**Accredited Ranking SINTA 2**
Decree of the Director General of Higher Education, Research and Technology, No. 158/E/KPT/2021
Validity period from Volume 5 Number 2 of 2021 to Volume 10 Number 1 of 2026

Published online on: **http://jurnal.iaii.or.id**

**JURNAL RESTI**

**(Rekayasa Sistem dan Teknologi Informasi)**

Vol. 7 No. 5 (2023) 1211 - 1223 ISSN Media Electronic: 2580-0760

# Robust Digital Watermarking on Vital Archives using Hybrid SVD and DWT Methods

Alita Wulan Dini[1], Shelvie Nidya Neyman[2], Toto Haryanto[3]
[1,2,3]Computer Science Departement, Faculty of Mathematics and Natural Sciences, Institut Pertanian Bogor, Bogor, Indonesia
[1]alitawulandini@apps.ipb.ac.id, [2]shelvie@apps.ipb.ac.id, [3]totoharyanto@apps.ipb.ac.id

**Abstract**

*The development of internet technology affects the dissemination of data, especially in vital government archives. This research uses a hybrid Singular Value Decomposition (SVD) and Discrete Wavelet Transform (DWT) method, which aims to protect the copyright of vital archives. The stages of the insertion and extraction process are carried out to test the effect of the alpha value on the quality (imperceptibility) and robustness of the inserted image by measuring the Peak Signal to Noise Ratio (PSNR), verifying similarity by measuring the Normalized Cross-Correlation (NC) and Structural Similarity Index (SSIM). The results of research with ten vital archives and a protection watermark logo in JPEG format with a size of 512x512 pixels obtained a maximum PSNR with a value of α = 0.01 of 41.0567 dB, NC of 0.98904, and SSIM of 0.98023 on the Cibereum Land Certificate. So it can be proven that this method produces vital archive watermarks that can be extracted and are robust to JPEG compression attacks of 75%, median filtering 3x3, Gaussian noise 0.01, speckle noise 0.01, and salt and pepper noise 0.01 but not resistant to rotation 80˚ and cropping attacks 2 %.*

Keywords: *vital archives; DWT; robustness; SVD; watermarking*

## 1. Introduction

Technological developments in the form of digital data, especially images, are straightforward to modify using the internet [1], many of which utilize copyright, mainly vital archives, for personal interests. Maintaining vital archives is a challenge for the government in maintaining the copyright of vital archives so that they remain authentic. Cryptography and encryption are several methods of protecting multimedia data [2]. The technique for protecting copyright is using watermarking [3]. The history of watermarking dates back to the 13th century in 1282 in Italy at the Fabriano paper mill [4]. Watermarking is a technique of inserting or hiding data in other data. The extraction technique consists of two parts [3], consisting of spatial domain techniques and frequency domain techniques. Watermarking maintains the originality of vital records and creates marks such as copyrights, trademarks, and patents.

Based on Law Number 43 of 2009 concerning archives in article [5], what is meant by archives or records are recordings of activities or events in various forms and media. Government Regulation of the Republic of Indonesia [6] and Regulation of the Minister of Law and Human Rights [7] is one of the management of dynamic records.

Several vital archives include land certificates, copyright certificates, birth certificates, passports, building plans, vehicle registration certificates, marriage certificates, diplomas, driver's licenses, and daktiloscopes. Characteristics of vital government archives are used to determine the position to maintain ownership rights as an example of misuse of ownership rights, namely the brand's PT Ayam Geprek Benny Sujono and Geprek Bensu Ruben Onsu Year 2022. As for preventing unauthorized reproduction (piracy protection or copy control) and broadcast monitoring, a watermarking method is required by archival principles, namely authenticity, the integrity of original rules (principle of the original order), and origin (principle of provenance) as well as protecting the media from security disturbances. Furthermore, to protect Intellectual Property Rights (HAKI) [8], especially on copyrights of vital archives and multimedia data [9], watermarking is a process or technique of hiding information [10] by looking at copyright from the multimedia data [11]. Several studies have been conducted on watermarking [9] with a hybrid DWT-SVD scheme to produce a more effective watermarking scheme [12]. Digital watermarking has criteria for

Accepted: 21-03-2023 | Received in revised: 30-09-2023 | Published: 28-10-2023

imperceptibility, security, and robustness [13]. Research [14] provides copyright protection for e-government documents. Research [15] improved performance on the imperceptibility and robustness of medical images against attack. Research [16] resulted in resistance to signal processing and geometric attacks on government documents.

This research uses a hybrid SVD method with DWT because it has good resistance to receiving various types of attacks and has good enough transparency so that the inserted information will not be visible. In contrast, watermarked images are very susceptible to distortion [17]. This research aims to obtain watermarked vital archive image results that are robust and invisible and can be extracted well without reducing the quality of the vital archive so that it can protect the copyright of the Ministry of Law and Human Rights vital archive, which is currently still implemented in hardcopy form. Characteristics of vital archive images in the Region of Interest (ROI), where the part that must be robust as ownership or copyright. Furthermore, the vital archive image will be tested with JPEG compression attack, rotation, cropping, filtering, gaussian noise, speckle noise, and salt and pepper noise. The vital archive images used are raster images with *.jpeg format, consisting of ten host images and one watermarking logo. To prove that the extracted watermark is the same as the watermark inserted in the vital archive media by testing the effect of the alpha value on the quality (imperceptibility) of the inserted image by measuring the Peak Signal to Noise Ratio (PSNR), the verifiability of similarity with the original image of the vital archive by measuring the Normalized Cross-Correlation (NC) and Structural Similarity Index (SSIM) against the robustness of attacks that will affect the quality of the vital archive watermark.

## 2. Research Methods

This research uses a robust digital watermarking hybrid SVD technique with DWT through data collection, preprocessing, system design, and attack testing on vital archival images.

### 2.1 Research Data

Data collection was carried out using a quantitative method, namely collecting vital archival data at the Secretariat General and Directorate General of KI in the form of land certificates, trademark certificates, and copyright certificates, as shown in Table 1 and Figure 1 and 2.


Figure 1. Pengayoman Logo Watermark Image (7.93 x 8.28 cm)

Table 1. Image Dataset

| Image Data | Format | Size (cm) | Resolution (pixel) |
|---|---|---|---|
| Cibereum Land Certificate | RGB | 15.74 x 22.28 | 595 x 842 |
| Mount Sindur Land Certificate | RGB | 16.19 x 20.95 | 612 x 792 |
| Lebak Bulus Land Certificate | RGB | 16.19 x 20.95 | 612 x 792 |
| Jagakarsa Land Certificate | RGB | 15.74 x 22.28 | 595 x 842 |
| Kedoya Land Certificate | RGB | 15.74 x 22.28 | 595 x 842 |
| Kojal Logo Brand | RGB | 19.05 x 23.81 | 720 x 900 |
| Irubistie Logo Brand | RGB | 12.70 x 15.88 | 720 x 900 |
| Human Solidarity Logo Brand | RGB | 10.23 x 15.29 | 580 x 867 |
| Antaranews Logo Brand | RGB | 29.99 x 47.10 | 1700 x 2670 |
| Create a Book | RGB | 16.19 x 24.76 | 612 x 936 |
| Pengayoman Logo | RGB | 7.93 x 8.28 | 936 x 978 |


Figure 2. Copyright Certificate for Women's Empowerment Books as the Host Image (16.19 x 24.76 cm)

### 2.2 Data Preprocessing

This research preprocesses the data by cropping the Region of Interest (ROI) section of vital archival images to obtain vital archival image objects to be protected. Furthermore, all image data is given RGB format with *.jpg extension with host image and one shelter logo as watermark image, which is resized to 512 x 512 pixels as shown in Table 2.

Table 2. Image Dataset Preprocessing

| Image Data | Format | Size (cm) |
|---|---|---|
| Cibereum Land Certificate | RGB | 512 x 512 |
| Mount Sindur Land Certificate | RGB | 512 x 512 |
| Lebak Bulus Land Certificate | RGB | 512 x 512 |
| Jagakarsa Land Certificate | RGB | 512 x 512 |
| Kedoya Land Certificate | RGB | 512 x 512 |
| Kojal Logo Brand | RGB | 512 x 512 |
| Irubistie Logo Brand | RGB | 512 x 512 |
| Human Solidarity Logo Brand | RGB | 512 x 512 |
| Antaranews Logo Brand | RGB | 512 x 512 |
| Create a Book | RGB | 512 x 512 |
| Pengayoman Logo | RGB | 512 x 512 |

### 2.3 Discrete Wavelet Transform (DWT)

The discrete signaling method is used to provide time-frequency representation. The transformation process can be done repeatedly or recursively, called a multiscale transform, which produces a $2^n$-1 approximation coefficient containing the low-frequency components of the image and the wavelet coefficient containing the high-frequency.

DWT decomposition will divide four types of the subband, low frequency on the low-pass filter (LL) function, and three high frequencies on the high-pass

DOI: https://doi.org/10.29207/resti.v7i5.5003

filter (HL), vertical (LH), and diagonal (HH) functions [18]as shown in Figure 3.

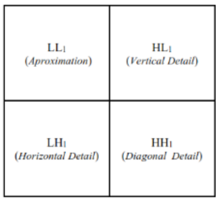



Figure 3. The Structure of The 1 DWT Scale Representation [18]

DWT consists of LL, HL, LH, and HH [19]. The equation can be seen in Formula 1.

$$W(j,k) = \sum_j \sum_k x(k) 2^{-j/2}\, \psi((2^{-j}x - k) \quad (1)$$

x is the sampled signal and is the mother wavelet, and x is the sampled signal$\psi(t)$ (See Figure 4).

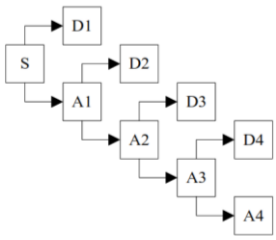



Figure 4. Decomposition DWT 4 Levels [20]

2.4 Singular Value Decomposition (SVD)

Three characteristics of SVD, namely the hanger matrix (U), stretcher (S), and aligner (V) [21] in Formula 2.

$$A = U\, S\, V^T \quad (2)$$

A is the size matrixes $mxn$ $t$he singular vector of the matrix A, D is the singular store value, $VT$ ($^T$ means transpose) singular vectors. The matrix factorization process decomposes a matrix using the Eigenvector basis [22].

2.5 Research Related to Hybrid SVD-DWT

This study [14] uses a size of 256 x 1024 pixels with JPEG compression attacks, salt and pepper noise, and Gaussian noise with a PSNR value of 22.24 dB and NC of 0.589, where it is necessary to increase the capacity of embedding e-government document watermarks. The hybrid technique is a fusion of two techniques. Here, DWT and SVD are used together to improve the quality of digital watermarking and hence increase the robustness and imperceptibility of an image. Research [15] increased performance on the imperceptibility and robustness of medical images of salt and pepper attack, speckle noise, gaussian, rescaling, histogram, gamma correction, rotation, and Gaussian low pass filter. Research [16] produced resistance to signal processing and geometric attacks on three grayscale three-ministerial e-government document header hosts in Jordan, host image 512 x 512 pixels and one watermark image 32 x 32 pixels with four levels of decomposition, with compression attacks JPEG, scaling, gaussian noise, rotation, and median filtering.

2.6 System Planning

This research is designed to conduct the insertion and extraction process watermarked images are separated into watermarked images again. Then you can find out the quality of the extracted watermark image by looking for the PSNR, NC, and SSIM values in Figure 5.

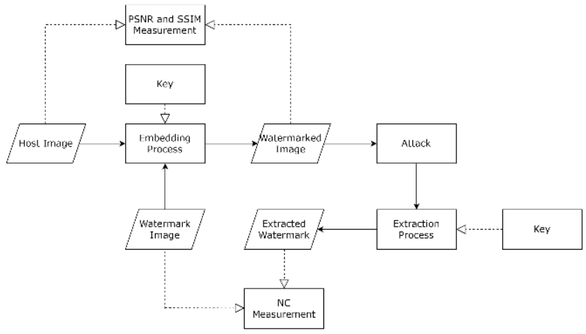



Figure 5. Watermarking System Design

2.7 Embedding Process

The process of embedding the watermarked image into the original image.

SVD transformation with DWT is performed on the host image, and a watermark is inserted to form a watermarked image. First, using 3-level DWT. Subband, LL, HL, LH, and HH are Level 1. Subbands LL2, HL2, LH2, HH2, HL, LH, and HH are level 2. At level 3, the LL2 subband is decomposed to get the LL3 subband. Factorize the LL3 subband with SVD. The formula is where A=subband LL3. Key generation uses the LL3 subband.$A = U\, S\, V^{T.}$

*Watermarks* will be inserted, and the ROI calculation will be carried out. Then, a 3-level decomposition will be carried out. On the L_L3 matrix, the watermark with SVD on the LL3 matrix. In L_L3, the LL2 subband is inserted with Formula 3.

$$f' = f + \alpha . w(k) + K(k), k = 1, \dots, L \quad (3)$$

$f'$ is the watermarked image, $f$ is the host image, $w$ is the watermark, $\alpha$ is the value of the amount of watermark inserted, $K$ namely the key, $k$ which is (m,n) subband LL3 to get a watermarked image. The insertion process is shown in Figure 6.

This research is designed to conduct the insertion and extraction process, and watermarked images are separated into watermarked images again.

2.8 Extraction Process

In the watermarking extraction, the input is the watermarked host image *C'*, and the output is extracted watermark *W'*.

DOI: https://doi.org/10.29207/resti.v7i5.5003

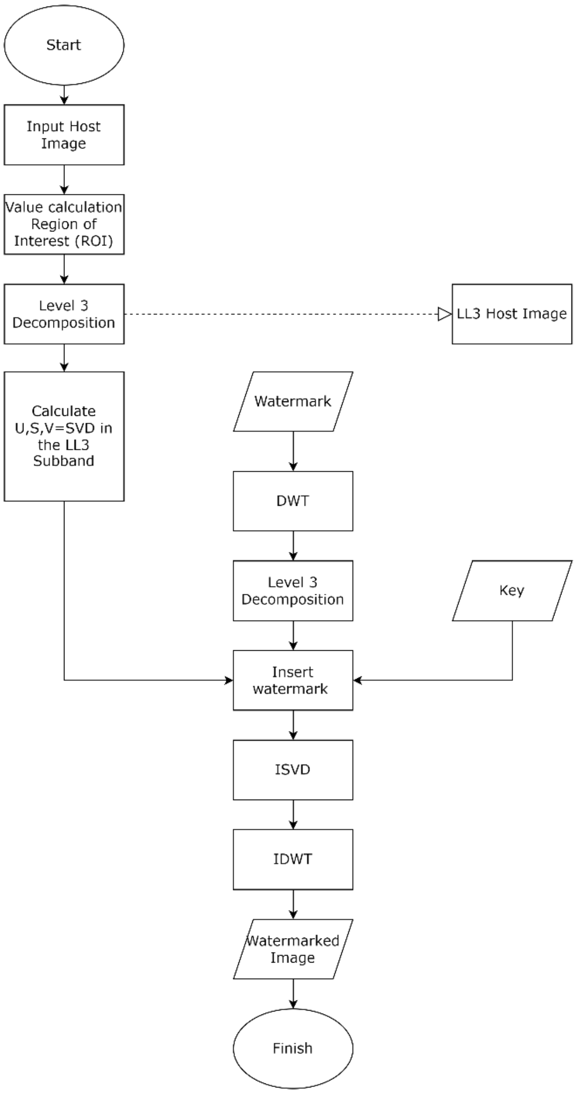



Figure 6. Embedded Process Diagram

The size of W' is $N$x$N$. The LL subband consists of the LL2, HL2, LH2, HH2, HL, LH, and HH subbands at level 2. The LL2 subband at level 3 is decomposed to produce the LL3 subband. Before the extraction process, perform critical matching by matching the value of the scalar quantity in the host image. The extraction process is carried out by removing the watermark from the host image. PSNR, MSE, SSIM, and NC were performed to perform watermark detection calculations to determine the success of the vital archive image extraction. The procedure of the watermarking extraction is shown in Figure 7.

PSNR is one way to measure image quality [22]. It compares the maximum value of the measured signal with the amount of noise that affects the signal. The PSNR equation is expressed in dB units as in Formula 4.

$$PSNR = 10 \log_{10}(\frac{l^2 max}{MSE}) \quad (4)$$

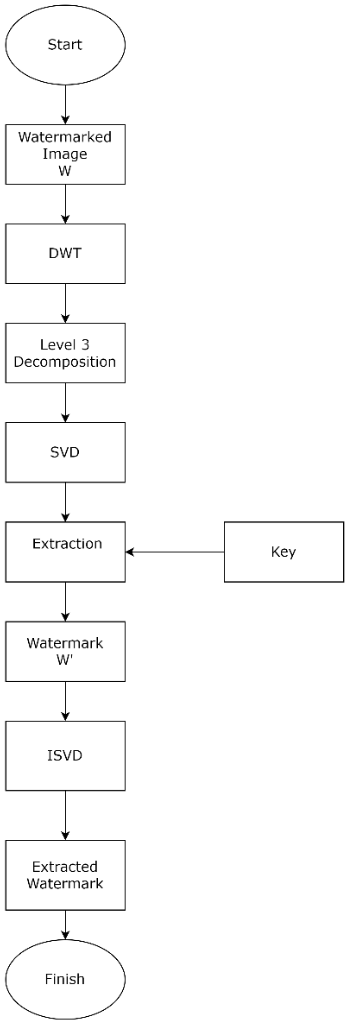



Figure 7. Extraction Process Diagram

$l^2 max$ the maximum pixel value of the image $l$ in the Mean Square Error Formula 5.

$$MSE = \frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} (S_{xy} - l_{xy})^2 \quad (5)$$

The image coordinates are x and y, the dimensions are M and N, the watermark is denoted as $S_{xy}$, and the host image is denoted as $l_{xy}$. PSNR is in decibels (dB). PSNR < 30 dB has a reasonably low image quality, and > 30 dB has a high image quality [23].

Normalized Cross-Correlation (NC), is a standard tool for evaluating the degree of similarity between the original watermark and the extracted watermark, namely testing the robustness of the image [24]. The following are defined in Formula 6.

$$NC(W, W') = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} [W(i,j).W\prime - (i,j)]}{\sum_{i=1}^{m} \sum_{j=1}^{n} (W(i,j))^2} \quad (6)$$

$W$ is the watermark image, and $W'$ is the extracted watermark image.

DOI: https://doi.org/10.29207/resti.v7i5.5003

The structural Similarity Index (SSIM) is a method for finding the similarity between the original image and a watermarked image. It is a perception-based model that considers image degradation as a perceived change in structural information, as shown in Formula 7.

$$SSIM = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad (7)$$

$\mu_x$ and $\mu_y$ the X and Y images are the means, the covariance of the X versus Y images is $\sigma_{xy}$, the X image variance is $\mu\frac{2}{x}$, the Y image variance is $\mu\frac{2}{y}C_1$, is $(k_1L)^2$ and $C_2$ is $(k_2L)^2$, L is the dynamic range of the image $(2^{bit} - 1)$.

Region of Interest (ROI) is defined as a rectangle around the center of the image. The ROI will be divided into blocks of 6x6 pixels. We use a smaller 6x6 pixels block size instead of 8x8 pixels to achieve better tamper localization accuracy and better-recovered image quality.

We need to prepare a one-to-one block mapping sequence A->B->C->D->…->A for watermark embedding in ROI, where each symbol denotes an individual block. We use a similar mapping sequence proposed by Zain in Formula 8.

$$B = [(k\ x\ B) mod Nb] + 1 \quad (8)$$

*B*, *k*[1,$N_b$],*k* is the aprime number, and $N_b$ is the total number of blocks in the ROI.

2.9 Image Attack

In this study, an attack on vital archive images was carried out on watermarked vital archive images. The matrix that is given the attack then performs an absolute calculation of LL3 when it is given an attack with the key that has been generated.

Based on research [14]-[16], this research uses parameter values α=0.01, α=0.05, α=0.5, α=0.7, and α=0.9 with some that attack shown in Table 3.

Table 3. Attack on Watermark Image

| No | Attack Type | Parameter |
|---|---|---|
| 1 | JPEG compression | 75% |
| 2 | Rotation | 80˚ |
| 3 | cropping | 2% |
| 4 | filtering | Median 3x3 |
| 5 | Gaussian Noise | 0.01 |
| 6 | Speckle Noise | 0.01 |
| 7 | Salt and Pepper Noise | 0.01 |

The total test combination scenarios in this research are 105 tests to determine the level of complexity of this research. The graphical process of testing using various attacks can be seen in Figure 8.

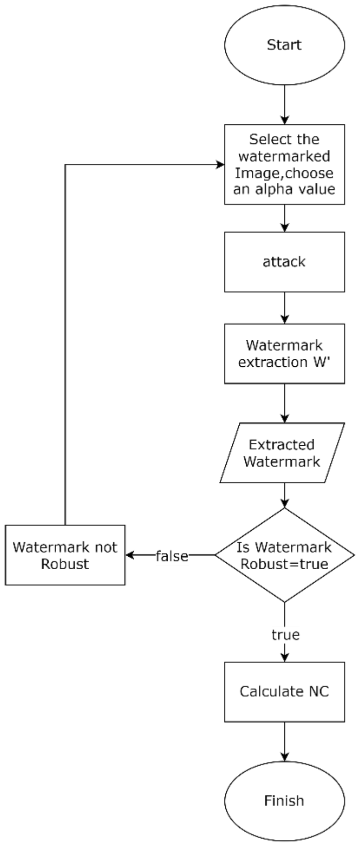



Figure 8. Attack Process Diagram

## 3. Results and Discussions

The test results in this research to prove that the extracted watermark is the same as the watermark inserted in the vital archive media by testing the effect of the alpha value on the quality (imperceptibility) of the inserted image by measuring the PSNR, verifiability of similarity with the original image of the vital archive by measuring the NC and SSIM against the robustness of attacks that will affect the quality of the vital archive watermark.

The first test is a vital archive image inserted with a watermark of the Pengayoman logo. The second test inserts a watermark into a vital archive image with 3 levels of decomposition, while the third test is carried out by giving various attacks on the watermarked image.

The research was conducted with ten vital archive images consisting of Cibereum Land Certificate.jpg, Mount Sindur Land Certificate.jpg, Lebak Bulus Land Certificate.jpg, Jagakarsa Land Certificate.jpg, Kedoya Land Certificate.jpg, Kojal Logo Brand.jpg, Irubistie Logo Brand.jpg, Human Solidarity Logo Brand.jpg, Antaranews Logo Brand.jpg, and Create a Book.jpg which has a size of (512 x 512) with one watermark in the form of Pengayoman Logo.jpg.

DOI: https://doi.org/10.29207/resti.v7i5.5003

This test is conducted to obtain the PSNR, NC, and SSIM values to determine the quality of the extracted watermark vital archive image. The analysis of the three tests will be explained in detail in the following subsections:

## 3.1 Specification

This research is supported by software and hardware, as shown in Table 4.

Table 4. Experimental Environment

| No | Simulation Environment | Environment Configuration |
|---|---|---|
| 1 | Software | Matlab R2021b |
| 2 | Operation System | Windows 11 |
| 3 | CPU | Intel Core i7 @ 2.80 GHz |
| 4 | Memory | 16 GB |

## 3.2 Image Testing Results Without Attack

Results of analysis of host image testing without attack with α=0.01, α=0.05, α=0.5, α=0.7, and α=0.9 as shown in Table 5-Table 8.

Table 5. Image Test Results in PSNR Without Attack

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 51.7825 | 42.0278 | 26.9824 | 24.8659 | 23.4694 |
| b | 48.1378 | 38.6902 | 25.9378 | 24.3800 | 23.3328 |
| c | 48.9553 | 39.6758 | 26.1591 | 24.1234 | 22.7214 |
| d | 47.7105 | 35.7715 | 23.4565 | 22.1600 | 23.4565 |
| e | 47.7106 | 37.3785 | 25.2248 | 23.6044 | 22.4718 |
| f | 48.2035 | 35.6959 | 21.6613 | 20.2442 | 19.2320 |
| g | 48.2920 | 35.8767 | 21.6531 | 20.2275 | 19.2351 |
| h | 48.1762 | 35.9364 | 22.0571 | 20.6106 | 19.5875 |
| i | 48.2112 | 35.8985 | 22.1035 | 20.5270 | 19.3542 |
| j | 48.2203 | 35.4027 | 20.3508 | 19.0453 | 18.1518 |

Table 6. Image Test Results NC Without Attack

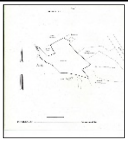
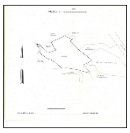
| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.99955 | 0.99524 | 0.85869 | 0.80174 | 0.75901 |
| b | 0.99913 | 0.98803 | 0.79345 | 0.74142 | 0.70362 |
| c | 0.99946 | 0.99376 | 0.87878 | 0.83596 | 0.8005 |
| d | 0.99933 | 0.98962 | 0.82432 | 0.77423 | 0.82432 |
| e | 0.9995 | 0.99222 | 0.82126 | 0.76231 | 0.71713 |
| f | 0.99994 | 0.99893 | 0.95482 | 0.92954 | 0.90365 |
| g | 0.99992 | 0.99866 | 0.94525 | 0.91628 | 0.88751 |
| h | 0.99989 | 0.99828 | 0.93279 | 0.89744 | 0.86307 |
| i | 0.99973 | 0.99615 | 0.86972 | 0.80949 | 0.7535 |
| j | 0.99986 | 0.99785 | 0.92241 | 0.88532 | 0.84783 |

Table 7. Image Test Results From SSIM Without Attack

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.99843 | 0.97698 | 0.94973 | 0.93865 | 0.93049 |
| b | 0.99912 | 0.97064 | 0.94604 | 0.93741 | 0.93179 |
| c | 0.99912 | 0.96972 | 0.94604 | 0.93905 | 0.93179 |
| d | 0.99967 | 0.9626 | 0.94057 | 0.93491 | 0.94057 |
| e | 0.99966 | 0.96743 | 0.94817 | 0.93968 | 0.93304 |
| f | 0.99977 | 0.9421 | 0.87509 | 0.83553 | 0.8058 |
| g | 0.99976 | 0.93293 | 0.86366 | 0.8181 | 0.78499 |
| h | 0.99973 | 0.9253 | 0.86919 | 0.82821 | 0.79724 |
| i | 0.99969 | 0.92962 | 0.87582 | 0.83276 | 0.79727 |
| j | 0.99974 | 0.92089 | 0.85479 | 0.81012 | 0.76704 |

The results of the extracted watermark test at level 3 are similar to the original watermark. The best PSNR value in the (a) Cibereum Land Certificate image of 51.7825 dB, NC=0.9995, and the SSIM=0.99843 indicating the level of similarity of the original watermark with the extracted watermark is very high and the vital archive image is of good quality.

Table 8. Image Extraction Result Without Attack

| Cibereum Land Certificate α =0.01 | | | |
|---|---|---|---|
| Host Image | Logo Image | Watermarked Image | Extracted Watermark |
|  |  |  |  |

## 3.1 JPEG Compression Attack Test Results

JPEG compression attack with a quality factor (QF) of 75% (Table 9-Table 12).

Table 9. JPEG Compression Attack Test Results PSNR

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 41.0567 | 38.8197 | 26.3634 | 24.3397 | 23.0971 |
| b | 40.7962 | 37.0525 | 25.6772 | 24.1973 | 23.2111 |
| c | 36.8744 | 35.1405 | 24.9758 | 23.5778 | 22.2788 |
| d | 39.5062 | 34.8195 | 23.5702 | 22.2708 | 21.325 |
| e | 39.8636 | 36.0491 | 25.2719 | 23.6094 | 22.4519 |
| f | 33.3972 | 31.456 | 21.6501 | 20.2671 | 19.2753 |
| g | 33.082 | 31.4173 | 21.5206 | 20.1308 | 19.1761 |
| h | 32.6995 | 31.0949 | 21.9564 | 20.5707 | 19.593 |
| i | 34.0107 | 31.9583 | 21.7761 | 20.2311 | 19.0904 |
| j | 32.8524 | 30.9357 | 20.2554 | 18.9677 | 18.096 |

Table 10. JPEG Compression Attack Test Results NC

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.98904 | 0.98389 | 0.83604 | 0.78013 | 0.74314 |
| b | 0.98573 | 0.976 | 0.78039 | 0.72826 | 0.69085 |
| c | 0.98125 | 0.97666 | 0.85184 | 0.82536 | 0.78916 |
| d | 0.98134 | 0.97182 | 0.79479 | 0.74174 | 0.69778 |
| e | 0.98674 | 0.98026 | 0.80857 | 0.74544 | 0.69632 |
| f | 0.99253 | 0.99183 | 0.94669 | 0.92064 | 0.89389 |
| g | 0.99039 | 0.98947 | 0.93195 | 0.90093 | 0.87118 |
| h | 0.98615 | 0.98506 | 0.91817 | 0.88208 | 0.84717 |
| i | 0.97978 | 0.9773 | 0.83694 | 0.77004 | 0.70871 |
| j | 0.98438 | 0.98307 | 0.90228 | 0.86122 | 0.82164 |

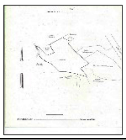
Table 11. JPEG Compression Attack Test Results SSIM

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.98023 | 0.97698 | 0.94028 | 0.93023 | 0.92333 |
| b | 0.97286 | 0.97064 | 0.93524 | 0.9283 | 0.92356 |
| c | 0.97023 | 0.96972 | 0.92567 | 0.92351 | 0.91359 |
| d | 0.96561 | 0.9626 | 0.93584 | 0.93067 | 0.92666 |
| e | 0.97092 | 0.96743 | 0.93739 | 0.9289 | 0.92291 |
| f | 0.94258 | 0.9421 | 0.8177 | 0.78822 | 0.76697 |
| g | 0.93271 | 0.93293 | 0.79491 | 0.75673 | 0.7321 |
| h | 0.92571 | 0.9253 | 0.80293 | 0.77381 | 0.7539 |
| i | 0.92908 | 0.92962 | 0.80301 | 0.77159 | 0.74646 |
| j | 0.92245 | 0.92089 | 0.77618 | 0.73306 | 0.70253 |

DOI: https://doi.org/10.29207/resti.v7i5.5003

The best PSNR value α=0.01 and parameter 75% is (a) Cibereum Land Certificate image is 41.0567 dB, NC=0.98904, and SSIM=0.98023 indicating the level of similarity of the original watermark with the extracted watermark is very high and the vital archive image is of good quality, and robust to attacks.

Table 12. JPEG Compression Attack Image Extraction Result

| Cibereum Land Certificate α =0.01 | | | |
|---|---|---|---|
| Host Image | Logo Image | Watermarked Image | Extracted Watermark |
|  |   |  |  |

### 3.4 Rotation Attack Test Results

Rotation is an attack that will change the image, as it can make all pixels move or disappear—rotation 80˚ attack as shown in Table 13-Table 16.

Table 13. Rotation Attack Test Results in PSNR

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 11.0532 | 11.0385 | 10.8004 | 10.6877 | 10.5967 |
| b | 11.523 | 11.5039 | 11.3078 | 11.2407 | 11.1873 |
| c | 11.1413 | 11.1311 | 10.967 | 10.8664 | 10.7648 |
| d | 11.4678 | 11.4367 | 11.1549 | 11.0624 | 10.979 |
| e | 11.2871 | 11.261 | 11.0596 | 10.9682 | 10.8845 |
| f | 9.714 | 9.6625 | 9.4245 | 9.3926 | 9.3689 |
| g | 9.8447 | 9.7895 | 9.5046 | 9.4534 | 9.4151 |
| h | 10.4079 | 10.3595 | 10.0947 | 10.033 | 9.9782 |
| i | 11.5254 | 11.4834 | 11.1666 | 11.0571 | 10.9457 |
| j | 10.8254 | 10.7638 | 10.269 | 10.169 | 10.0947 |

Table 14. Rotation Attack Test Results NC

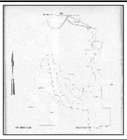
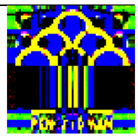
| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | -0.0277 | -0.0277 | -0.0264 | -0.0256 | -0.0250 |
| b | 0.14651 | 0.14566 | 0.13987 | 0.13848 | 0.13737 |
| c | 0.06149 | 0.06161 | 0.06046 | 0.05941 | 0.05838 |
| d | 0.00122 | 0.00199 | 0.00976 | 0.01156 | 0.01300 |
| e | 0.01699 | 0.01670 | 0.01617 | 0.01603 | 0.01600 |
| f | 0.04112 | 0.04318 | 0.05756 | 0.06074 | 0.06319 |
| g | -0.0216 | -0.02203 | -0.02347 | -0.02310 | -0.0226 |
| h | 0.03543 | 0.03599 | 0.03518 | 0.0348 | 0.03448 |
| i | 0.13373 | 0.13315 | 0.12599 | 0.12337 | 0.12088 |
| j | 0.00598 | 0.00584 | 0.00629 | 0.00660 | 0.00712 |

Table 15. Rotation Attack Test Results SSIM

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.77032 | 0.77305 | 0.77387 | 0.7736 | 0.77309 |
| b | 0.78863 | 0.79312 | 0.81015 | 0.8115 | 0.81215 |
| c | 0.70964 | 0.71142 | 0.72251 | 0.72499 | 0.72638 |
| d | 0.80177 | 0.80145 | 0.80928 | 0.80895 | 0.80874 |
| e | 0.78377 | 0.7866 | 0.79091 | 0.7906 | 0.79047 |
| f | 0.36878 | 0.36912 | 0.40339 | 0.4135 | 0.42038 |
| g | 0.35188 | 0.3525 | 0.39181 | 0.40345 | 0.41112 |
| h | 0.42307 | 0.4243 | 0.45808 | 0.46694 | 0.47312 |
| i | 0.48197 | 0.4816 | 0.51323 | 0.52284 | 0.52965 |
| j | 0.35284 | 0.35216 | 0.37939 | 0.39 | 0.39959 |

The test results of images subjected to rotation attacks all failed to be extracted. All tested images have a low NC value of around 0.01-0.2, which shows the level of similarity between the extracted watermark and the original watermark is very low. As for the PSNR value in the whole image, around 9-11 dB, which shows the image quality is not good.

Table 16. Rotation Attack Image Extraction Result

| Mount Sindur Land Certificate α =0.01 | | | |
|---|---|---|---|
| Host Image | Logo Image | Watermarked Image | Extracted Watermark |
|  |   |  |  |

### 3.5 Cropping Attack Test Results

Cropping is similar to a rotation attack that will change the image, as it can make all pixels move or disappear—cropping attack 2% as shown in Table 17-Table 20.

Table 17. Cropping Attack Test Results PSNR

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 22.4075 | 22.3052 | 20.5729 | 19.8637 | 19.346 |
| b | 24.6668 | 24.2595 | 21.5586 | 20.9136 | 20.4339 |
| c | 21.1308 | 21.0065 | 19.5475 | 18.8899 | 18.3219 |
| d | 25.054 | 24.4928 | 20.8131 | 22.5142 | 19.4837 |
| e | 22.7376 | 22.4055 | 20.3828 | 19.7315 | 19.2148 |
| f | 14.3382 | 14.2686 | 13.7819 | 13.6912 | 13.6185 |
| g | 14.6131 | 14.5452 | 14.0084 | 13.8874 | 13.7911 |
| h | 15.5601 | 15.477 | 14.882 | 14.7248 | 14.5827 |
| i | 18.3077 | 18.1429 | 16.7497 | 16.3007 | 15.8894 |
| j | 16.1198 | 16.0073 | 14.7501 | 14.4696 | 14.2619 |

Table 18. Cropping Attack Test Results NC

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.18176 | 0.19405 | 0.26491 | 0.27188 | 0.2746 |
| b | 0.3058 | 0.29573 | 0.24516 | 0.24212 | 0.24133 |
| c | 0.28345 | 0.28193 | 0.26505 | 0.25935 | 0.25456 |
| d | 0.37533 | 0.37932 | 0.32739 | 0.07137 | 0.3084 |
| e | 0.16222 | 0.16559 | 0.15973 | 0.15838 | 0.15694 |
| f | 0.37789 | 0.3862 | 0.41328 | 0.41529 | 0.4161 |
| g | 0.29758 | 0.30627 | 0.32811 | 0.32808 | 0.3271 |
| h | 0.27038 | 0.2791 | 0.29877 | 0.29812 | 0.29644 |
| i | 0.18867 | 0.19584 | 0.17226 | 0.15994 | 0.14882 |
| j | 0.2243 | 0.2363 | 0.2645 | 0.26028 | 0.25566 |

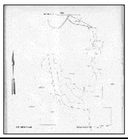
Table 19. Cropping Attack Test Results SSIM

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.8666 | 0.87099 | 0.87439 | 0.87452 | 0.87444 |
| b | 0.89176 | 0.89718 | 0.90277 | 0.90201 | 0.90146 |
| c | 0.82046 | 0.82378 | 0.8328 | 0.8343 | 0.83499 |
| d | 0.88238 | 0.88313 | 0.89924 | 0.86533 | 0.89875 |
| e | 0.87646 | 0.88113 | 0.88646 | 0.88639 | 0.88626 |
| f | 0.47034 | 0.47093 | 0.51028 | 0.51942 | 0.52508 |
| g | 0.44628 | 0.44704 | 0.48553 | 0.49443 | 0.50028 |
| h | 0.49745 | 0.49887 | 0.53199 | 0.53865 | 0.54268 |
| i | 0.54352 | 0.54288 | 0.56789 | 0.5754 | 0.58071 |
| j | 0.40798 | 0.40671 | 0.4351 | 0.44459 | 0.45251 |

DOI: https://doi.org/10.29207/resti.v7i5.5003

Table 20-Table 23 shows that all images given a cropping attack failed to be extracted. The NC value is very small, between 0.1-0.4, which shows that the level of similarity between the original watermark and the extracted watermark is very low. The quality of the extracted watermark is good because the PSNR value obtained ranges from 22-24 dB.

Table 20. Cropping Attack Image Extraction Result

| Mount Sindur Certificate α =0.01 | | | |
|---|---|---|---|
| Host Image | Logo Image | Watermarked Image | Extracted Watermark |
|  |  |  |  |

### 3.6 Filtering Attack Test Results

The 3 x 3 Median Filtering attack is shown in Table 21-Table 24.

Table 21. Filtering Attack Test Results PSNR

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 32.6601 | 32.3707 | 24.4222 | 24.1669 | 23.1174 |
| b | 35.0168 | 33.6716 | 25.5671 | 24.2033 | 23.2544 |
| c | 30.9627 | 30.4891 | 24.7942 | 23.1282 | 21.9328 |
| d | 34.4856 | 32.1703 | 23.5001 | 22.2518 | 21.3292 |
| e | 33.0128 | 31.8005 | 24.8718 | 23.3732 | 22.3205 |
| f | 21.4062 | 21.1678 | 18.2095 | 17.4881 | 16.9323 |
| g | 21.2308 | 21.0164 | 18.1598 | 17.4626 | 16.9314 |
| h | 22.7689 | 20.125 | 19.2098 | 18.4278 | 17.8154 |
| i | 24.4319 | 24.067 | 19.9952 | 18.939 | 18.0738 |
| j | 24.6935 | 24.2077 | 18.7103 | 17.7599 | 17.096 |

Table 22. Filtering Attack Test Results NC

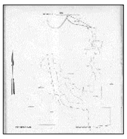
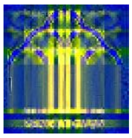
| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.92761 | 0.91897 | 0.71484 | 0.72991 | 0.70176 |
| b | 0.942 | 0.93152 | 0.75573 | 0.71226 | 0.67993 |
| c | 0.93078 | 0.92435 | 0.81238 | 0.77798 | 0.74921 |
| d | 0.93462 | 0.92281 | 0.76166 | 0.71979 | 0.68452 |
| e | 0.9289 | 0.92074 | 0.75503 | 0.70189 | 0.66291 |
| f | 0.87355 | 0.8729 | 0.82287 | 0.79632 | 0.77078 |
| g | 0.84078 | 0.84009 | 0.78066 | 0.75105 | 0.72245 |
| h | 0.85657 | 0.73486 | 0.78548 | 0.75061 | 0.71755 |
| i | 0.79868 | 0.79796 | 0.65827 | 0.60103 | 0.55187 |
| j | 0.89122 | 0.88845 | 0.80657 | 0.76925 | 0.73266 |

Table 23. Filtering Attack Test Results SSIM

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.9699 | 0.96416 | 0.91576 | 0.92494 | 0.91996 |
| b | 0.96965 | 0.96473 | 0.9317 | 0.92648 | 0.92305 |
| c | 0.96319 | 0.95933 | 0.92506 | 0.91614 | 0.90943 |
| d | 0.97115 | 0.96747 | 0.93423 | 0.93037 | 0.92736 |
| e | 0.96928 | 0.96394 | 0.93117 | 0.92457 | 0.91965 |
| f | 0.83469 | 0.83256 | 0.74866 | 0.72268 | 0.70434 |
| g | 0.78941 | 0.78743 | 0.70927 | 0.68634 | 0.6687 |
| h | 0.81548 | 0.69279 | 0.74212 | 0.71991 | 0.70259 |
| i | 0.81894 | 0.81665 | 0.74537 | 0.72166 | 0.70284 |
| j | 0.80552 | 0.80358 | 0.71909 | 0.69122 | 0.66488 |

Table 25-Table 28, with values α=0.01 is the (b) Mount Sindur Certificate image, where the durability and quality level of similarity of the extracted watermark and the original watermark is very high.

Table 24. Filtering Attack Image Extraction Result

| Mount Sindur Certificate α =0.01 | | | |
|---|---|---|---|
| Host Image | Logo Image | Watermarked Image | Extracted Watermark |
|  |  |  |  |

### 3.7 Gaussian Noise Attack Test Results

Gaussian noise is noise consisting of white dots with input values of average and variation. The results of the analysis of image testing with α=0.01, α=0.05, α=0.5, α=0.7, and α=0.9. Gaussian Noise 0.01 attack as shown in Table 25-Table 28.

Table 25. Gaussian Noise Attack Test Results PSNR

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 23.6259 | 26.3105 | 25.7359 | 24.6801 | 25.7163 |
| b | 23.5877 | 26.0138 | 25.8889 | 25.2596 | 25.1164 |
| c | 23.4064 | 25.6264 | 22.419 | 21.8729 | 21.8073 |
| d | 23.1639 | 25.1277 | 24.2937 | 23.7259 | 23.5058 |
| e | 23.5389 | 25.8951 | 25.2813 | 24.3313 | 23.8638 |
| f | 21.9895 | 22.5355 | 15.2261 | 13.9099 | 13.3942 |
| g | 21.992 | 22.5045 | 15.6497 | 14.4839 | 14.0183 |
| h | 22.1746 | 22.8826 | 15.6397 | 15.6397 | 15.6397 |
| i | 22.2406 | 23.0624 | 18.2071 | 17.6771 | 17.5755 |
| j | 21.4652 | 21.6151 | 15.3576 | 14.6797 | 14.4971 |

Table 26. Gaussian Noise Attack Test Results NC

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.67957 | 0.74547 | 0.67116 | 0.43195 | 0.67116 |
| b | 0.59366 | 0.64813 | 0.55176 | 0.31828 | 0.081344 |
| c | 0.73657 | 0.78137 | 0.51179 | 0.22386 | 0.061209 |
| d | 0.57426 | 0.63153 | 0.62334 | 0.43523 | 0.20122 |
| e | 0.65004 | 0.71029 | 0.70013 | 0.55653 | 0.27281 |
| f | 0.90274 | 0.91551 | 0.7883 | 0.58101 | 0.31471 |
| g | 0.88618 | 0.89886 | 0.76355 | 0.56308 | 0.3033 |
| h | 0.86243 | 0.87958 | 0.52801 | 0.52801 | 0.52801 |
| i | 0.76546 | 0.78878 | 0.57049 | 0.30698 | 0.076041 |
| j | 0.82058 | 0.83499 | 0.66451 | 0.41535 | 0.14314 |

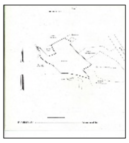
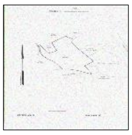
Table 27. Gaussian Noise Attack Test Results SSIM

| Image Data | α | | | | |
|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.41353 | 0.56433 | 0.91544 | 0.91034 | 0.90995 |
| b | 0.37153 | 0.51622 | 0.92504 | 0.92416 | 0.924 |
| c | 0.40532 | 0.54532 | 0.88654 | 0.87921 | 0.87833 |
| d | 0.31557 | 0.43805 | 0.92391 | 0.92015 | 0.9196 |
| e | 0.36034 | 0.49874 | 0.91904 | 0.91626 | 0.91599 |
| f | 0.43989 | 0.50361 | 0.66436 | 0.61044 | 0.59239 |
| g | 0.45316 | 0.51362 | 0.63158 | 0.58036 | 0.56214 |
| h | 0.43673 | 0.50484 | 0.61315 | 0.61315 | 0.61315 |
| i | 0.40252 | 0.47459 | 0.66907 | 0.6465 | 0.64357 |
| j | 0.42699 | 0.47057 | 0.57841 | 0.53595 | 0.52698 |

DOI: https://doi.org/10.29207/resti.v7i5.5003

In Table 30-Table 34, with values α=0.05, on the Gunung Sindur Certificate Image, the PSNR value is 26.3105 dB, NC=0.74547, SSIM=0.56433 where the resistance is quite good, where the robustness is quite good, and the watermark extraction result is degraded.

Table 28. Gaussian Noise Attack Image Extraction Result

| Cibereum Land Certificate α =0.05 | | | |
|---|---|---|---|
| Host Image | Logo Image | Watermarked Image | Extracted Watermark |
|  |  |  |  |

### 3.8 Speckle Noise Attack Test Results

The results of the analysis of image testing with α=0.01, α=0.05, α=0.5, α=0.7, and α=0.9. Speckle Noise 0.01 attack as shown in Table 29-Table 32.

Table 29. Speckle Noise Attack Test Results PSNR

| Image | α | | | | |
|---|---|---|---|---|---|
| Data | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 23.08 | 16.1139 | 6.5175 | 5.7817 | 5.3677 |
| b | 23.1353 | 16.1875 | 6.5801 | 5.8554 | 5.4446 |
| c | 23.1357 | 16.1851 | 6.6209 | 5.8865 | 5.4589 |
| d | 22.9288 | 16.297 | 6.7809 | 6.0311 | 5.6245 |
| e | 23.1736 | 16.2407 | 6.6423 | 5.907 | 5.5047 |
| f | 22.755 | 22.755 | 7.2882 | 6.5598 | 6.1493 |
| g | 22.6829 | 16.384 | 7.2446 | 6.5215 | 6.1059 |
| h | 22.678 | 16.3548 | 7.1374 | 6.4199 | 5.9949 |
| i | 22.5904 | 16.2667 | 7.0709 | 6.3419 | 5.9348 |
| j | 22.3063 | 16.2771 | 7.4094 | 6.6938 | 6.2798 |

Table 30. Speckle Noise Attack Test Results From NC

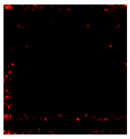
| Image | α | | | | |
|---|---|---|---|---|---|
| Data | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.77072 | 0.44225 | 0.10689 | 0.088795 | 0.079967 |
| b | 0.59374 | 0.28206 | 0.051552 | 0.044964 | 0.039481 |
| c | 0.74504 | 0.41084 | 0.080761 | 0.064981 | 0.055466 |
| d | 0.57712 | 0.29206 | 0.059951 | 0.050156 | 0.045059 |
| e | 0.65244 | 0.33945 | 0.075949 | 0.063404 | 0.059571 |
| f | 0.92018 | 0.92018 | 0.26104 | 0.22213 | 0.1993 |
| g | 0.90465 | 0.69996 | 0.23329 | 0.19802 | 0.17775 |
| h | 0.88056 | 0.64716 | 0.19532 | 0.16536 | 0.14661 |
| i | 0.78569 | 0.48554 | 0.11374 | 0.089866 | 0.079933 |
| j | 0.84851 | 0.59483 | 0.16849 | 0.1404 | 0.1217 |

Table 31. Speckle Noise Attack Test Results SSIM

| Image | α | | | | |
|---|---|---|---|---|---|
| Data | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.3547 | 0.13519 | 0.024683 | 0.019823 | 0.017355 |
| b | 0.31722 | 0.11386 | 0.019146 | 0.015611 | 0.014066 |
| c | 0.35756 | 0.14497 | 0.026936 | 0.022013 | 0.018674 |
| d | 0.27714 | 0.11009 | 0.021135 | 0.016727 | 0.015182 |
| e | 0.31336 | 0.1189 | 0.02095 | 0.017043 | 0.015598 |
| f | 0.44011 | 0.44011 | 0.079187 | 0.065824 | 0.057711 |
| g | 0.45088 | 0.25125 | 0.076587 | 0.064417 | 0.056956 |
| h | 0.42719 | 0.22927 | 0.06442 | 0.053125 | 0.046788 |
| i | 0.39258 | 0.18918 | 0.041779 | 0.032436 | 0.028761 |
| j | 0.43938 | 0.23002 | 0.057635 | 0.046887 | 0.040873 |

In Table 35-Table 38 with value α=0.01, PSNR is 23.1736 dB, NC=0.65244, SSIM=0.31336 where the (e) Kedoya Land Certificate Image.

Table 32. Speckle Noise Attack Image Extraction Result

| Kedoya Land Certificate α =0.01 | | | |
|---|---|---|---|
| Host Image | Logo Image | Watermarked Image | Extracted Watermark |
|  |  |  |  |

### 3.9 Salt and Pepper Noise Attack Test Results

Salt and Pepper Noise is noise consisting of black and white dots. In Matlab, input with a constant value between 0-1, the greater the constant value inputted, the more blurred the image will be. Salt and Pepper Noise testing results are shown in Table 33-Table 36.

Table 33. Salt and Pepper Noise Attack Test Results PSNR

| Image | α | | | | |
|---|---|---|---|---|---|
| Data | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 23.0569 | 16.097 | 6.1029 | 4.6569 | 3.563 |
| b | 23.1619 | 16.2274 | 6.2089 | 4.7353 | 3.6283 |
| c | 23.066 | 16.2348 | 6.2236 | 4.7568 | 3.6727 |
| d | 23.4274 | 16.397 | 6.3765 | 4.9148 | 3.8222 |
| e | 23.1486 | 16.2248 | 6.248 | 4.7778 | 3.6823 |
| f | 23.7455 | 16.8124 | 6.8019 | 5.3352 | 4.251 |
| g | 23.8941 | 16.7607 | 6.7958 | 5.3365 | 4.2384 |
| h | 23.7253 | 16.6912 | 6.7216 | 5.2522 | 4.1624 |
| i | 23.7096 | 16.72 | 6.7069 | 5.2284 | 4.1427 |
| j | 24.039 | 17.0356 | 7.0237 | 5.5777 | 4.4926 |

Table 34. Salt and Pepper Noise Attack Test Results NC

| Image | α | | | | |
|---|---|---|---|---|---|
| Data | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.73405 | 0.42464 | 0.087975 | 0.048487 | 0.01584 |
| b | 0.59655 | 0.30824 | 0.060826 | 0.031638 | 0.011788 |
| c | 0.73214 | 0.43326 | 0.090205 | 0.050776 | 0.015223 |
| d | 0.60742 | 0.31386 | 0.060562 | 0.034415 | 0.011249 |
| e | 0.6409 | 0.34331 | 0.068744 | 0.036182 | 0.011831 |
| f | 0.93595 | 0.75657 | 0.20715 | 0.11109 | 0.036689 |
| g | 0.92753 | 0.72589 | 0.19035 | 0.10404 | 0.03332 |
| h | 0.90526 | 0.67537 | 0.16845 | 0.091295 | 0.028476 |
| i | 0.83132 | 0.5446 | 0.11972 | 0.064901 | 0.017996 |
| j | 0.89479 | 0.65359 | 0.15421 | 0.083326 | 0.027563 |

Table 35. Salt and Pepper Noise Attack Test Results SSIM

| Image | α | | | | |
|---|---|---|---|---|---|
| Data | 0.01 | 0.05 | 0.5 | 0.7 | 0.9 |
| a | 0.95107 | 0.78285 | 0.074123 | 0.24727 | 0.0085624 |
| b | 0.95066 | 0.7805 | 0.069551 | 0.021794 | 0.007693 |
| c | 0.95024 | 0.78346 | 0.077148 | 0.026848 | 0.0090882 |
| d | 0.94939 | 0.7698 | 0.06463 | 0.022122 | 0.0081123 |
| e | 0.95065 | 0.7789 | 0.070707 | 0.022644 | 0.0081558 |
| f | 0.95267 | 0.78759 | 0.10158 | 0.042008 | 0.01505 |
| g | 0.95457 | 0.78896 | 0.10408 | 0.044005 | 0.014746 |
| h | 0.95322 | 0.78619 | 0.09763 | 0.040184 | 0.013767 |
| i | 0.95099 | 0.77959 | 0.084274 | 0.03226 | 0.010891 |
| j | 0.95046 | 0.77688 | 0.090027 | 0.03711 | 0.013228 |

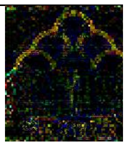
The results of Table 40-Table 44 have the same pattern as the test results of the Gaussian Noise attack, with values α=0.01, on the (g) Irubistie Logo Brand, the

DOI: https://doi.org/10.29207/resti.v7i5.5003

PSNR value is 23.8941 dB, NC=0.92753, SSIM=0.95457.

The watermark can be extracted well when the input constant is small with a high NC value and the similarity level of the extracted watermark with the original watermark is high. But when the input noise constant is larger, the watermark fails to be extracted, and the NC value obtained is low, indicating the similarity level of the original watermark with the extracted watermark is low. This proves that a high level of similarity will result in a lower error rate. At the same time, the PSNR value shows good image quality.

Table 36. Salt and Pepper Noise Attack Image Extraction Result

| Irubistie Logo Brand α =0.01 | | | |
|---|---|---|---|
| Host Image | Logo Image | Watermarked Image | Extracted Watermark |
|  |  |  |  |

## 3.10 SVD-DWT Method Test Results

The test results of the SVD-DWT method with ten vital archive images have a graphic pattern or characteristic of the best PSNR, NC, and SSIM values with almost the same pattern with various attacks seen in the images in Table 37-Table 39, and comparison of PSNR, NC and SSIM values in Figure 9-Figure 21.

Table 37. Summary Table of PSNR with Various Attacks

| No | Image Data | Attack | α | PSNR |
|---|---|---|---|---|
| 1 | Cibereum Land Certificate | JPEG Compression 75% | 0.01 | 41.0567 |
| 2 | Mount Sindur Land Certificate | Filtering Median 3x3 | 0.01 | 35.0168 |
| 3 | Cibereum Land Certificate | Gaussian Noise 0.01 | 0.01 | 26.3105 |
| 4 | Lebak Bulus Land Certificate | Speckle Noise 0.01 | 0.05 | 24.039 |

Table 38. Summary Table of NC with Various Attacks

| No | Image Data | Attack | α | NC |
|---|---|---|---|---|
| 1 | Kojal Land Certificate | JPEG Compression 75% | 0.01 | 0.99253 |
| 2 | Jagakarsa Land Certificate | Filtering Median 3x3 | 0.01 | 0.93462 |
| 3 | Kojal Land Certificate | Speckle Noise 0.01 | 0.05 | 0.92018 |
| 4 | Kojal Land Certificate | Salt and Pepper Noise 0.01 | 0.01 | 0.93595 |

Table 39. Summary Table of SSIM with Various Attacks

| No | Image Data | Attack | α | SSIM |
|---|---|---|---|---|
| 1 | Cibereum Land Certificate | JPEG Compression 75% | 0.05, 0.7 | 0.97698 |
| 2 | Mount Sindur Land Certificate | Rotation 80˚ | 0.9 | 0.81215 |
| 3 | Mount Sindur Land Certificate | Cropping 2% | 0.5 | 0.90277 |
| 4 | Cibereum Land Certificate | Filtering Median 3x3 | 0.01 | 0.96965 |
| 5 | Irubistie Logo Brand | Salt and Pepper Noise 0.01 | 0.01 | 0.95457 |

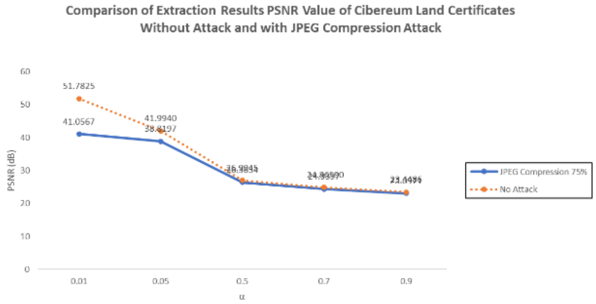



Figure 9. PSNR with JPEG Compression 75%

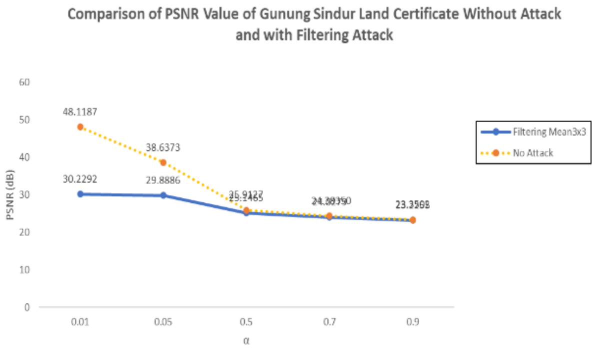



Figure 10. PSNR with Filtering Median 3x3

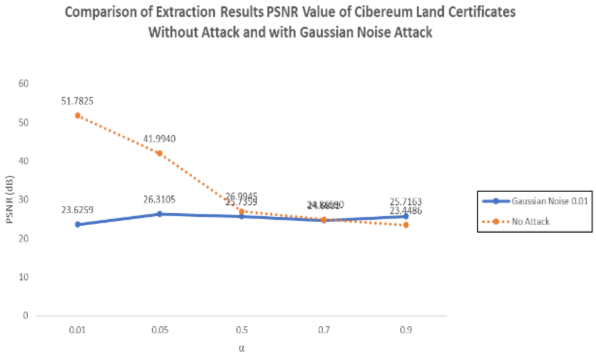



Figure 11. PSNR with Gaussian Noise 0.01

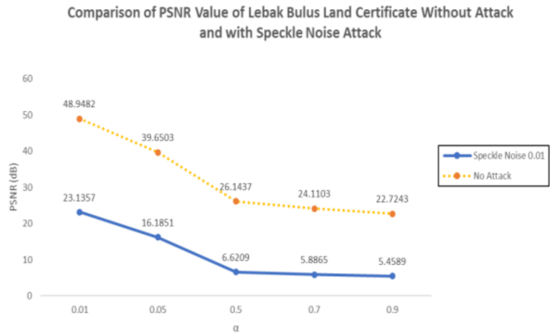



Figure 12. PSNR with Speckle Noise 0.01

DOI: https://doi.org/10.29207/resti.v7i5.5003

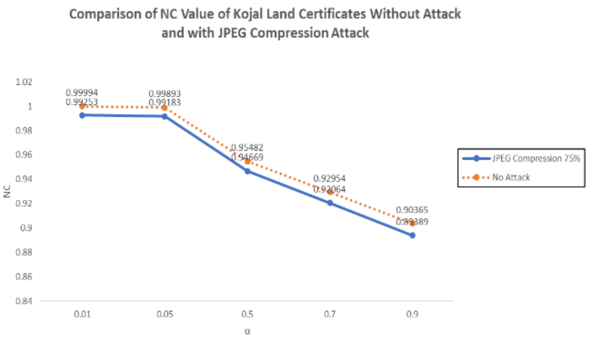



Figure 13. NC with JPEG Compression 75%

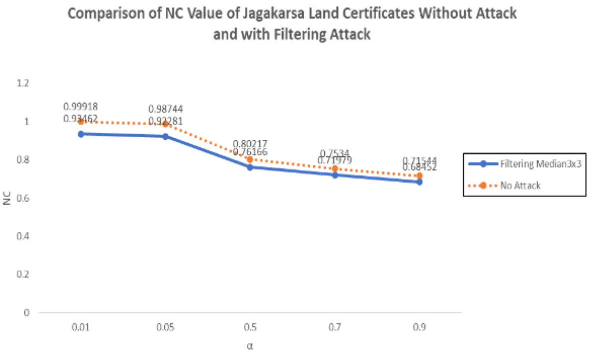



Figure 14. NC with Filtering Median 3x3

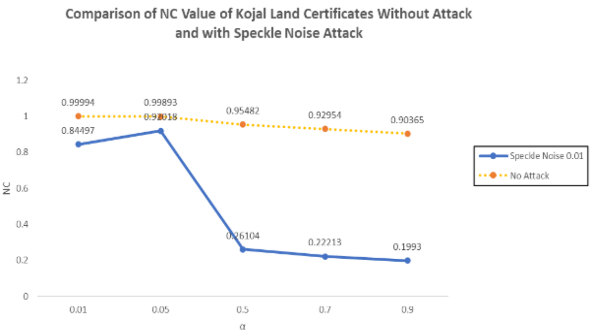



Figure 15. NC with Speckle Noise 0.01

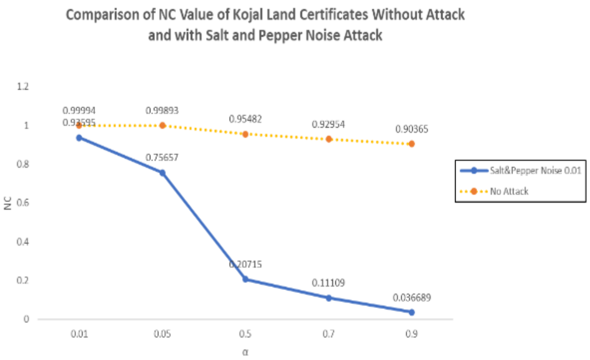



Figure 16. NC with Salt and Pepper Noise 0.01

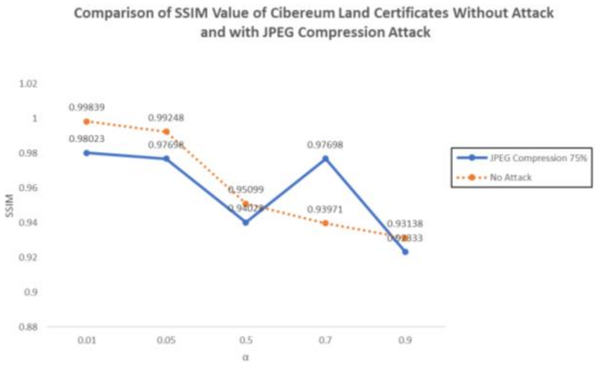



Figure 17. SSIM with JPEG Compression 75%

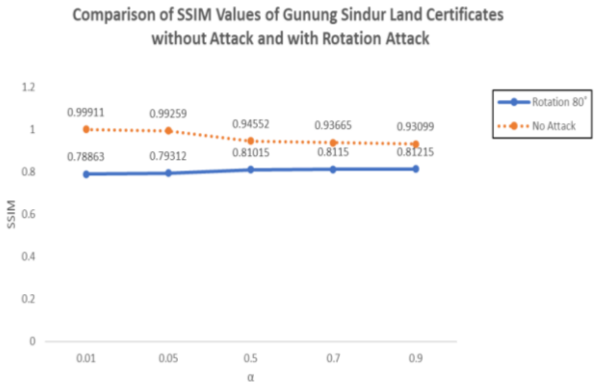



Figure 18. SSIM with Rotation 80 ˚

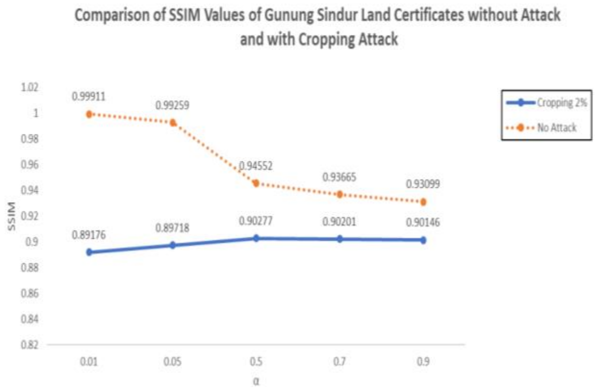



Figure 19. SSIM with Cropping 2%

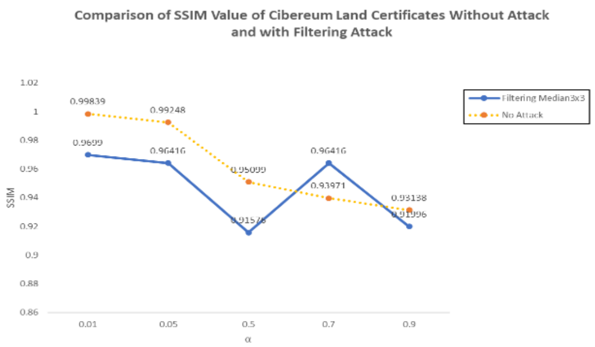



Figure 20. SSIM with Filtering Median 3x3

DOI: https://doi.org/10.29207/resti.v7i5.5003

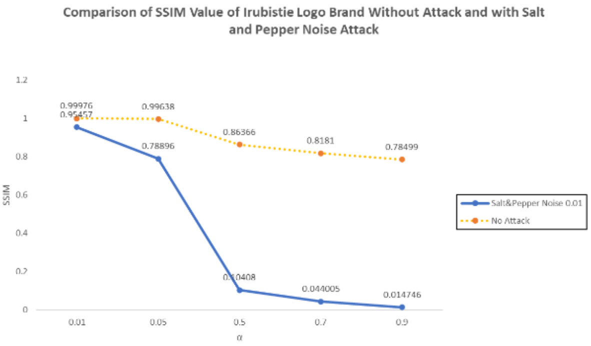



Figure 21. SSIM with Salt and Pepper Noise 0.01

In Figure 9-Figure 21 without attacks, the PSNR value pattern is above 30 dB, while NC, and SSIM are close to the value of 1, indicating the level of similarity of the original watermark with the extracted watermark is very high and the vital archive image is of good quality. The test results with various attacks get a pattern of PSNR values ranging from 20-40 dB, NC=0.9, and SSIM ranging from 0 to 1. These results show that the level of similarity of the original watermark with the extracted watermark is very low, but the extracted watermark is good and robust to 75% JPEG compression attacks, median filtering 3x3, gaussian noise 0.01, speckle noise 0.01, and salt and pepper noise 0.01 but the watermark is not robust to rotation and cropping attacks.

## 4. Conclusion

The results of the research and discussion were carried out, and it can be concluded that the SVD hybrid robust digital watermarking technique with DWT can be extracted back well by previous research using vital archives. The best PSNR without attack test is the Cibereum Land Certificate with a size of 512 x 512 pixels 51.7825 dB, MSE=0.09896, NC=0.9995, and SSIM=0.99843. The results of testing on JPEG compression attacks with a quality of 75% obtained the best PSNR values on the Cibereum Land Certificate with PSNR = 41.0567 dB, MSE=2.6002, NC = 0.98904, and SSIM = 0.98023. Test results filtering median 3 x 3 images can be appropriately extracted using α=0.01 obtained the best PSNR value of 35.0168 dB, MSE=1.1764, NC=0.942, and SSIM=0.96965, there is the Mount Sindur Land Certificate. The increasing value of alpha (α) causes imperceptibility to have a decreased image quality. When the PSNR value is above 25-30 dB, it shows good image quality. If the NC and SSIM values are close to 1, the more similar the host image or the quality of the detected watermark is getting better. So it can be proven that digital image watermarking with hybrid SVD and DWT watermarking techniques can be extracted well with PSNR values above 25 dB, NC, and SSIM 0.9. Produce watermarks that are resistant to several attacks such as 75% JPEG compression attack, median filtering 3 x 3, gaussian noise 0.01, speckle noise 0.01, and salt and pepper noise 0.01. Still, the watermark is not robust to 80˚ rotation and 2% cropping attacks. This method is very well for protecting digital images of vital archives and can maintain authentication of image ownership, which is more robust to attack. In the Future research can use additional attack variations in testing and use image color models other than RGB, such as HSI (Hue, Saturation, Intensity) and CMY (Cyan, Magenta, Yellow).

## References

[1] A. G. Gani, “Pengenalan Teknologi Internet Serta Dampaknya,” *Jurnal Sistem Informasi Universitas Suryadarma*, vol. 2, Feb. 2014, doi: https://doi.org/10.35968/jsi.v2i2.49.

[2] R. A. A. B. and P. A. M. I. Ukkas, “ “Teknik Pengamanan Data Dengan Steganografi Metode End Of File (EOF) Dan Kriptografi Vernam Cipher,’’,” *Sebatik*, vol. 17, pp. 20–26, Jan. 2017, Accessed: Jul. 22, 2022. [Online]. Available: https://jurnal.wicida.ac.id/index.php/sebatik/article/view/82.pdf

[3] R. Munir, “Image Watermarking untuk Citra Berwarna dengan Metode Berbasis Korelasi dalam Ranah DCT,” *Program Studi Teknik Informatika. Institut Teknologi Bandung. Bandung.*, 2010, Accessed: Jul. 30, 2022. [Online]. Available: https://Informatika.Stei.Itb.Ac.Id/~rinaldi.Munir/Penelitian/MakalahdiJurnalPETIR.Pdf.

[4] J. K. F. T. L. and T. S. I. J. Cox, “Secure Spread Spectrum Watermarking for Multimedia,” *IEEE Transaction on Image Processing*, vol. 6, no. 12, pp. 1673–1987, Dec. 1997, doi: doi:10.1109/83.650120.

[5] Arsip Nasional Republik Indonesia, “Undang-Undang No. 43 Tahun 2009 Tentang Kearsipan,” *Sekretariat Negara*, no. 152. Jakarta, 2009. Accessed: Oct. 05, 2023. [Online]. Available: https://jdihn.go.id/files/4/2009uu043.pdf

[6] Arsip Nasional Republik Indonesia, “Peraturan Pemerintah Republik Indonesia Nomor 28 Tahun 2012 Pelaksanaan Undang-Undang No. 43 Tahun 2009 Tentang Kearsipan.,” no. 41. Sekretariat Negara, Jakarta, 2005. Accessed: Oct. 05, 2023. [Online]. Available: https://jdih.kemenkeu.go.id/fullText/2012/28TAHUN2012PP.pdf

[7] Kementerian Hukum dan Hak Asasi Manusia, “Peraturan Menteri Hukum dan Hak Asasi Mnausia Republik Indonesia Nomor 23 Tahun 2017 Tata Kelola Arsip Vital dan Arsip Terjaga di Lingkungan Kementerian Hukum dan Hak Asasi Manusia,” *Sekretariat Negara*, no. 1668. Jakarta, 2017.

[8] K. Naoe and Y. Takefuji, “Damageless Information Hiding using Neural Network on YCbCr Domain,” 2008. [Online]. Available: https://www.researchgate.net/publication/252319078

[9] Y. J. Chang, R. Z. Wang, and J. C. Lin, “A sharing-based fragile watermarking method for authentication and self-recovery of image tampering,” *EURASIP J Adv Signal Process*, vol. 2008, 2008, doi: 10.1155/2008/846967.

[10] C. S. Shieh, H. C. Huang, F. H. Wang, and J. S. Pan, “Genetic watermarking based on transform-domain techniques,” *Pattern Recognit*, vol. 37, no. 3, pp. 555–565, 2004, doi: 10.1016/j.patcog.2003.07.003.

[11] B. Isac and V. Santhi, “A Study on Digital Image and Video Watermarking Schemes using Neural Networks,” 2011.

[12] R. Azhar, D. Tuwohingide, D. Kamudi, Sarimuddin, and N. Suciati, “Batik Image Classification Using SIFT Feature Extraction, Bag of Features and Support Vector Machine,” in *Procedia Computer Science*, Elsevier, 2015, pp. 24–30. doi: 10.1016/j.procs.2015.12.101.

[13] L. R.-Y. and W. Lei. Z. Zhi-Ming, “Adaptive Watermark Scheme with RBF Neural Networks,” International Conference on Neural Networks and Signal Processing, 2003. Proceedings of the 2003, 2003, pp. 1517-1520.”.

[14] A. , & B. H. (2017) Al-Haj, "Copyright protection of e-government document images using digital watermarking. 2017 3rd International Conference on Information Management (ICIM).".

[15] Y. Gangadhar, V. S. Giridhar Akula, and P. C. Reddy, "An evolutionary programming approach for securing medical images using a watermarking scheme in invariant discrete wavelet transformation," *Biomed Signal Process Control*, vol. 43, pp. 31–40, May 2018, doi: 10.1016/j.bspc.2018.02.007.

[16] H. Barouqa and A. Al-Haj, "Watermarking E-Government Document Images Using the Discrete Wavelets Transform and Schur Decomposition," in *2021 7th International Conference on Information Management, ICIM 2021*, Institute of Electrical and Electronics Engineers Inc., Mar. 2021, pp. 102–106. doi: 10.1109/ICIM52229.2021.9417146.

[17] A. Cheddad, J. Condell, K. Curran, and P. Mc Kevitt, "Digital image steganography: Survey and analysis of current methods," *Signal Processing*, vol. 90, no. 3. pp. 727–752, Mar. 2010. doi: 10.1016/j.sigpro.2009.08.010.

[18] Madenda S. 2015., *Pengolahan Citra Dan Video Digital : Teori, Aplikasi, Dan Pemrograman Menggunakan MATLAB. Jakarta: Erlangga. .*

[19] S. G. Mallat, "A Theory for Multiresolution Signal Decomposition: The Wavelet Representation," 1989.

[20] A. and M. A. (2010). Al-Haj, "Digital Audio Watermarking Based on the Discrete Wavelets Transform and Singular Value Decomposition. European Journal of Scientific Research, 39, 6-21.".

[21] A. G. Akritas and G. I. Malaschonok, "Applications of singular-value decomposition (SVD)," in *Mathematics and Computers in Simulation*, Sep. 2004, pp. 15–31. doi: 10.1016/j.matcom.2004.05.005.

[22] J. Kardamis, "Audio watermarking techniques using singular value Audio watermarking techniques using singular value decomposition decomposition." [Online]. Available: https://scholarworks.rit.edu/theses

[23] W. C. Chen and M. S. Wang, "A fuzzy c-means clustering-based fragile watermarking scheme for image authentication," *Expert Syst Appl*, vol. 36, no. 2 PART 1, pp. 1300–1307, 2009, doi: 10.1016/j.eswa.2007.11.018.

[24] L. Qiao and K. Nahrstedt, "Watermarking Schemes and Protocols for Protecting Rightful Ownership and Customer's Rights," 1998. Accessed: Oct. 05, 2023. [Online]. Available: https://www.sciencedirect.com/science/article/abs/pii/S104732039890391

DOI: https://doi.org/10.29207/resti.v7i5.5003