

Application of Digital Watermarking Using DWT for Copyright Security of Digital Images : Literature Review

M. Rafif Syauqi Al Hadi *, Lailan Sofinah Harahap, Taufik Hidayat

Program Studi Ilmu Komputer, Universitas Islam Negeri Sumatera Utara
Jln. Lapangan Golf, Desa Durian Jangak, Kecamatan Pancur Batu, Kabupaten Deli Serdang, Indonesia

Article Info

Article history:

Received June 18, 2025

Revised August 7, 2025

Accepted October 22, 2025

Keywords:

Digital Watermarking, Discrete Wavelet Transform (DWT), Peak Signal-to-Noise Ratio (PSNR)

ABSTRACT

By adding invisible information to photos, digital watermarking becomes a viable copyright protection method. In order to improve the protection of digital image copyrights, this study examines the use of the Discrete Wavelet Transform (DWT) approach in digital watermarking. This study compares the findings of watermarking quality measures using Peak Signal-to-Noise Ratio (PSNR) and Mean Squared Error (MSE) parameters, and assesses the benefits and drawbacks of DWT in comparison to alternative watermarking techniques through a survey of ten pertinent publications. The analysis's findings demonstrate that DWT works well for embedding invisible watermarks, preserving images' visual quality, and offering strong resistance to a range of attacks, including compression and modification. Additionally, this approach performs better than spatial domain-based watermarking methods like Least Significant Bit (LSB). This study stimulates more research to improve parameters and investigate combinations of various watermarking techniques, and it suggests using DWT as the major method in digital watermarking for digital image copyright protection.

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Corresponding Author:

M. Rafif Syauqi Al Hadi
Universitas Islam Negeri Sumatera Utara
Email: lailansofinahharahap@umsu.ac.id

INTRODUCTION

In the current digital era, using digital photos has become a need in both personal and business settings. Digital images are widely employed in a variety of industries, such as social media, marketing, education, and entertainment, thanks to improvements in information and communication technology. However, issues with copyright protection are also becoming more prevalent as digital photographs become more widely available and distributed. For material providers, copyright infringement including theft and illegal use has grown to be a major issue. Digital image copyright protection is so essential. One method for safeguarding digital photographs' copyright is digital watermarking. Using this method, invisible information can be embedded into an image to track its usage or serve as ownership proof. Although there are several ways to watermark, the Discrete Wavelet Transform (DWT) is one of the best. The watermark may be added without substantially affecting the image's visual quality thanks to DWT, a technology that enables image analysis in the frequency domain. Watermark embedding in areas less susceptible to visual changes is made possible by DWT's ability to divide image information into many frequency components. As a result, even though the embedded watermark is concealed from view, it can still be removed when necessary. Because of this, DWT is a very appealing technique for digital watermarking, particularly when it comes to copyright protection. In this study, we will examine a number of journals that address the use of DWT in digital watermarking to protect digital

images' copyright. We'll assess this method's benefits and drawbacks and contrast it with alternative watermarking strategies. We will also go over the technical metrics, including Mean Squared Error (MSE) and Peak Signal-to-Noise Ratio (PSNR), that are used to gauge the quality of watermarking.

METHOD

This inquire about employments library investigate or writing ponder. To discover writing survey information, one can allude to books, nearby and worldwide investigate diaries, logical works, and investigate conducted by others. A writing survey could be a outline of writing on a point. This writing survey gives data almost the most recent improvements within the field. A writing survey permits analysts to present certain strategies, create certain strategies, and recognize their relationship with logic and their relationship with particular inquire about topics/results. Investigate devices utilize portable gadgets, portable workstations, and Wi-Fi systems to inquiry existing investigate information to distinguish diaries distributed within the final five a long time, from 2019 to 2024. Browse or utilize distribution sources to look for writing and utilize Google Researcher and related references to conduct looks.

RESULTS

Based on the search results regarding the Application of Digital Watermarking Using DWT for Digital Image Copyright Security, there are several relevant journals related to this research. The analysis results from these journals will be described in Table 1 below.

Title	Year	Result
IMPLEMENTATION OF DISCRETE WAVELET TRANSFORM ALGORITHM FOR ADDING INVISIBLE WATERMARKING TO DIGITAL IMAGES(Syahdilan & Tanjung, 2024)	2024	The application created from this inquire about can be utilized to include undetectable watermarks to advanced pictures. The method of inserting watermark messages into advanced pictures is carried out utilizing steganography strategies. The calculation utilized for the imperceptible watermark expansion prepare is Discrete Wavelet Change (DWT). The application in this investigate was built utilizing Visual Studio computer program with the C# (C Sharp) programming dialect. Advanced pictures that can be utilized within the imperceptible watermark expansion prepare are advanced pictures with the .jpeg expansion. Pictures with undetectable watermarks produced by the application in this inquire about have the .png expansion.
SECURING DIGITAL IMAGE COPYRIGHTS WITH WATERMARKING TECHNIQUES USING HYBRID SVD WITH DWT METHOD(Asroni & Serumena, 2021)	2021	Within the application of Half breed Picture Watermarking DWT with SVD, the alpha esteem can influence the imperceptibility level of the watermarked picture, since the alpha esteem demonstrates the perceivability level of the watermark on the cover picture. The lower the alpha esteem, the less unmistakable the watermark gets to be and the higher the imperceptibility level. From tests conducted with batik theme objects, the leading alpha esteem was found to be 0.01, since it yielded the most noteworthy PSNR esteem compared to others. Based on the strength test, the Half breed Picture Watermarking DWT-SVD strategy within the LL subband incorporates a adequately tall level of resistance against endeavors to evacuate the watermark, which serves as the authentic possession personality of a computerized picture, as long as the watermarked picture isn't controlled with clamor assaults.
Implementation of Digital Image Processing Using Discrete Hermite Wavelet Filter Technique in Watermarking Images(Putri dkk., 2024)	2024	This investigate found that Discrete Hermite Wavelet Change (DHWT) is utilized within the handle of inserting watermarks into computerized pictures. The method steps start with perusing pictures utilizing the numpy, matplotlib, and scipy libraries, and guaranteeing record availability through Google Drive. Pictures are at that point changed over from RGB organize to grayscale employing a straight approach based on the weighted components of ruddy, green, and blue colors, which disentangles picture preparing. DHWT change is utilized to deconstruct grayscale pictures into four sub-frequency components, to be specific LL (Estimation), LH (Flat Subtle elements), HL (Vertical Points of interest), and HH (Inclining Points of interest). This handle points to extricate moo and tall recurrence components to encourage watermark implanting.
IMPLEMENTATION OF DIGITAL IMAGE SECURITY BASED ON 2D LOGISTIC MAP ENCRYPTION AND DNA ENCODING WITH LSB	2022	The comes about of this ponder appear that both watermarking methods executed, to be specific recurrence domain-based watermarking (DWT), give way better inserting comes about than spatial space (LSB) when seen from an normal MSE esteem of zero

AND DWT EMBEDDING(Rudhistiar, 2022)		with an normal PSNR esteem of 44.59db. Based on handling time, the DWT method is additionally quicker than the LSB method for all handled information sizes.
OPTIMIZATION OF HYBRID INVISIBLE WATERMARKING RDWT-DCT-SVD USING PSO ALGORITHM IN DIGITAL IMAGES(nendi dkk., 2020)	2020	The comes about of this inquire about are the plan, usage, testing, and comparison of cross breed watermarking. It can be concluded that cross breed watermarking utilizing RDWT-DCT-SVD and PSO optimization is competent of creating great imperceptible picture quality and does not altogether harm the picture amid inserting or extraction. The execution of PSO in crossover undetectable watermarking, as clarified already, is able of inserting watermark pictures randomly,so that it cannot be effectively assaulted and produces great imperceptibility. At that point the coming about PSNR found the middle value of 50dB. This proposed cross breed watermarking RDWT-DCT-SVD and PSO optimization has essentially higher comes about than past half breed watermarking.
IMPLEMENTATION OF DATA ENCRYPTION STANDARD (DES) ON IMAGE WATERMARKING USING DISCRETE COSINE TRANSFORM (DCT) ALGORITHM(Muhammad dkk., 2019)	2019	This investigate concluded that it can be demonstrated with the torrential slide impact information comes about that when the key is changed by 1-bit, it approaches 50%, and when the mystery picture is changed by 1-bit, it approaches 0%. On the off chance that the key is changed by 1-bit, at that point 50% of the scrambled picture will alter, and in case the mystery picture is changed by 1-bit, at that point the scrambled picture changes by roughly 0. The quality of the watermarked picture can be seen from the PSNR and MSE values coming about from the inserting test.
INVISIBLE WATERMARK ON DIGITAL VIDEO USING DYNAMIC CELL SPREADING (DCS) METHOD(Ikhsan dkk., 2023)	2023	These discoveries come about in an application that can be utilized to implant imperceptible content watermarks into computerized recordings. The method of watermarking content into advanced recordings is done utilizing the Energetic Cell Spreading (DCS) strategy. Advanced video records that can be watermarked with content are video records with the .mp4 expansion. There will be clamor at the starting of the outline since it is utilized as the area for embeddings the content watermark. The application made in this investigate was created utilizing Android Studio computer program. And the programming dialect utilized to construct the application is Java.
OPTIMIZATION OF INVISIBLE WATERMARKING DCT METHOD BASED ON SVD IN COLOR IMAGES(Utomo dkk., 2024)	2024	Picture quality assessment utilizing Cruel Squared Blunder (MSE) and Top Signal-to-Noise Proportion (PSNR) measurements has been distinguished. For the Lena.bmp picture, the most reduced MSE esteem was recorded at Level 1 with 0.075, whereas the most noteworthy PSNR esteem was accomplished at Level 1 with 48.17 dB. Then again, for the Peppers.png picture, the least MSE esteem was recorded at Level 1 with 0.0083, and the most noteworthy PSNR esteem was accomplished at Level 1 with 48.17 dB. In the mean time, for the Baboon.jpg picture, the most reduced MSE esteem was 0.0097, which happened at Level 1, and the most noteworthy PSNR esteem was too recorded at Level 1 with 48.17 dB. Within the setting of the comes about gotten, it is suggested to further consider Level 1 within the picture investigation prepare since it gives the leading quality with the least MSE esteem and most noteworthy PSNR.
Watermark Insertion Using LSB (Least Significant Bit) Method for Medical Image Authentication(Alveda & Rakhmawati, 2024)	2024	This investigate appears that the Slightest Noteworthy Bit (LSB) strategy is viable for watermarking restorative pictures without decreasing visual quality. The embedded watermark isn't obvious to the naked eye, so the initial picture cannot be recognized. Extricating the watermark from controlled pictures appears that the watermark can be effectively extricated indeed within the nearness of commotion such as Gaussian clamor, dot commotion, and salt & pepper clamor. The test comes about appear that the quality of the watermarked picture diminishes. This could be measured by an increment within the MSE (Cruel Squared Mistake) esteem and a diminish within the PSNR (Top Signal-to-Noise Proportion) esteem. Be that as it may, the watermark can still be extricated with tall exactness. Hence, the LSB strategy is safe to different sorts of clamor and successful in keeping up the keenness and genuineness of therapeutic pictures in telemedicine applications, guaranteeing the security and unwavering quality of restorative information transmitted over networks.Robust

		Watermarking for Therapeutic Pictures within the Discrete Wavelet Change Space Utilizing Lattice Decay with Molecule Swarm Optimization
Robust Watermarking for Medical Images in the Discrete Wavelet Transform Domain Using Matrix Decomposition with Particle Swarm Optimization(Resandy dkk., 2024)	2024	The investigation comes about of the watermarking conspire for therapeutic pictures appear great imperceptibility quality with the most elevated PSNR esteem of 49.8469 dB and SSIM higher than 0.98. Assessment utilizing the NC parameter appears the scheme's strength against commotion, compression, channel, honing assaults, and a few geometric assaults such as turn and rescale.

DISCUSSION

The use of digital watermarking with DWT yields consistent results in terms of robustness and imperceptibility, according to an examination of ten pertinent journals. An application that can preserve image quality while preserving an invisible watermark in processed JPEG images and converting them back to PNG format is described in one publication (2024). According to a different study, using hybrid techniques—such as DWT and Singular Value Decomposition (SVD)—can increase resistance to attempts to remove watermarks, particularly when the alpha parameter is adjusted optimally (an alpha value of approximately 0.01 produces the maximum PSNR). In order to facilitate watermark implantation, wavelet variations like the Discrete Hermite Wavelet Transform are also used to streamline processing by transforming color images to grayscale and carrying out decomposition into frequency components. Additionally, a comparison of spatial approaches (LSB) and frequency domain-based methods (DWT) reveals that DWT offers superior watermark quality with faster processing times. While preserving picture integrity throughout the embedding and extraction process, a number of optimizations, including the hybrid RDWT-DCT-SVD technique's application of the Particle Swarm Optimization (PSO) algorithm, can create extremely delicate watermarks (average PSNR of 50 dB). Due to their extreme sensitivity to changes in the key and secret image, even common encryption techniques like DES are used at the watermarking stage with the DCT approach to offer an extra layer of security.

The Dynamic Cell Spreading (DCS) methodology has been successfully used to apply DWT-based digital watermarking techniques to digital video in addition to static images, thereby extending copyright protection to video assets. While matrix-based and particle optimization techniques exhibit strong resistance to interference, the LSB watermarking approach has demonstrated efficacy in guaranteeing the authenticity of medical images without compromising the visual quality required for diagnosis in medical applications. All things considered, watermarking technology with DWT offers a dependable way to preserve the security and authenticity of digital photos by embedding invisible watermarks that are impervious to different types of attacks and preserve excellent visual quality. Results from technical measurements, such as PSNR close to 50 dB and extremely low MSE values, show that this methodology was successfully applied.

CONCLUSION

By preserving image quality and watermark resilience against modification and outside intervention, the Discrete Wavelet Transform (DWT) method of digital watermarking has demonstrated remarkable efficacy in safeguarding the copyright of digital photographs. This technique maintains the original image's visual integrity while enabling the addition of an invisible watermark. In order to preserve the validity, security, and copyright protection of digital works, it is therefore strongly advised that DWT be used as a watermarking technology in commercial and medical applications. To improve the system's resilience and adaptability, further studies are anticipated to investigate more complex parameters and the incorporation of other watermarking techniques.

REFERENCES

- [1] Alveda, A., & Rakhmawati, L. (2024). Penyisipan Watermark Menggunakan Metode LSB (Least Significant Bit) untuk Autentikasi Citra Medis. *JURNAL TEKNIK ELEKTRO*, 13(3), 273–280. <https://doi.org/10.26740/jte.v13n3.p273-280>
- [2] Asroni, O., & Serumena, D. R. (2021). Pengamanan Hak Cipta Citra Digital dengan Teknik Watermarking Menggunakan Metode Hybrid SVD dengan DWT. *Jurnal Syntax Admiration*, 2(11), 2145–2157. <https://doi.org/10.46799/jsa.v2i11.334>
- [3] Ikhsan, M., Sriani, & Tarigan, S. perida B. (2023). INVISIBLE WATERMARK PADA VIDEO DIGITAL MENGGUNAKAN METODE DINAMIC CELL SPREADING (DCS). *Jurnal Informatika Dan Rekayasa Elektronik*, 6(1), 18–27. <https://doi.org/10.36595/jire.v6i1.738>
- [4] Muhammad, R., Raharjo, J., & Andini, N. (2019). Implementasi Data Encryption Standard (des) Pada Image Watermarking Citra Menggunakan Algoritma Discrete Cosine Transform (dct). *eProceedings of Engineering*, 6(2), Article 2. <https://openlibrarypublications.telkomuniversity.ac.id/index.php/engineering/article/view/10441>
- [5] nendi - -, Insani, O. J., & Abdullah, I. N. (2020). Optimasi Hybrid Invisible Watermarking RDWT-DCT-SVD menggunakan Algoritma PSO pada Citra Digital. *Jurnal Teknologi Terpadu*, 6(1), Article 1. <https://doi.org/10.54914/jtt.v6i1.230>
- [6] Putri, S. W., Siregar, T. A. N., Salsabilah, R. B., & Saputra, G. E. (2024). Implementasi Digital Image Processing Menggunakan Discrete Hermite Wavelet Filter Technique Dalam Pemberian Watermark Pada Citra. *Jurnal Ilmiah Teknologi Informasi Dan Robotika*, 6(2), Article 2. <https://doi.org/10.33005/jifti.v6i2.160>
- [7] Resandy, R., Purnamasari, R., & Atmaja, R. D. (2024). Robust Watermarking Untuk Citra Medis Pada Domain Discrete Wavelet Transform Menggunakan Dekomposisi Matriks Dengan Particle Swarm Optimization. *eProceedings of Engineering*, 11(4), 2778–2784.
- [8] Rudhistiar, D. (2022). IMPLEMENTASI PENGAMANAN CITRA DIGITAL BERBASIS ENKRIPSI 2D LOGISTIC MAP DAN DNA ENCODING DENGAN PENYISIPAN LSB DAN DWT. *Jurnal Mnemonic*, 5(1), Article 1. <https://doi.org/10.36040/mnemonic.v5i1.4436>
- [9] Syahdilan, A., & Tanjung, M. A. P. (2024). IMPLEMENTASI ALGORITMA DISCRETE WAVELET TRANSFORM UNTUK MENAMBAHKAN INVISIBLE WATERMARKING PADA CITRA DIGITAL. *JATI (Jurnal Mahasiswa Teknik Informatika)*, 8(6), Article 6. <https://doi.org/10.36040/jati.v8i6.11711>
- [10] Utomo, D. W., Sari, C. A., & Rachmawanto, E. H. (2024). OPTIMASI INVISIBLE WATERMARKING METODE DCT BERBASIS SVD PADA CITRA BERWARNA. *Semnas Ristek (Seminar Nasional Riset Dan Inovasi Teknologi)*, 8(01), Article 01. <https://doi.org/10.30998/semnasristek.v8i01.7140>