



DWT-SVD Combination Method for Copyrights Protection

Desi Purwanti Kusumaningrum¹, Eko Hari Rachmawanto², Christy Atika Sari³, Rizky Putra Pradana⁴

^{1,2,3,4}Informatics Engineering Department, Faculty of Computer Science,
Universitas Dian Nuswantoro, Indonesia

Email: ¹desi.purwanti.kusumaningrum@dsn.dinus.ac.id, ²eko.hari@dsn.dinus.ac.id,
³christy.atika.sari@dsn.dinus.ac.id, ⁴rizkyppradana@gmail.com

Abstract

Many irresponsible people who download other people's artwork then modify and redistribute the work of someone without permission by not including the owner's name. Based on that problem an attempt was made to provide an invisible watermark so as not to be easy to do the watermark removal process on the artwork, using a 2-level DWT and SVD combination method that can embed watermarks invisibly and increase watermarking resistance to the image from various image manipulation processes such as noise, JPEG compression, and so on. From combination method of DWT-SVD got the highest PSNR value with watermark image size 32x32 and 64x64 which is 59.2656 dB and 54.7414 dB, respectively.

Keywords: Watermarking, SVD, DWT, Watermarking combined method

1. INTRODUCTION

The development of technology, especially in the field of the internet, is increasing rapidly [1] [2], facilitate some people in accessing something practically on the internet [3]. People often use the internet as a social media to communicate with each other without having to meet face-to-face, disseminate information or spread a work of art such as digital painting, original music, animated videos, and so forth. The easier accessing internet, many irresponsible people who download the artwork of others then modify [4], and redistribute the work without permission and does not include the owner's name that caused the loss to the owner in case of misuse of the dissemination done illegally [5]. So, we make an effort to provide watermarks on the artwork.

The visible watermark [6] is good to know directly who the owner of the artworks but in that way, it will degrade the quality of work because it will be covered by the watermark and make irresponsible people to easily remove the watermark in various ways, whereas if watermarking is done invisibly [4] the work will not be covered and confuse irresponsible people who want to remove the watermark from the artwork.

According to [7], embedding the invisible watermark can be grouped into 2 ways, which are the spatial domain and the transform domain. The spatial domain can embed the watermark directly into the host image pixel and can be implemented easily and quickly, while in the transform domain, the host image is converted to the frequency form before embedding watermark [8]. The domain transform method, robust against various kinds of image manipulation processes such as compression process [2], therefore, in this paper use domain transform method.

One of the transform domain methods used in this paper is the combination of the SVD (Singular Value Decomposition) method and the 2-level DWT (Discrete Wavelet Transform) method. After method has been applied, it has been tested with various attacks such as salt and pepper, Gaussian filter and JPEG compression and analyzed using PSNR (Peak to Signal Noise Ratio) calculation to measure imperceptibility value and NC calculation (Normal Correlation) to measure robustness value [9].

2. METHODS

2.1. Digital Watermarking

The watermarking technique works by embedding a message that can be text, image, or audio that shows ownership of digital media without degrading image quality [10]. The goal is to embed an invisible watermark image and measure the imperceptibility criteria. Good or bad criteria on watermarking can be known by using the calculation of PSNR (Peak Signal to Ratio) and see the value of equation (1) and equation (2) [11].

The formula for embedding the watermark image process into the host image:

$$f^o = f^i + \alpha * W \quad (1)$$

and the extraction process formula to get the watermark image from the watermarked image.

$$Y = \frac{f^o - f^i}{a} \quad (2)$$

Where,

f^i = host image

f^o = watermarked image

a = coefficient multiplier to determine the strength of the watermark image to be embedded

W = watermark image

Y = extracted watermark image.

2.2. 2D-Discrete Wavelet Transform

The DWT method can be used for image transformation and image compression. In addition to image processing, the DWT method can also be applied to the steganography and watermarking fields [12]. The process of the wavelet transforms

conceptually simple. The original image is decomposed into 4 new sub-images LL, LH, HL, and HH [13].



Figure 1. DWT Sub-images [10]

In Figure 1, the sub-image in HL, LH, and HH positions will look like a rough version of the host image because it contains high-frequency components of the host image, while for the LL sub-image looks like the host image and looks smoother as it contains low-frequency components of the host image [14]. Since it is similar to the host image, the LL sub-image can embed the watermark image to the host image [6]. While the pixel values of LH, HL, and HH sub-images tend to be low-value and sometimes zero, so they are easy to compress.

2.3. Singular Value Decomposition

The result of the SVD method is the singular value stored in a diagonal matrix, S , in the appropriate order from high to low [13]. Where the value of the singular value of an image has good stability when given a little disturbance will not be too influential [15]. If I is a real $m \times n$ size matrix, it is decomposed using the SVD method and will produce the matrices U , S , and V , where the matrices U and V are orthogonal singular vectors and S is the diagonal vector that stores the singular value of the matrix I [16].

2.1 Noise Salt and Pepper (Impulse Noise)

Noise on the image can occur either because of pixel dysfunction in the digital camera sensor [16]. In grayscale, the noise will appear as salt and pepper that is white if the grayscale value is 255 and black if the grayscale value is 0.

2.2 Filter Gaussian

Gaussian filters are helpful in terms of reducing noise, high-frequency effects, or softening edges in an image [17]. In this paper, Gaussian filter is used to test the robustness of the DWT-SVD combination method.

2.3 JPEG Compression

JPEG (Joint Photographics Extent Group) is a standard digital image compression scheme. There are two methods in JPEG compression, which are lossy and lossless methods. The lossy compression method results in a higher compression ratio than the lossless method [18].

2.4 Watermarking Evaluation

In this paper will use PSNR calculations as an evaluation tool to measure the quality between the original image and the watermark image [19] and the NC calculation to measure the similarity of the watermarked extraction image. The NC value ranges from 0 - 1, where if the watermarked extraction value is close to 1 or equal to 1 then it is similar to the watermark image as shown in equation (3) until equation (5).

$$PSNR = 10 \log_{10} \left(\frac{255^2}{\sqrt{MSE}} \right) \quad (3)$$

where :

$$MSE = \frac{1}{m \times n} \sum_{i=1}^n \sum_{j=1}^m (f_{ij}^o - f_{ij}^i)^2 \quad (4)$$

NC calculation formula:

$$NC = \frac{\sum_{i=0}^{n-1} \sum_{j=0}^{m-1} W(i,j) Y(i,j)}{\sum_{j=1}^m \sum_{i=1}^n [W(i,j)]^2} \quad (5)$$

where :

W = watermark image

Y = extracted watermark

2.5 Proposed Method using DWT-SVD

In this paper DWT transformation performed 2 level on the host grayscale image, then decomposed SVD and pasted on the diagonal vector. The watermarking scheme as illustrated in Figure 2 and Figure 3.

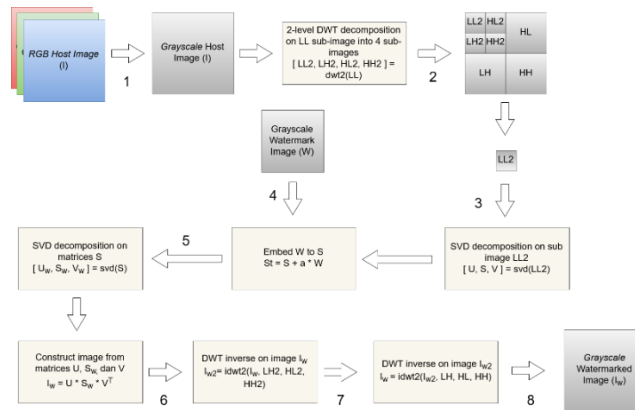


Figure 2. DWT-SVD watermark embedding scheme

Explanation of Figure 2:

- 1) The RGB host image (I) is transformed into grayscale host image (I)
- 2) Once transformed into the grayscale image, then decomposed with 2-level DWT method on the sub-image LL into LL2, LH2, HL2, and HH2.
- 3) Then LL2 image is decomposed with SVD method into matrix U, S, V, to get singular value on the diagonal vector (S)

- 4) After that, the grayscale watermark image (W) is embedded into the diagonal vector (S)
- 5) The matrix of S_t decomposes with the SVD method, so it becomes the matrix U_w, S_w, V_w . Then reconstruct the image of the matrix $U, S_w,$ and V .
- 6) A 1-level DWT inverse process is performed on the I_w image.
- 7) A 2-level DWT inverse process is performed on the I_w2 image.
- 8) Watermarked image is obtained.

As for the extraction process of watermark image using non-blind method that requires the host image to perform the extraction process. Here's the watermark extraction scheme on the grayscale image as shown in Figure 3.

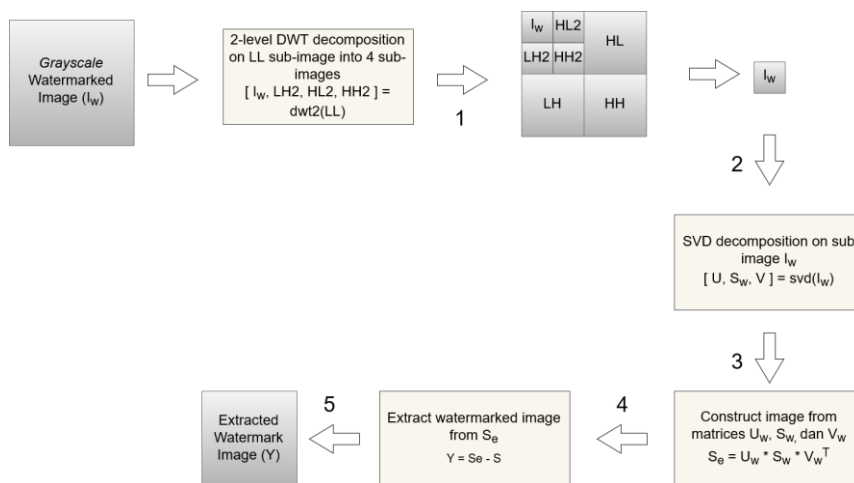


Figure 3. DWT-SVD watermark extraction scheme

Explanation of Figure 3:

- 1) The grayscale watermark image (I_w) is decomposed with 2-level DWT method on the LL sub-image to $I_w, LH2, HL2,$ and $HH2$
- 2) Then I_w image decomposed with SVD method into matrix $U, S_w,$ and V
- 3) After that reconstruct the image from the $U_w, S_w,$ and V_w matrices
- 4) Then extract the watermark image from S_e
- 5) Extracted watermark image is obtained

After obtaining the watermarked image and the watermark image of the extraction result, the image will be tested with the various attack from giving of noise salt and pepper, Gaussian filter, and JPEG Compression with a lossy method. Then we will calculate the PSNR value from the watermarked image and calculate the NC value of the watermarked image of the extraction result.

3. RESULT AND DISCUSSION

The following will display the original RGB image that has been transformed into a grayscale image (512x512 pixel size) of 5 .png format images. And also, will display watermark image, watermarked image (512x512 pixel size), and extracted watermark image with and without attack. Using the 2-level DWT-SVD combination method, the SVD method, and the DWT method with its alpha value have been determined i.e. $\alpha = 0.1$.

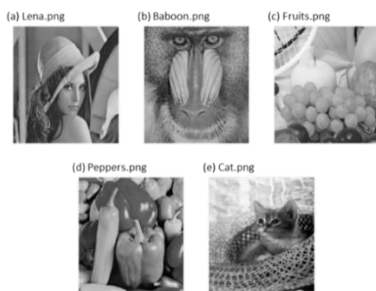






















Figure 4. Host grayscale image



Figure 5. Watermark grayscale image

Table 1. The resulting image of DWT-SVD combination method with 64x64 watermark size

Image	Lena	Baboon	Fruits	Peppers	Cat
watermarked image					
	PSNR = 53.9215 dB	PSNR = 53.2401 dB	PSNR = 54.4811 dB	PSNR = 54.3392 dB	PSNR = 54.7414 dB
extracted watermark image (No Attack)					
	NC = 1.0000	NC = 1.0000	NC = 1.0000	NC = 1.0000	NC = 1.0000
extracted watermark image (Salt and pepper)					
	NC = 0.8840	NC = 0.9360	NC = 0.7708	NC = 0.8433	NC = 0.8082
extracted watermark image					






(gaussian filter)	NC = 0.9541	NC = 0.8992	NC = 0.9388	NC = 0.9608	NC = 0.8508
extracted watermark image (JPEG compression)					
	NC = 0.9998	NC = 0.9999	NC = 0.9996	NC = 0.9999	NC = 0.9998

Table 2. Results of SVD combination method with 64x64 watermark size



















































Citra	Lena	Baboon	Fruits	Peppers	Cat
					
watermarked image	PSNR = 53.7932 dB	PSNR = 52.2277 dB	PSNR = 54.6680 dB	PSNR = 54.2839 dB	PSNR = 54.4047 dB
extracted watermark image (No Attack)					
	NC = 1.0000	NC = 1.0000	NC = 1.0000	NC = 1.0000	NC = 1.0000
extracted watermark image (Salt and pepper)					
	NC = 0.5628	NC = 0.7439	NC = 0.5076	NC = 0.5085	NC = 0.7061
extracted watermark image (gaussian filter)					
	NC = 0.8601	NC = 0.4374	NC = 0.7887	NC = 0.8885	NC = 0.5949
extracted watermark image (JPEG compression)					
	NC = 0.9999	NC = 0.9992	NC = 0.9995	NC = 0.9999	NC = 0.9998

Table 3. Results of DWT combination method with 64x64 watermark size

Citra	Lena	Baboon	Fruits	Peppers	Cat
watermarked image	 PSNR= 39.9218 dB	 PSNR= 39.9218 dB	 PSNR= 39.9218 dB	 PSNR= 39.9218 dB	 PSNR= 39.9218 dB
extracted watermark image (No Attack)	 NC= 1.0000	 NC= 1.0000	 NC= 1.0000	 NC= 1.0000	 NC= 1.0000
extracted watermark image (Salt and pepper)	 NC= 0.6905	 NC= 0.6919	 NC= 0.3850	 NC= 0.6902	 NC= 0.4400
extracted watermark image (Gaussian filter)	 NC= 0.9390	 NC= 0.8389	 NC= 0.7795	 NC= 0.9660	 NC= 0.7969
extracted watermark image (JPEG compression)	 NC= 0.9955	 NC= 0.9925	 NC= 0.9859	 NC= 0.9953	 NC= 0.9953

Based on Table 1, we can see that the PSNR value of the DWT method is clearly less good than the SVD method and the DWT-SVD combination. In Figure 1 we can see the PSNR value is 54.7414 dB, in Table 7 the PSNR value is 54.6680 dB, and Table 3 the PSNR value is 39.9218 dB.

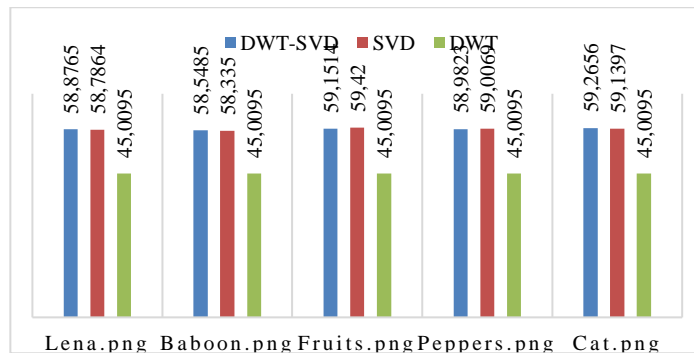


Figure 6. The result comparison of PSNR value with the 32x32 watermark image size

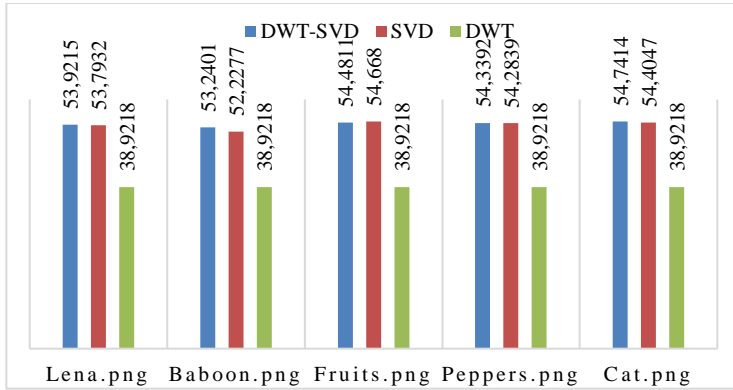


Figure 7. The result comparison of PSNR value with the 64x64 watermark image size

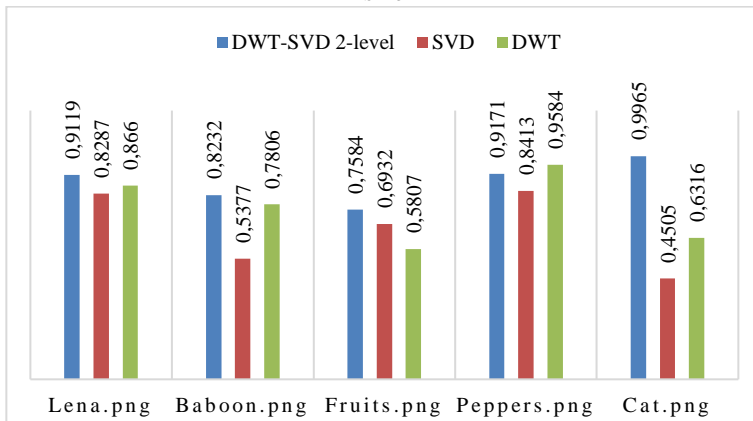


Figure 8. The result comparison of NC value with attack Gaussian filter with the 32x32 watermark image size

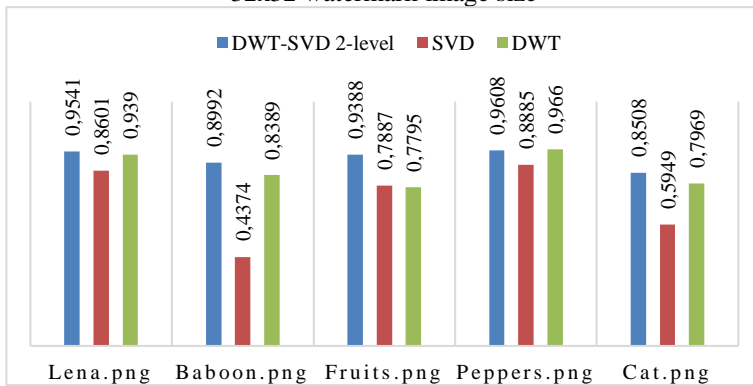


Figure 9. The result comparison of NC value with attack Gaussian filter with the 64x64 watermark image size

As describe in Figure 6 and Figure 7, the lowest PSNR value is the DWT method. In Figure 6 and Figure 7, the lowest average NC value with the attack Gaussian filter is the DWT method and the highest average NC value with the attack gaussian filter is the DWT-SVD combination method. In this paper, experiment has been tested and compared the PSNR values between the 3-level DWT-SVD combination method and the 2-level DWT-SVD combination method with the 32x32 watermark image size. The PSNR value comparison results in Figure 8.

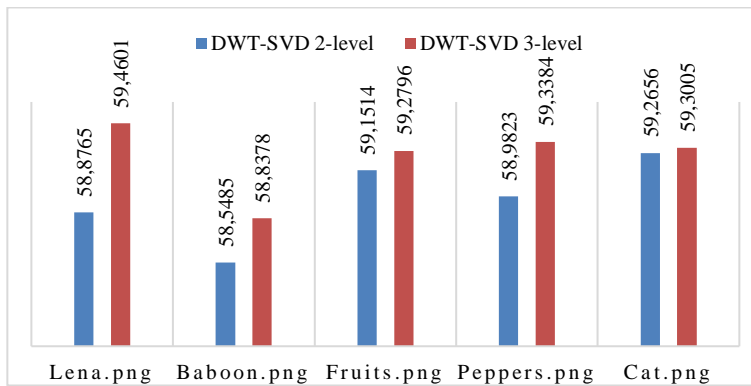


Figure 10. The PSNR value comparison results between the 2-level DWT-SVD combination method and the 3-level DWT-SVD combination method with the 32x32 watermark image size

According to Figure 10, the PSNR value between the 3-level DWT-SVD combination method is higher than the 2-level DWT-SVD combination method, where the highest value is 59,4601 dB.

4. CONCLUSION

From the results of the research, it can be concluded that the average DWT-SVD combination method produces high PSNR values rather than SVD or DWT methods, making it hard to see the watermark image visually. The DWT-SVD combination method also proves to be resistant to JPEG compression, noise, and Gaussian filters.

5. REFERENCES

- [1] Jin, C. and Jin, S. (2010). Adaptive digital image watermark scheme based on Fuzzy Neural Network for copyright protection. *2010 International Conference on Image Analysis and Signal Processing*, Zhejiang, China, 2010, pp. 599–602.
- [2] Kabra, R.G. and Agrawal, S.S. (2016). Robust embedding of image watermark using LWT and SVD. *International Conference on Communication and Signal Processing, ICCSP 2016*, Melmaruvathur, India, 2016, pp. 1968–1972.

- [3] Gupta, P. and Parmar, G. (2017). Image watermarking using IWT-SVD and its comparative analysis with DWT-SVD. *2017 International Conference on Computer, Communications and Electronics (Comptelix)*, Jaipur, India, 2017, pp. 527–531.
- [4] Muzakir, A. and Habibi, M. (2017). Watermarking techniques using least significant bit algorithm for digital image security standard solution- based android. *Scientific Journal of Informatics (SJI)*, 4(1), 20-26
- [5] Liu, J., et al. (2019). An optimized image watermarking method based on hd and svd in dwt domain. *IEEE Access*, 7, pp. 80849 – 80860
- [6] Nikbakht, P., and Mahdavi, M. (2017). Targeted watermark removal of a SVD-based image watermarking scheme. *7th Conference on Information and Knowledge Technolog*, Urmia, Iran, 2017, pp. 1-5.
- [7] Ur-Rehman, O., Tabatabaei, S.A.H.A.E., Zivic, N., and Ruland, C. (2015). Spatial and frequency domain complementary watermarks for image authentication and correction. *10th International ITG Conference on Systems, Communications and Coding (SCC)*, Hamburg, German, 2015.
- [8] Panda, J., Uppal, A., Nair, A.S., and Agrawal, B. 2017. Genetic algorithm based optimized color image watermarking technique using SVD and DWT. *IEEE 7th International Advance Computing Conference (IACC)*, Hyderabad, India, 2017, pp. 579–583.
- [9] Deb, K., Al-Seraj, M.S., Hoque, M.M., and Sarkar, M.I.H. (2012). Combined DWT-DCT based digital image watermarking technique for copyright protection. *7th International Conference on Electrical and Computer Engineering*, Dhaka, Bangladesh, 2012, pp. 458–46.
- [10] Thind, D.K., and Jindal, S. (2015). A Semi blind DWT-SVD video watermarking. *Procedia Computer Science*, 46, 1661-1667.
- [11] Ali, M., and Ahn, C.W. (2015). Comments on “Optimized grayscale image watermarking using DWT-SVD and firefly algorithm. *Expert Systems with Applications*, 42(1), 2392-2394.
- [12] Araghi, T.K., and Manaf, A.A. (2019). An enhanced hybrid image watermarking scheme for security of medical and non-medical images based on DWT and 2-D SVD. *Future Generation Computer Systems*, 101, 1223-1246
- [13] Poonam and Arora, S.M., (2018). A DWT-SVD based Robust Digital Watermarking for Digital Images. *Procedia Computer Science*, 132, 1441-1448
- [14] Guo, Y., Li, B., and Goel, N. (2017). Optimised blind image watermarking method based on firefly algorithm in DWT-QR transform domain. *IET Image Processing*, 11(6), 406 – 415
- [15] Adi, P.W. and Rahmanti, F.Z., (2016). Robust integer haar wavelet based watermarking using singular value decomposition. *Jurnal Ilmu Komputer dan Informasi (Journal of Computer Science and Information)*, 9 (9), 26-34
- [16] Arrasyid, A. A., Setiadi, D.R.I.M., Soeلمان, M.A, Sari, CA, and Rachmawanto, E.H.. (2018). Image watermarking using triple transform (DCT-DWT-SVD) to improve copyright protection performance.

International Seminar on Research of Information Technology and Intelligent Systems (ISRITI), Yogyakarta, Indonesia, 2018.

- [17] Anand, A., and Singh, A.K. (2020). An improved DWT-SVD domain watermarking for medical information security. *Computer Communications* 152, 72-80
- [18] Sari, WS., and Sari, CA. (2019). A high result in wavelet watermarking using singular value decomposition. *KINETIK : Game Technology, Information System, Computer Network, Computing, Electronics, and Control*, 4(3), 269-276
- [19] Rachmawanto, E., Setiadi, D., Sari, C. and Rijati, N., (2019). Imperceptible and secure image watermarking using DCT and random spread technique. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, 17(4), p.1750.