Journal of Discrete Mathematical Sciences & Cryptography
ISSN 0972-0529 (Print), ISSN 2169-0065 (Online)
Vol. 26 (2023), No. 7, pp. 1971–1979
DOI : 10.47974/JDMSC-1785

Medical images utilization for significant data hiding based on machine learning

Salwa Mohammed Nejrs
Directorate of Private University Education
Ministry of Higher Education
Baghdad
Iraq

Abstract

This paper uses a machine-learning algorithm to suggest a reliable watermarking approach. The watermarked image propagation through the download physical layer (PhyLyr) of WiMAX standards is simulated in this work (WiMAX is based on the IEEE suite of standards 802.16). By downloading the Physical Layer (PhyLyr) through OFDM, transform coefficients of the host image (Hosting-Image) can be embedded there. Data associated with watermarks are initially encrypted. In a medical image, Support Vector Networks (SVN) are used to classify regions of interest (ROI) and regions of no interest (Non-ROI). The findings of this manuscript revealed that greater signal-to-noise ratios might achieve a 106-bit error rate (Bit-Err-Rate), this means that SNR is exceeds 10.4 dB of SNR. The received cover image's peak SNR (PSNR) for clinical applications is more than 37 dB.

Subject Classification: *62H35, 65D18.*

Keywords: *Support vector networks (SVN), WiMAX standard, Bit error rate (Bit-Err-Rate), Physical layer (PhyLyr).*

1. Introduction

In the past, humans utilized several techniques to transmit messages and information between locations, but the efficiency of these techniques varied depending on the length and message distance. For instance, distinctive flags, smoke signals, SMS, and other visual clues were utilized for short-range communication[1]. However, couriers were a more practical and essential option for delivering messages over long distances. With audio, video, and text messages being easily transmitted over long

E-mail: salwamn@uomisan.edu.iq

© Taru Publications

distances without lag time, a new information and communication era has begun [2]. As a consequence, there is an urgent demand for mobile Internet. Since the previous few years, there have been significant changes in how people utilize mobile devices , tablets, netbooks, and PC-laptop with wireless and internet connections, tens of millions more users [3]. These illustrations highlight the enormous need for faster mobile Internet connections, improved availability, and higher transfer rates. Researchers and the telecom sector have been putting a lot of effort into developing innovative concepts for low-cost network design and high-speed broadband connections for mobile access[4].

For a variety of applications, including text, voice, and data transmission, network infrastructure similar to the 1-Giga, 2-Giga, 2.5-Giga, 3-Giga, and Wireless network generations with worldwide interoperability for microwave access (WiMAX) have been built. Numerous telemedicine apps make utilize of this infrastructure. Low data speeds and secure transmission, however, remain the key problems. The key problems remain, however, low data speeds and insecure transmission. Mobile communication is made possible by WiMAX[5]. It is a mobile network that uses 4G technology. Using point-to-point connectivity and full mobile phone functionality, WiMAX is a telecommunications technology that transmits wireless data over long distances. A communications provider uses it to deliver wireless broadband connectivity as the last step in replacing cable and DSL. A wireless access standard based on IEEE 802.16, Broadband Wireless Access, is used by the standard [6]. This strategy allows for different network operators' varying bandwidth allotments and spectrum availability to provide various services. Compared to 4G network carriers, the WiMAX approach fully utilizes the spectrum's available bandwidth for high data rates and the services of the voice. In order to provide dependable communication between hospitals and other medical institutions for telemedicine applications, WiMAX technology is utilized[7]. Data security, dependability, and integrity must be carefully considered while sending data across an open-channel network. Unauthorized access, modification, or destruction of the secure data must be prevented. Utilizing steganography, all of these prerequisites are readily fulfilled. This stimulates learning how to secure the patient's critical information by utilizing often seen clinical images. Watermarking digital images may thus be quite useful for these kinds of applications. As a result of the utilization of WiMAX/4G technology, the peak signal-to-noise ratio (PSNR) and bit error rate of the received signal have been evaluated for

telemedicine applications. With SNR values exceeding 10.4 dB, a 106 Bit-Error-Rate rating can be achieved. A PSNR of more than 37 dB is required for clinical applications. Embedding in telemedicine may prove beneficial based on promising findings [8][9].

2. An Overview of WiMAX Standards- PhyLyr

A crucial component of WiMAX PhyLyr is orthogonal frequency division multiplexing. DSL, Wi-Fi, DVB-H, Media FLO, and WiMAX are commercial broadband systems that deliver high-speed data, video, and multimedia communications using OFDM as the principal transmission technique. In a multi-path, non-line-of-sight wireless environment, OFDM efficiently transmits huge data rates [10]. WiMAX supports several modulation and coding schemes, and depending on the channel conditions, the scheme may be altered for each connection. The base station may be informed about the download channel quality via the channel quality feedback indication on the smartphone. The base station may choose the quality of the channel for the upload based on the quality of the received signal[11][12].

3. Model for Proposed Watermarking

Secret data is embedded via the watermarking method into a carrier or host signal so that it may later be retrieved for validation and verification. The process of medical image (MedImg) watermarking essentially involves three steps. The first step consists of separating ROIs and non-ROIs, the second stage involves embedding the watermark in the Hosting Image, and the final step is extracting the data for the watermarks. SVN, a machine-learning algorithm often utilized for classification issues, may be quite helpful in the classification step. The transform domain approaches, on the other hand, are resistant to various assaults throughout the embedding and extraction process. Singular value decomposition (SVD), DCT, and DWT are examples. When watermarking non-watermarked images with DWT, the three major negatives are a lack of phase information, poor directional information, and false-positive issues associated with SVD [8] as shown in the Figure 1.

Using shuffled SVD (SSVD), you can eliminate false positives. Partitioning the original image into unit images improves the quality of the reconstructed image. Based on SVD and data-independent permutation, SSVD is defined by the original image permuted. As a result

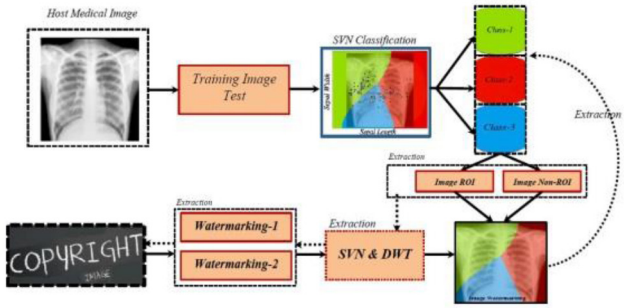

Figure 1

The Proposed Watermarking Model's Flow Diagram

of its beneficial spatial localization and multiresolution abilities, DWT has its significance in digital image watermarking approaches. The image's multiresolution characteristic displays a variety of details. The data was divided into various frequency components utilizing the wavelet function. DWT has the benefit over conventional transform approaches in that it can study signals with discontinuities and abrupt spikes. One of the numerical approaches utilized for diagonalizing the input images is SVD. There are several utilizes for this numerical approach. In order to represent image I, you may use the matrix of MxN nonnegative with scalar values. Singular values are found in the diagonal matrix S of MxN after using SVD to divide it into two orthogonal matrices U and V. The following mathematical statement may be utilized to represent the matrix's decomposition:

$$I = U * S * V' \tag{1}$$

Here, the suggested watermarking model's embedding and extraction procedures are covered.

First Side: Embedding the Watermarking Steps: Utilizing one-level DWT, the Non-ROI of Hosting-Image H is divided into 4 subbands.

$$W = P^1 + P^2 \tag{2}$$

LH and HL subbands are subjected to the SVD. After being split into two halves, the watermarking image W is jumbled. The adjusted singular values are subjected to SVD[20].

$$S^i + \alpha W^i = U_w^i S_w^i V_w^i \tag{3}$$

Scale factor (α) is a parameter utilized to assess the robustness of the implanted watermark (α). The DWT coefficients are tweaked, and the

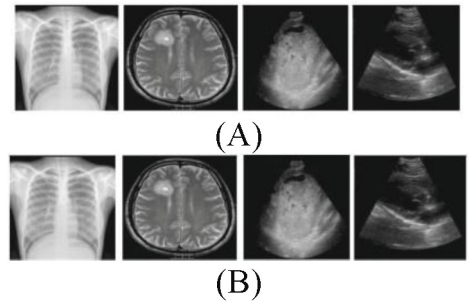

Figure 2

(A)Test-image hosting and (B) Image with a Watermark

results are produced. One-level inverse DWT is utilized to create watermarking images. Image H's ROI pixels are combined with this watermarked image to create the final WD image [20].

Second Side: Extracting the Watermarking Steps: The watermarking image WD is divided into 4 subbands utilizing a 1-level DWT. One applies the SVD. To 2-watermarking image subbands (LH2 and HL2)[19], i.e.

$$H^{*i} = U^i S_w^i V^i \tag{4}$$

$$Attain \quad E^{*i} = U_w^i S_w^i V_w^i \tag{5}$$

Extraction of the watermark's 2- encrypted halves, i.e.

$$E_w^{*i} = (E^{*i} - S^i)/\alpha \tag{6}$$

4. Findings and Discussion

Microsoft Windows 11 is running on an Intel Core_i7; 2.50 GHz_CPU, 2 TB hard drive, 4 GB of Double Data Rate -3 memory, and an Intel Core i7 2.50 GHz CPU. To test the suggested watermarking methodology, a 256 by 256 grayscale JPEG image is used. A hosting image as well as a watermarked image can be seen in Figure 2. A MATLAB Central database was used in this experiment. A grayscale image with a resolution of 128x128 is used as the watermark. During the experiment, 70,118 predictor points were measured on a JPEG image with 256 pixels by 256 pixels. After these data points are separated into training and testing data for the SVN model, 6428, or 15% of the total, are used for training. For cross-validation, 6483 of the remaining data points are used. A threshold value based on pixel

coordinates and intensity values is used here to classify the input image. The evaluation of proposed methodology based of Bit Error rate and PSNR are explained in Table 1. While Table 2 shows the evaluations of our proposed system against several attacks parameters.

Table 1

The Received Hosting-Image's Bit-Err-Rate and PSNR

SN.	SNR (dB)	Bit-Err-Rate (dB)	PSNRs (dB)
1	0.002	0.557	23.747
2	3.002	0.6578	26.617
3	5.602	0.6657	27.377
4	6.002	0.447	28.677
5	7.302	0.347	33.907
6	8.602	0.2761	34.727
7	8.902	0.2614	36.097
8	9.002	0.2542	36.427
9	9.502	0.2514	41.417
10	10.002	0.2502	43.327

Table 2

Structural Similarity Index Measure Values for Various Attacks.

Sr. No.	Attacks/ Noise	Structural Similarity Index Measure
1	Noise of salt and paper	0.794
2	Statistical noise	0.811
3	Jpg assault (87 %)	0.697
4	Jpg assault (71 %)	0.741
5	Jpg assault (61 %)	0.708
6	Jpg assault (52 %)	0.811
7	Noise of Speckle	0.821
8	Equalizing the histogram	0.798
9	Filtering by the Median	0.793
10	Crop (5%)	0.824
11	Average	0.779

Table 3

Variation of the Recovered X-Ray Image's BER and PSNR for Different SNR Values.

SNR (DB)	Bit-Err-Rate Average	PSNRs (dB) Average
0	0.9948	24.06
3.0	0.9467	25.21
5.0	0.7374	26.85
6.0	0.6183	32.47
7.5	0.5488	34.26
8.5	0.5185	41.69
8.7	0.5162	42.07
9.5	0.5057	48.86
10.5	0.5015	51.89
10.7	1.0202×10^{-3}	56.47
Signal-to-Noise Ration mentioned to SNR & Peak Signal-to-Noise Ration mentioned to PSNR.		

5. Conclusion

MedImg or data are transmitted between locations in the healthcare sector via wired or wireless technology. As a result, extra security is needed to transmit such information. The suggested approach assures that MedImg is readable and resistant to various image processing threats. This work presents a protected watermarked image transmission across a simulated WiMAX download PhyLyr. The received image has a imperceptibility of high quality at a PSNR value of 37 dB with a PSNR of 57.63 dB at a SNR of 13.25 dB as shown in Table 3. The encouraging simulation results may have telemedicine utilizes. The computational complexity, which has to be enhanced, may have grown due to the suggested model. It may be expanded in future works to include text embedding and delicate watermarking at various degrees of alteration. The performance of the suggested model will continue to improve, as shown by the next communication.

References

[1] Ma, X., Niu, Y., Gu, L., Wang, Y., Zhao, Y., Bailey, J., & Lu, F. : Understanding adversarial attacks on deep learning based medical image analysis systems. *Pattern Recognition* (2020).

[2] Balu, S., Babu, C. N. K., & Amudha, K. : Secure and efficient data transmission by video steganography in medical imaging system. *Cluster Computing*, *22*, 4057–4063 (2019).

[3] Shehab, A., Elhoseny, M., Muhammad, K., Sangaiah, A. K., Yang, P., Huang, H., & Hou, G. : Secure and robust fragile watermarking scheme for medical images. *IEEE Access*, *6*, 10269–10278 (2018).

[4] Prabhu, P., & Manjunath, K. N. : Secured image trans- mission in medical imaging applications—A survey. In *Computer Aided Intervention and Diagnostics in Clinical and Medical Images*, pp. 125–133 (2019).

[5] Kim, J. M., Lee, H. S., Yi, J., & Park, M. : Power adaptive data encryption for energy-efficient and secure communication in solar-powered wireless sensor networks. *Hindawi Publishing Corporation Journal of Sensors* (2016). https://doi.org/10.1155/2016/ 2678269.

[6] Manesha, R. A., & Velladurai, M. : Efficient image transmission in wireless sensor networks using wavelet coded preprocessing technique. *International Journal of Computer Networks and Wireless Communications, 2*(2) (2012).

[7] Roopa, B., Kumar, S., & Manvi, S. : Image fusion for wireless sensor networks. *Specialty Journal of Electronic and Computer Sciences*, *1*(1), 1–8 (2015).

[8] El-Bendary, M. A., & Abou El-Azm, A. E. : Complexity considerations: efficient image transmission over mobile com- munications channels. *Multimedia Tools and Applications,* 78(12), 16633–16664 (2019).

[9] Haouari, B., Khelifa, B., & Mohammed, B. : Image transmission model with quality of service and energy economy in Wireless Multimedia Sensor Network. *International Journal of Advanced Computer Science and Applications*, *7*(2), 180–184 (2016).

[10] Ghorbel, O., Ayedi, W., Jmal, M. W., & Abid, M. : Images compression in WSN: Performance analysis. In IEEE 14th international conference on presented at the communication technology, Chengdu (2012).

[11] Lu, Z. M., Xu, D. G., & Sun, S. H. : Multipurpose image watermarking algorithm based on multistage vector quantization. IEEE Transactions on Image Processing, 14(6), 822–831 (2005).

[12] Kim, H. S., & Lee, H. K. : Invariant image watermark using Zernike moments. IEEE Transactions on Circuits and Systems For Video Technology, 13(8), 766–775 (2003).

[13] Priya, S., & Santhi, B. : A novel visual medical image encryption for secure transmission of authenticated watermarked medical images. *Journal of Mobile Networks and Applications* (2019). https://doi.org/10.1007/s11036-019-01213-x.

[14] Li, W., Xue, X., & Lu, P. : Localized audio watermarking technique robust against time-scale modification. *IEEE Trans- actions on Multimedia*, *8*(1), 60–69 (2006).

[15] Han, F., Yu, X., & Han, S. : Improved baker map for imageencryption. In First international symposium on systems and control in aerospace and astronautics, pp. 1273–1276 (2006).

[16] El-Bendary, M. A. M. : FEC merged with double security approach based on encrypted image steganography for different purpose in the presence of noise and different attacks. *Multimedia Tools and Applications*, *76*(24), 26463–26501 (2017).

[17] Sengupta, A., & Rathor, M. : Structural obfuscation and crypto-steganography-based secured JPEG compression hardware for medical imaging systems. IEEE Access, 8, 6543–6565 (2020).

[18] Kasban, H., & El-Bendary, M. A. : performance improvement of digital image transmission over mobile WiMAX networks. *Wireless Personal Communications*, 94, 1087–1103 (2017).

[19] Sharma, B., Koundal, D., & Singh, S. : Medical imaging security and forensics: A systematic literature review. Advances in Computational Techniques for Biomedical Image Analysis, 2020, 273–297 (2020).

[20] Costa, D. G., Figueˆdo, S., & Oliveira, G. : Cryptography in Wireless Multimedia Sensor Networks: a survey and research directions. *Cryptography Journal*, 1, 1–18 (2017).

[21] Shubham Sharma & Ahmed J. Obaid. Mathematical modelling, analysis and design of fuzzy logic controller for the control of ventilation systems using MATLAB fuzzy logic toolbox, *Journal of Interdisciplinary Mathematics*, 23:4, 843-849 (2020), DOI: 10.1080/09720502.2020.1727611.

Received April 2023