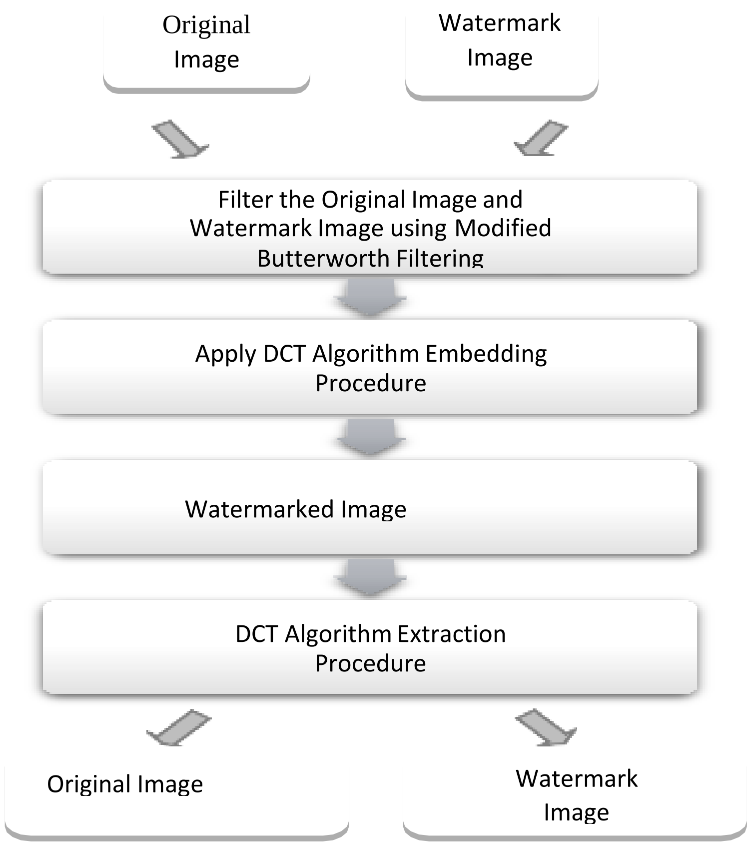


Table 1.4: DST based watermarking Performance Analysis

Sr. NO.	**Group Image**	**OriginalImage**	**WatermarkImage**	**Using DCT Algorithm**	
				PSNR	**MSE**
1	G1	girl.jpeg	lowers.jpeg	55.43	0.19
2	G2	car.png	kiwi.png	56.24	0.16
3	G3	guitar.png	ree.png	59.26	0.08
4	G4	canoe.tif	scene.tif	57.07	0.13
5	G5	autumn.tif	cameraman.tif	55.20	0.20
6	G6	land.bmp	orest.bmp	55.87	0.17
7	G7	flag.bmp	marbles.bmp	55.22	0.20

Table 1.5: DCT with Existing Butterworth Filter based Performance Analysis

Sr. NO.	**GroupImage**	**OriginalImage**	**WatermarkImage**	**Using DCT and existing Butterworth**	
				PSNR	**MSE**
1	G1	girl.jpeg	flowers.jpeg	55.41	0.19
2	G2	car.png	kiwi.png	56.22	0.16
3	G3	guitar.png	ree.png	59.24	0.08
4	G4	canoe.tif	scene.tif	57.06	0.13
5	G5	autumn.tif	cameraman.tif	55.17	0.20
6	G6	land.bmp	orest.bmp	55.79	0.17

7	G7	flag.bmp	marbles.bmp	55.17	0.20

Table 1.6: DCT with Modified Butterworth Filter based Performance Analysis

Sr. NO.	Group Image	OriginalImage	WatermarkImage	Using Modified Butterworth Filter	
				PSNR	MSE
1	G1	girl.jpeg	lowers.jpeg	55.52	0.18
2	G2	car.png	kiwi.png	56.32	0.15
3	G3	guitar.png	ree.png	59.53	0.07
4	G4	canoe.tif	scene.tif	57.21	0.12
5	G5	autumn.tif	cameraman.tif	55.27	0.19
6	G6	land.bmp	orest.bmp	56.27	0.15
7	G7	flag.bmp	marbles.bmp	55.32	0.19

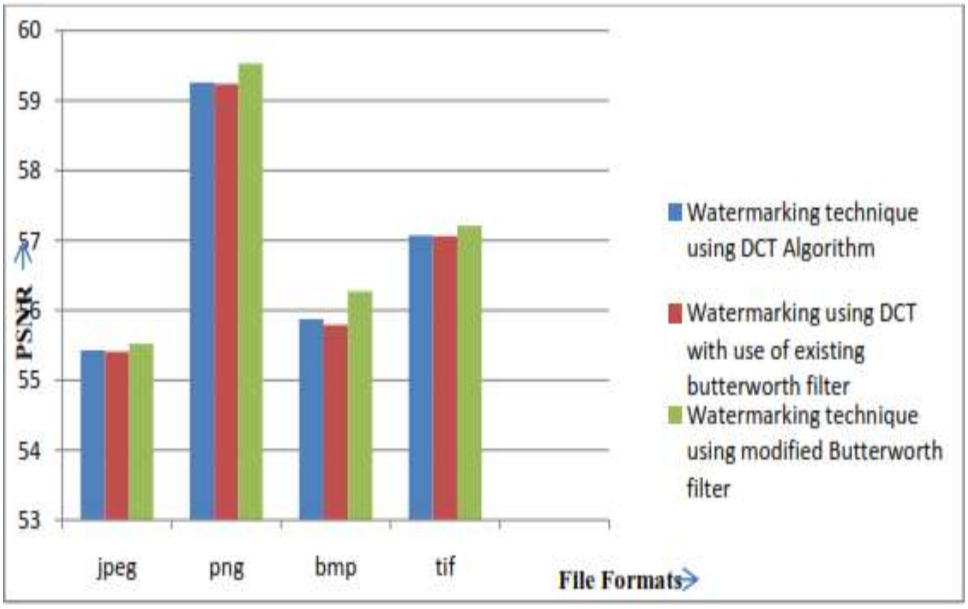


Fig 1.3: PSNR Value based Comparative flowchart

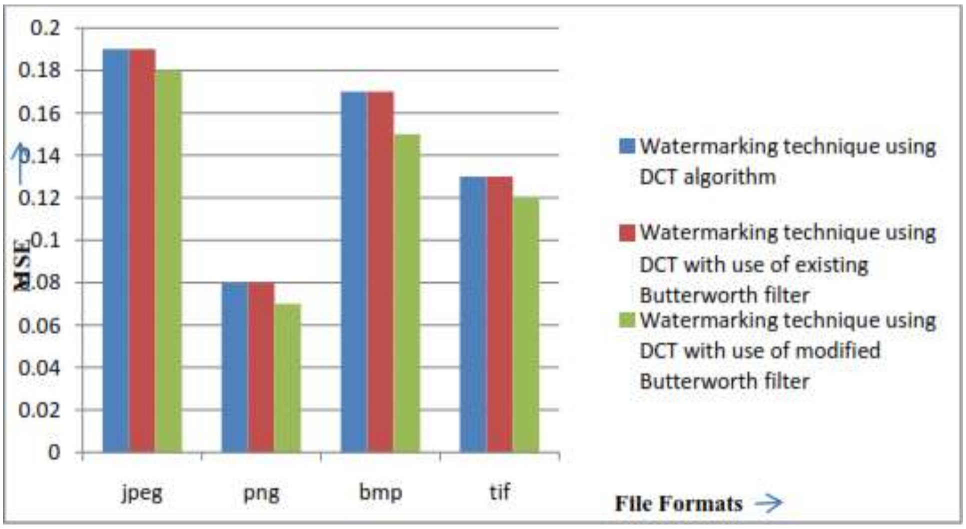


Fig.1.4: MSE Value based Comparative flow chart

2. Conclusion

Watermarking techniques have proven to be effective in combating intellectual property theft. The proposed approach in this paper, which utilizes a Modified Butterworth filter for image quality improvement in watermarking, was analyzed using two performance parameters: PSNR and MSE. The experimental results showed that the proposed approach performed best with png file format, with the highest PSNR value and the lowest MSE value. While the PSNR value remained consistent across different file formats, the MSE value varied more than 12%. Based on the results, it can be concluded that employing the DCT Watermarking Technique with Modified Butterworth Filter yielded the most favorable outcome, as evidenced by the highest PSNR value and the lowest MSE value for all images. These outcomes underscore the efficacy of the proposed method.

3. References

1. Afroja Akter, Nur-E-Tajnina, Ullah M.A., "Digital image watermarking based on DWT-DCT: Evaluate for a new embedding algorithm," International Conference on Informatics, Electronics & Vision (ICIEV), 2014, pp.1, 6, 23-24 May 2014
2. Chau-Jern Cheng; Wen-Jyi Hwang; Han-Yi Zeng; Yu-Chih Lin, "A Fragile Watermarking Algorithm for Hologram Authentication," Journal of Display Technology, vol.10, no.4, pp.263,271, April 2014
3. Charkari, N.M.; Chahooki, M.A.Z., "A Robust High Capacity Watermarking Based on DCT and Spread Spectrum," IEEE International Symposium on Signal Processing and Information Technology, 2007, pp.194, 197, 15-18 Dec. 2007
4. Chavan, S.; Shah, R.; Poojary, R.; Jose, J.; George, G., "A Novel Robust Colour Watermarking Scheme for Colour Watermark Images in Frequency Domain," International Conference on Advances in Recent Technologies in Communication and Computing (ARTCom), 2010, pp.96,100, Oct. 2010
5. Daxing Zhang, Zhigeng Pan, Haihua Li, "A novel watermarking algorithm in DCT domain to authenticate image content," IEEE International Conference on Intelligent Computing and Intelligent Systems, 2009. ICIS 2009, vol.3, pp.608, 611, Nov. 2009
6. Deb, K.; Al-Seraj, M.S.; Hoque, M.M.; Sarkar, M.I.H., "Combined DWT-DCT based digital image watermarking technique for copyright protection," International Conference on Electrical & Computer Engineering (ICECE), 2012, pp.458, 461, Dec. 2012
7. Deepshikha Chopra, Preeti Gupta, Gaur Sanjay B.C., Anil Gupta, "Lsb Based Digital ImageWatermarking For Gray Scale Image," IOSR Journal of Computer Engineering, 2012. IOSRJCE 2012, vol.6, pp. 36, 41, Oct. 2012
8. Gonge, S.S.; Ghatol, A.A., "Combined DWT-DCT digital Watermarking Technique Software Used for CTS of Bank," International Conference on Issues and Challenges in Intelligent Computing Techniques (ICICT), 2014, pp.776,783, Feb. 2014
9. Gurpreet Kaur, Kamaljeet Kaur, "Image Watermarking Using LSB (Least Significant Bit)," International Journal of Advanced Research in Computer Science and Software Engineering, 2013. IJARCSE 2013, pp. 858-861, April 2013
10. Irfan; Nazori Agani, "Embedding and Extracting Technique for Implementing Image Watermarking Based on DCT (Discrete Cosine Transform)", International Conference on Information Systems, 2013. ISICO2013. pp. 2, 4, Dec. 2013
11. Juan L. Mateo; Antonio Fernandez Caballero, "Finding out general tendencies in speckle noise reductionin ultrasound images", Journal of Expert Systems with Applications 2009, vol. 36, pp. 7786, 7797, 2009
12. Manpreet Kaur ;Sonika Jindal ;Sunny Behal, "A study of digital image watermarking", International Journal of Research in Engineering & Applied Sciences, 2012. IJREAS 2012, vol.2, pp. 126, 136, February 2012
13. Mehan, V.; Dhir, R.; Brar, Y.S., "Joint watermarking and fingerprinting approach for colored digital images in double DCT domain," IEEE International Conference on Signal Processing, Computing and Control (ISPCC), 2013, pp.1,6, Sept. 2013
14. Mehdi Hussain; Mureed Hussain, "A Survey of Image Steganography Techniques", International Journal of Advanced Science and Technology, 2013. IJASAT 2013, vol. 54, pp. 113, 124, May 2013
15. Mei Jiansheng; Li Sukang; Tan Xiaomei, "A Digital Watermarking Algorithm Based on DCT and DWT", International Symposium on Web Information Systems and Applications, 2009. WISA"09, pp.104, 107, May 2009
16. Mendoza-Noriega, J.A.; Kurkoski, B.M.; Nakano-Miyatake, M.; Perez-Meana, H., "Halftoning-based self-embedding watermarking for image authentication and recovery," IEEE International Midwest Symposium on Circuits and Systems (MWSCAS), 2010, pp.612, 615, Aug. 2010

17. Mrs. Rekha Chaturvedi; Mr. Abhay Sharm; Mr. Naveen Hemrajani; Mr. Dinesh Goyal, “Analysis of Robust Watermarking Technique Using Mid Band DCT Domain for Different Image Formats”, International Journal of Scientific and Research Publications,2012. IJSRP 2012, vol. 2, March 2012
18. M Yesilyurt; Y. Yalman; A. T. Ozcerit, “A New DCT Based Watermarking Method Using Luminance Component”, Elektronika IR Elektrotechnika, 2013. Vol. 19, pp. 47, 52, 2013
19. Naghsh Nilchi, A.R.; Taheri, A., "A new robust digital image watermarking technique based on the Discrete Cosine Transform and Neural Network," International Symposium on Biometrics and Security Technologies, 2008, ISBAST 2008, pp.1,7, April 2008
20. Namita Chandrakar; Jaspal Bagga, “Performance Comparison of Digital Image Watermarking Techniques: A Survey”, International Journal of Computer Applications Technology and Research, 2013. IJCAT 2013, vol. 2, pp. 126,130, 2013
21. Navnidhi Chaturvedi, “Various Digital Image Watermarking Techniques and Wavelet Transforms”, International Journal of Emerging Technology and Advanced Engineering, 2012. IJETAE 2012, vol. 2, pp. 363, 366, May 2012
22. Pooya Monshizadeh Naini,”Digital Watermarking Using MATLAB”, Engineering Education and Research Using MATLAB, University of Tehran Iran, 2011, pp. 465, 481, Oct. 2011
23. Potdar, V.M.; Song Han; Chang, E., "A survey of digital image watermarking techniques," IEEE International Conference on Industrial Informatics, 2005. INDIN' 05. 2005, pp. 709, 716, Aug. 2005
24. Prabhishek Singh; R S Chadha, “A Survey of Digital Watermarking Techniques, Applications and Attacks”, International Journal of Engineering and Innovative Technology, 2013, IJEIT 2013, vol. 2, pp. 165, 175, March 2013
25. Pradhan, C.; Saha, B.J.; Kabi, K.K.; Arun; Bisoi, A.K., "Blind watermarking techniques using DCT and arnold 2D cat map for color images," International Conference on Communications and Signal Processing (ICCSP), 2014, pp.026,030, April 2014
26. Pravin M. Pithiya; H.L.Desai, “DCT Based Digital Image Watermarking, Dewatermarking & Authentication”, International Journal of Latest Trends in Engineering and Technology, 2013, IJLTET 2013, vol. 2, pp. 213, 219, May 2013
37. Zhao Rui-mei; Lian Hua; Pang hua-wei; Hu Bo-ning, "A Blind Watermarking Algorithm Based on DCT," International Symposium on Intelligent Information Technology Application, 2008, IITA '08, vol.3, pp.821,824,
27. Qiusheng Wang; Shenghe Sun, "DCT-based image-independent digital watermarking", International Conference on Signal Processing Proceedings, 2000, vol.2, pp.942, 945, 2000
28. Saraju P. Mohanty, “Digital Watermarking: A Tutorial Review”, Dept of Comp Sc. and Eng., Universityof South Florida, Tampa, 1999
29. Sasmita Mishra; Amitav Mahapatra; Pranati Mishra, “A Survey on Digital Watermarking Techniques”, International Journal of Computer Science and Information Technologies, 2013. IJCSIT 2013, vol. 4, pp.451, 456, 2013
30. Shahin Shaikh; Manjusha Deshmukh, “Digital Image Watermarking In DCT Domain”, International Journal of Emerging Technology and Advanced Engineering, 2013. IJETAE 2013, vol. 3, pp. 289, 293, April 2013
31. Shuifa Sun; Jian Ling; Fangmin Dong; Junli Wan, "A New General Binary Image Watermarking in DCT Domain," International Seminar on Future BioMedical Information Engineering, 2008, FBIE '08. , vol., pp.34, 36, Dec. 2008
32. Ting Zhang; Yi Du, "A Digital Watermarking Algorithm for Color Images Based on DCT," International Conference on Information Engineering and Computer Science, 2009, ICIECS 2009, pp. 1, 4, Dec. 2009
33. Weimin Yang; Lingmei Meng, "A zeros-watermarking algorithm based on chaotic system and DCT," Asia-Pacific Conference on Computational Intelligence and Industrial Applications, 2009, PACIIA 2009, vol.1, pp.71,74, Nov. 2009
34. Xinshan Zhu; Jie Ding; Honghui Dong; Kongfa Hu; Xiaobin Zhang, "Normalized Correlation-Based Quantization Modulation for Robust Watermarking," IEEE Transactions on Multimedia, vol.16, no.7, pp.1888,1904, Nov. 2014
35. Zhang, J.; Ho, A.T.S., "An efficient digital image-in-image watermarking algorithm using the integer discrete cosine transform (IntDCT)," International Conference on Information, Communications and Signal Processing, vol.2, pp.1163,1167, Dec. 2003
36. Zhao Rui-mei; Lian Hua; Pang hua-wei; Hu Bo-ning, "A Watermarking Algorithm by Modifying AC Coefficies in DCT Domain," International Symposium on Information Science and Engineering, 2008, ISISE'08, vol.2, pp.159, 162, Dec. 2008
Dec. 2008
38. Zheng Chaomei; Li Yuan, "A blind watermarking algorithm based on block DCT for dual color images," International Conference on Computer Science and Network

Technology (ICCSNT), 2011, vol.3, pp.1690, 1694, Dec. 2011
39. Somwanshi, Devendra, Mahima Asthana, and Archika Agarwal. "An OTSU-discrete wavelet transform based secure watermark scheme." In Soft Computing: Theories and Applications: Proceedings of SoCTA 2016, Volume 1, pp. 273-283. Springer Singapore, 2018.
40. Soni, Satish, and Devendra Somwanshi. "Texture Based Approach for Image Watermarking." In 2018 3rd International Conference and Workshops on lo Conference on Emerg, vol. 2, pp. 109-115. 2018.
41. Chaturvedi, Anmol, Devendra Kumar Somwanshi, and Pranjal Ranjan. "A novel approach for data retrieval using watermark …
technique." In 2016 International Conference on Recent Advances and Innovations in Engineering (ICRAIE), pp. 1-5. IEEE, 2016.
42. Jain, Archika, Devendra Somwanshi, Chaitanya Khurana, and Kapil Joshi. "Review on Digital Watermarking Techniques and Its Retrieval." In 2022 International Conference on Fourth Industrial Revolution Based Technology and Practices (ICFIRTP), pp. 274-278. IEEE, 2022.
43. Somwanshi, Devendra, Indu Chhipa, Trapti Singhal, and Ashwani Yadav. "Modified Least significant bit algorithm of digital watermarking for information security." In Soft Computing: Theories and Applications: Proceedings of SoCTA 2016, Volume 2, pp. 473-484. Springer Singapore, 2018