International Journal of Computer Engineering and Technology (IJCET)
Volume 15, Issue 5, Sep-Oct 2024, pp. 152-163, Article ID: IJCET_15_05_015
Available online at https://iaeme.com/Home/issue/IJCET?Volume=15&Issue=5
ISSN Print: 0976-6367 and ISSN Online: 0976-6375
Impact Factor (2024): 18.59 (Based on Google Scholar Citation)
DOI: https://doi.org/10.5281/zenodo.13743988

REVERSIBLE IMAGE STEGANOGRAPHY BASED ON EDGE DETECTION AND MPVD

Habiba Sultana and A.H.M. Kamal
Department of Computer Science and Engineering,
Jatiya Kabi Kazi Nazrul Islam University, Mymensingh 2220, Bangladesh

ABSTRACT

The development of reversible image steganography techniques is of great interest to many scholars. We also presented a reversible image steganography in this study using modified pixel value differencing (MPVD) and edge detection. We gather edge and non-edge pixels from the cover image by using the edge detection technique. The amount of implanted bits into the cover pixels is then determined by dividing the difference between the edge and non-edge pixels. Using the MPVD technique, we implant secret bits in edge pixels and produce a stego image. This stego image will be delivered to the recipient. The concealed message and cover media are extracted by the recipient at their end. This approach works well for subliminal messaging. It simultaneously preserves the quality of the visuals and shields implanted data's privacy from different kinds of cyber-attacks. The experimental findings yield encouraging results.

Keywords: Edge, Modified Pixel Value Differencing, PSNR, SSIM and Steganography.

Cite this Article: Habiba Sultana and A.H.M. Kamal, Reversible Image Steganography Based on Edge Detection and MPVD, *International Journal of Computer Engineering and Technology (IJCET)*, 15(5), 2024, pp. 152-163.
https://iaeme.com/MasterAdmin/Journal_uploads/IJCET/VOLUME_15_ISSUE_5/IJCET_15_05_015.pdf

1. INTRODUCTION

Information security is a field that researchers are knowledgeable about. There are several ways to guarantee data security when communicating over the Internet, such as information fusion, cryptography, steganography, and watermarking [1–9]. The most popular of these is steganography. Cover media for steganographic algorithms might be text, audio, video, image, etc. Steganography is a widely used technique in which the sender creates stego media by embedding hidden messages into cover media using an algorithm. The recipient gets this stego media. The secret is extracted from the stego image by a receiver at the receiving end. Without assistance from the sender side, certain people might be able to reconstruct the cover media from the stego media.

A method is referred to as a reversible process if it can extract both the secret message and the cover. Conversely, the irreversible plans merely retrieve the information. Their focus is not on the reconstruction of the cover image. Reversible techniques are more beneficial in specific application areas even though they withdraw the cover and secret message.

Augmenting edge pixels with more bits than non-edge pixels is a very strict method of enhancing data security. To distinguish between edge and non-edge pixels in an image, such a technique first uses an edge detection algorithm. Next, data bits are conceived using the identified edge and non-edge pixels. Our goal is to conceal data in pixels that are edge and non-edge. We looked at various edge detection-based strategies. These are, nevertheless, irreversible plans. Because of this, our second goal is to create a reversible procedure that is extremely similar to those.

A hybrid edge-based image steganography system was proposed by Chen et al. [7]. They implanted hidden bits using the least significant substitution methodology, and they combined canny and fuzzy logic-based edge images using the OR operator in their method. They tracked the edge status within image pixels. This results in low embedding capacity and poor visual quality for this concept. Tseng and Leng [8] suggested block and hybrid edge-based image steganography techniques to address the issue [7]. Additionally, they stored edge status information within image pixels, although the visual quality of that data is equally subpar. The shortcomings of [7] and [8] were overcome by the plan put forth in [15]. The authors of that technique make use of the entire embedding space without keeping track of edge information.

A novel edge-based image steganography technique was proposed by Sun [10]. In this system, the author uses the Canny edge detection algorithm to find and implant just edge pixels. They concurrently encrypted the secret data using the Huffman encoding algorithm and enhanced the image quality of the stego images using the 2k correction approach. Due to the selection of only edge pixels, the technique has a low embedding capacity. Another pixel value differencing (PVD)--based image steganography technique was presented by Swain [11]. There is insufficient embedding capacity in this scheme. A true edge-based approach to image steganography was presented by Khan et al. [12]. A new steganography strategy was presented by Hussain et al. [13] by combining reversible and irreversible techniques. Pixel value difference (PVD), substitution of the least significant bit (LSB), PVD shift, and modification of prediction error (MPE) are the foundations of their methodology. An innovative image steganography technique based on edge detection and XOR coding was proposed by Al-Dmour and Al-Ani [14]. They either implant secrets in the cover image's transform or spatial domains. The technique presented in [3] integrated steganography and cryptography algorithms. They use the Data Encryption Standard (DES) to encrypt the secret data, and they implant the LSB technique on the edge region of the cover image which is produced by the canny edge detection algorithm on the cover image. Additionally, steganography and cryptography techniques were combined by Vanmathi and Prabu [16]. They implant the secret data using LSB and variable-length data that is hidden on the edge and non-edge areas of the cover image, which is generated using a fuzzy edge detector, and they encrypt it using the chaotic technique. A unique image steganographic algorithm based on hybrid hamming codes and the canny edge detection algorithm was proposed in the scheme of [17]. Another steganography technique based on XOR coding, dilation morphological operator, and canny edge detection was presented by Gaurav and Ghanekar [18]. A fuzzy edge detection method-based image steganography was proposed by Kumar et al. [20]. They use a 2-bit cleared image to identify edge pixels using the fuzzy edge detection algorithm, and then they implant 2-bit secrets on the chosen edge using the LSB method. Another image steganography technique based on hybrid edge detection and LSB approach was proposed by Setiadi and Jumanto [19].

An image steganography technique based on the LSB approach, the dilation morphological operator, and the hybrid edge detection algorithm was proposed by Setiadi [21]. A method of image steganography based on the Kirsch edge detection algorithm and implanting secrets into each triplet of pixels was proposed by Ghosal et al. [26]. An image steganography technique based on PVD and an edge detection algorithm were presented in the scheme of [22]. An image steganographic approach based on a logistic map for secret information encryption and the Laplacian of Gaussian (LoG) edge operator for locating edge regions of the cover image was proposed by Jan et al. [23]. An image steganography approach based on hybrid edge detection and the LSB method was proposed by Sultana and Kamal [25]. Reversible image steganography based on reduplicated exploiting modification direction, image interpolation, and a canny edge detection technique was proposed by Lee et al. [29]. A multi-layer data embedding approach based on prediction error was presented by Kamal and Islam [28]. [30, 31, 32, and 33] presented a reversible algorithm for image steganography. A local binary pattern (LBP)-based image steganography technique was presented by Chakraborty and Jalal [24]. An algorithm for image steganography based on prediction error and LBP coding was proposed by Kamal and Islam [27]. Reversible image steganography based on the XOR operator and the LBP code was proposed by Sahu et al. [34].

This research is focused on reversible image steganography. The contributions of this research are:

- Developing edge detection and MPVD- based reversible image steganography.
- The scheme preserves the stego image's visual quality.
- The scheme protect the privacy of implanted data from various potential cyber-attacks.

The article is divided into multiple sections for the remainder of it. Specifics of related works are given in Section 2. Section 3 presents the proposed approach. The simulated outcomes of our scheme are presented in Section 4. Section 5 brings the article to a close.

2. LITERATURE REVIEW

Sultana and Kamal's hybrid edge detection-based image steganography technique was presented in 2021 [25]. On *m*-bit cleared images, they used *x* edge detectors, and then they hybridized those edge images using the AND operator. After that, they divided the cover pixels into edge and non-edge categories. They also use the chaotic method to encrypt the secret message at the same time. To create a stego image, they embed *m* bits into edge pixels and *n* bits into non-edge pixels where $m > n$.

Kamal and Islam [27] introduced LBP in their prediction error-based image steganography technique in 2022. The conventional LBP approach was altered by them. The image is pre-processed to transform all pixels to odd or even before the LBP method is applied. Pixel values are even until they are less than their reference value, at which point they become odd. They modified the LBP code as 1 and -1. Here -1 is used in place of 0. The encoded error and encoded pixel values are then calculated. Stego errors are produced when they insert hidden bits into the encoded error. Lastly, by combining encoded pixel values with encoded errors, this approach creates stego pixels.

Sahu et al. introduced the LBP-based reversible data-hiding method [34]. The image is divided into non-overlapping 3 × 3 blocks. LBP codes are gathered from every block. They split the eighteen embeddable bits into three pieces, two of which have eight bits each, while the third part has two bits. After that, they concatenated the three segments by XORing them with the LBP code of a single block. Once more, they split those XORed values into nine segments, each of which has two bits that follow one another.

The first eight-bit segments are then implanted using the LSB method in neighboring pixels of a block, and the bits from segment nine are implanted in the block's center pixel. All data are inserted in this manner. Two stego images are generated throughout the data implantation process. Secret message fragments and cover images are recovered at the extraction stage by applying the opposite procedure.

3. PROPOSED METHOD

Presenting an edge and MPVD-based reversible image steganography is the goal of our research. Three components make up the proposed scheme: data extraction, data embedding, and preprocessing. The steps are presented below and are displayed graphically in Figure 1.

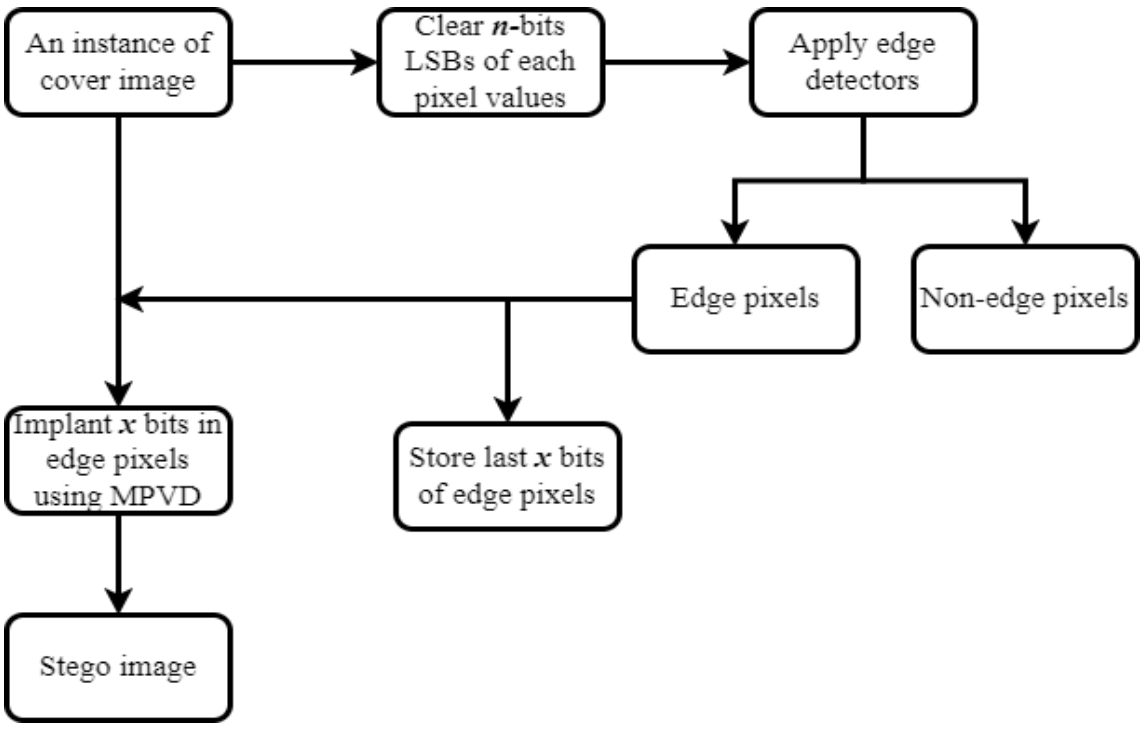
3.1. Preprocessing and data embedding steps

- First take an instance of cover image and copy it
- Cleared n-bits LSBs from copied image
- Apply edge detector such as canny on cleared image
- Then collect edge pixels from cover image and also same number of non-edge pixels
- Embeds x bits secret bits in edge pixels using MPVD method
- Store last x bits of edge pixel where x is the embeddable bits
- Finally, it creates a stego image by embedding all secret bits in edge pixels.

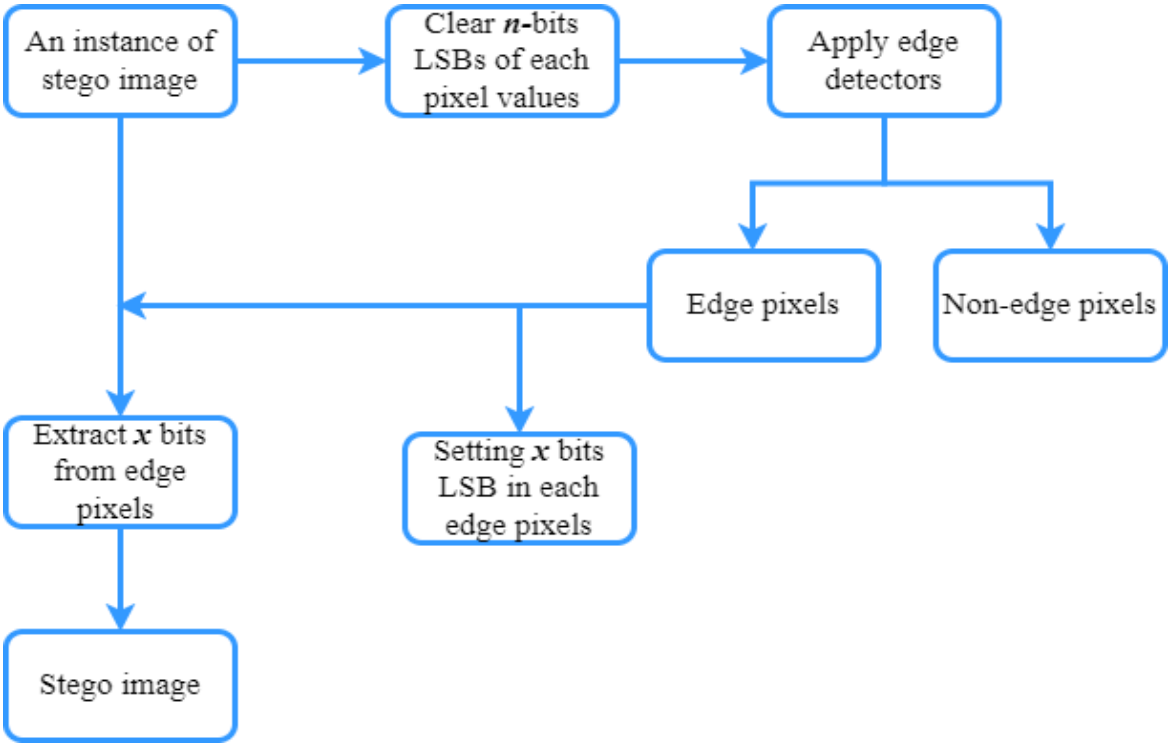
3.2. Data extraction

There is the stego image in the extraction process. The following steps are then taken by the scheme to reconstruct the cover image and extract the embedded secrets.

- First take an instance of stegor image and copy it
- Cleared n-bits LSBs from copied image
- Apply edge detector such as canny on cleared image
- Then collect edge pixels from cover image and also same number of non-edge pixels
- Extracts x bits secret bits in edge pixels
- Setting x bits LSB in each edge pixels
- Afterward, the cover image is rebuilt.



(a)



(b)

Figure 1. Proposed method approach. (a) Process of embedding; (b) Process of extraction.

4. RESULTS AND DISCUSSION

This section presents the experimental findings used to assess the proposed scheme's performance with Sultana's [25], Kamal's [27], and Sahu's [34] studies. We used MATLAB 2017 on Windows 10 to implement our proposed approach. Ten commonly used test images and an image dataset were utilized in this experiment. The cover images are shown in Figure 2, and the corresponding stego images are shown in Figure 3.

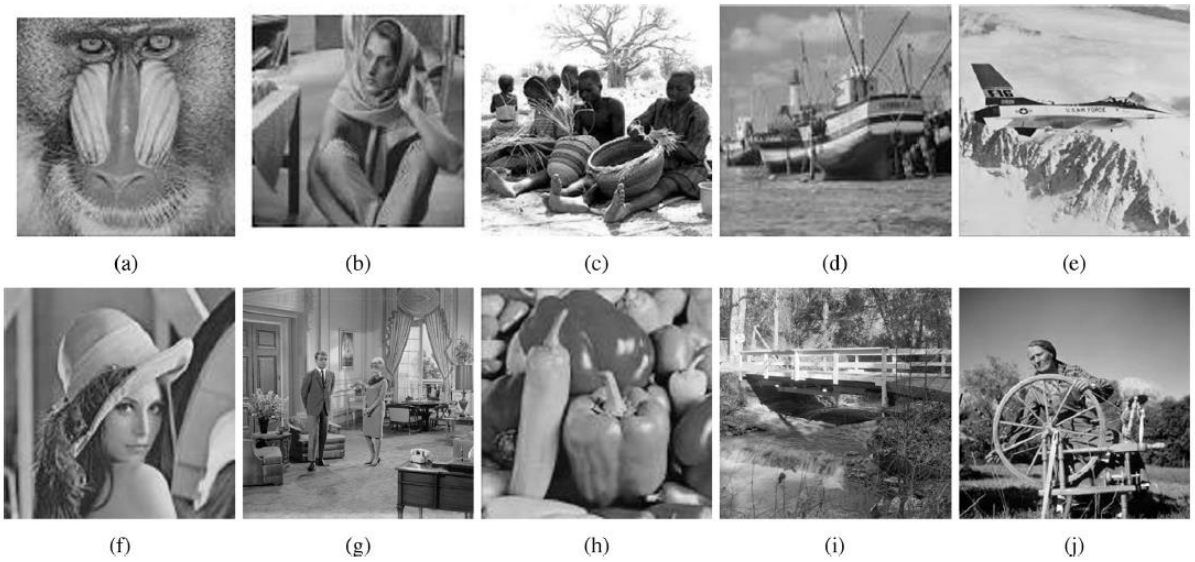


Figure 2. Cover images for experiment

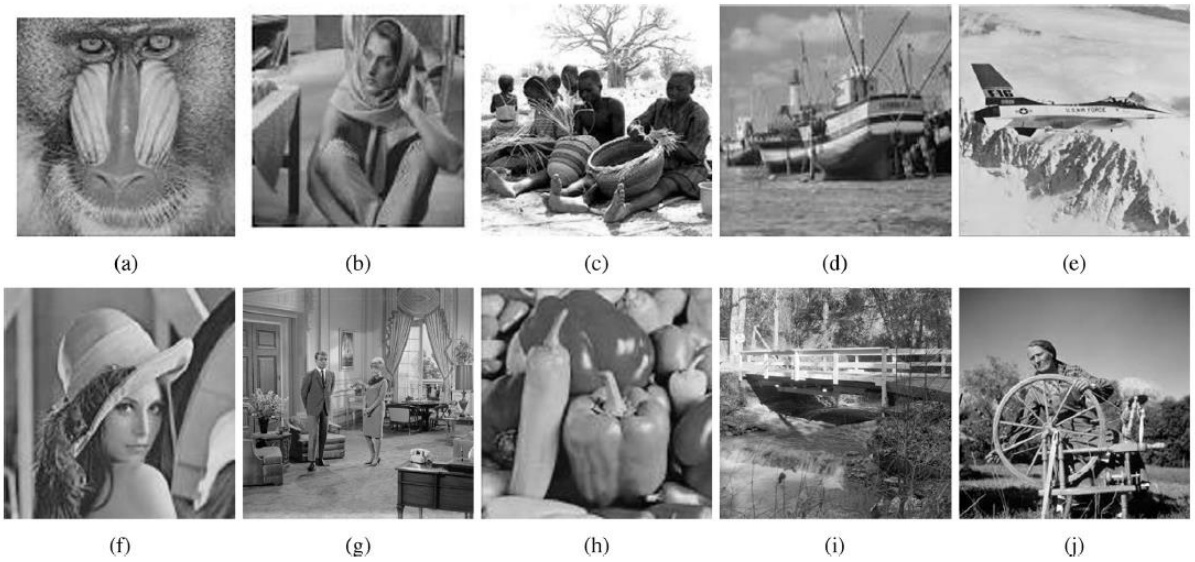


Figure 3. Stego images for corresponding cover images

The performance of the proposed method was measured with several feature values, such as payload, embedding capacity, peak signal-to-noise ratio (PSNR), structural similarity index matrix (SSIM), correlation coefficient and entropy, etc.

The maximum number of embedding bits into a cover image is called payload and achieved by

$$payload = total\ maximum\ number\ of\ embedding\ bits \ldots\ldots\ldots\ldots (1)$$

Measured payload are tabulated in Table 1.

Table 1. Payload of various schemes.

ImageName	**Payload**			
	Proposed	**Sultana[25]**	**Kamal[27]**	**Sahu[34]**
Baboon.png	118611	279784	262144	73929
Barbara.png	183442	266862	262144	90273
Basket.png	185760	284119	262144	84750
Boat.png	120215	294957	262144	84073
F16.png	144076	268416	262144	81061
Lena.png	119470	289808	262144	76271
Livingroom.png	148093	289262	262144	96891
Pepper.png	125476	293868	262144	80579
Walkbridge.png	217357	286277	262144	97510
Wheel.png	122663	283729	262144	77433

The term "embedding capacity" refers to the maximum number of embedding bits per pixel (bpp). This embedding capacity is achieved by

$$Embedding\ capacity = \frac{maximal\ embedding\ bits}{(h * w)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, h and w are the height and width of the cover image, respectively.

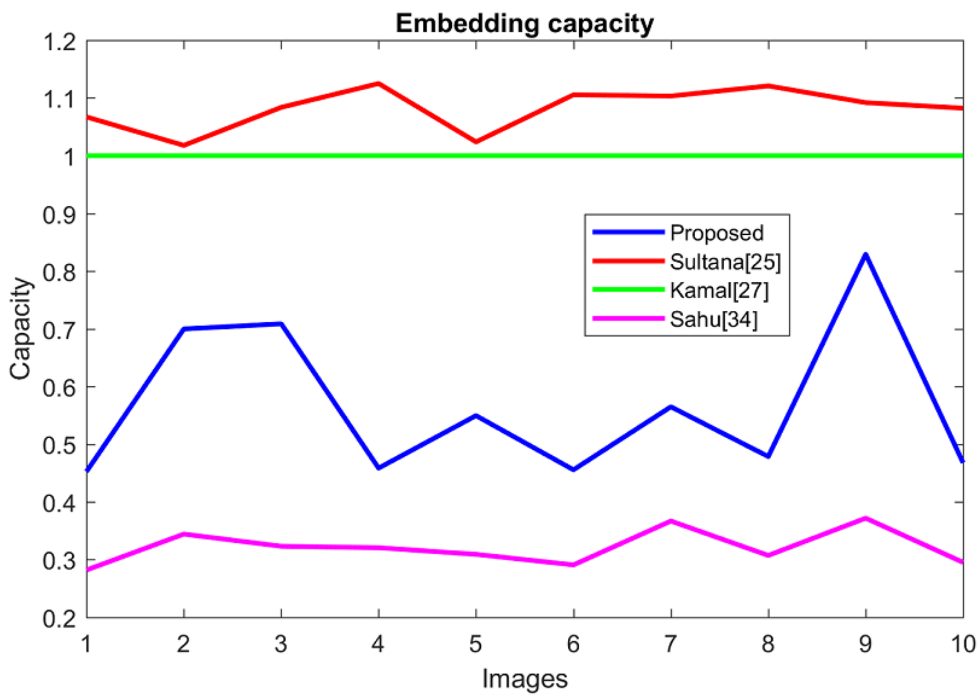


Figure 4. Embedding capacities of different images of different schemes. Since the proposed method only embeds edge pixels, the figure indicates that it has the third lowest embedding capacity.

Peak signal-to-noise ratio (PSNR), structural similarity index measurement (SSIM), and other metrics are used to assess the image quality of the proposed method.

The PSNR is measured by

$$PSNR = 10log10\left(\frac{255^2}{MSE}\right) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \dots \dots . (3)$$

Where MSE is the mean square error and calculated by

$$MSE = \sum_{i=1}^{W\times H} \frac{(St - A)^2}{W \times H}$$

Where St and A are the pixel values of the stego and cover images respectively.

Measured PSNR are presented in Table 2.

Table 3. PSNR values of various schemes.

ImageName	**PSNR**			
	Proposed	**Sultana[25]**	**Kamal[27]**	**Sahu[34]**
Baboon.png	59.45	46.38	52.92	56.83
Barbara.png	60.19	45.45	59.43	55.95
Basket.png	68.98	59.83	59.85	56.22
Boat.png	62.80	60.42	58.48	56.25
F16.png	60.17	60.71	55.00	56.41
Lena.png	56.94	43.60	37.56	56.66
Livingroom.png	62.10	59.85	55.15	56.65
Pepper.png	61.57	59.26	57.63	55.46
Walkbridge.png	60.60	59.96	55.15	55.61
Wheel.png	62.03	60.12	55.15	56.61

The SSIM is measured by

$$SSIM = \frac{(2\mu_c\mu_s + C_1)(2\sigma_{cs} + C_2)}{(\mu_c{}^2 + \mu_s{}^2 + C_1)(\sigma_c{}^2 + \sigma_s{}^2 + C_2)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Where for the cover and stego image, μ_c, μ_s and σ_c, σ_s are the mean pixel values and variance, σ_{cs} is the covariance between the cover and stego image, C_1 and C_2 are the constants.

Figure 5 illustrates the SSIM values. According to this figure, the proposed method yields better outcomes in nearly every image.

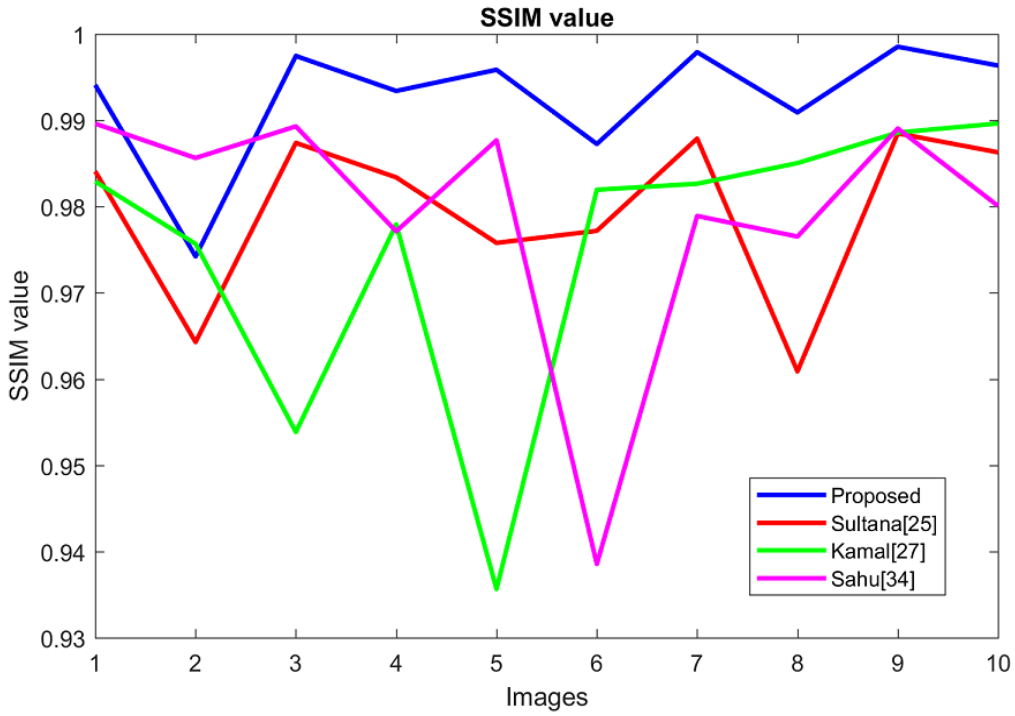


Figure 5. SSIM values for various schemes and images. According to the figure, the proposed scheme has the highest SSIM value.

A statistical indicator of how similar the two images are to one another is correlation. With the built-in MATLAB function, correlation can be measured in the following ways.

$$correlartion = corr2(A, S) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

Where, A is a cover image and S is stego image.

Table 3 displays the correlation results. According to this table, the proposed method is superior to the others.

Table 3. Correlation values of various schemes.

ImageName	**Correlation**			
	Proposed	**Sultana[25]**	**Kamal[27]**	**Sahu[34]**
Baboon.png	0.9991	0.9928	0.9958	0.9938
Barbara.png	0.9854	0.9797	0.9827	0.9832
Basket.png	0.9910	0.9890	0.9899	0.9859
Boat.png	0.9920	0.9899	0.9856	0.9830
F16.png	0.9900	0.9880	0.9845	0.9840
Lena.png	0.9937	0.9910	0.9920	0.9848
Livingroom.png	0.9931	0.9879	0.9875	0.9857
Pepper.png	0.9920	0.9890	0.9897	0.9878
Walkbridge.png	0.9877	0.9812	0.9815	0.9851
Wheel.png	0.9961	0.9825	0.9865	0.9825

Entropy is a statistical tool used to quantify how much an image has been altered. It measures disorder or unpredictability. A high entropy value in an image suggests greater alteration, whereas a low number suggests less manipulation. The entropy is calculated by

$$entropy = -sum(p.* \log_2(p)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where, the normalized histogram numbers that imhist returned are contained in p.

In Figure 6, the entropy values are shown. According to this figure, the proposed method exhibits less manipulation than the others. Therefore, our proposed method is superior to others.

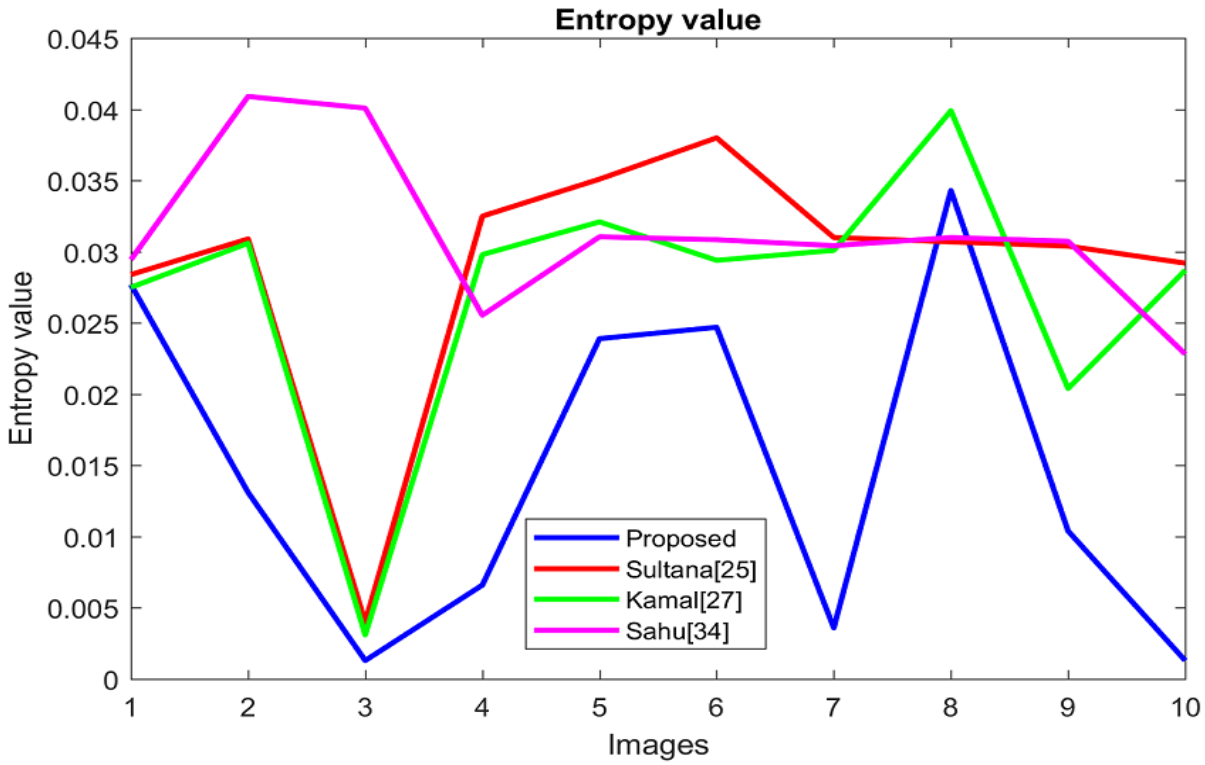


Figure 6. values of entropy for various schemes' images. According to the figure, the proposed approach has the lowest entropy values.

Our proposed method implants only edge pixels. The primary goal of our work is to achieve reversibility through improved stego image retention during concealed bit implantation.

5. CONCLUSIONS

We presented a reversible image steganography in this study using modified pixel value differencing (MPVD) and edge detection. We gather edge and non-edge pixels from the cover image by using the edge detection technique. The amount of implanted bits into the cover pixels is then determined by dividing the difference between the edge and non-edge pixels. We also store last *x*-bits LSBs of edge pixels where *x* is the embeddable bits. Using the MPVD technique, we implant secret bits in edge pixels and produce a stego image. This stego image will be delivered to the recipient. The concealed message and cover media are extracted by the recipient at their end. This approach works well for subliminal messaging. It simultaneously preserves the quality of the visuals and shields implanted data's privacy from different kinds of cyber-attacks. Moreover, in future we will increase the embedding capacity and full utilize the embedding space.

ACKNOWLEDGEMENTS

This research is financially supported by the Research and Extension Center of Jatiya Kabi Kazi Nazrul Islam University. Therefore, we would like to make that acknowledged.

REFERENCES

[1] Kadhim, I.J.; Premaratne, P.; Vial, P.J.; Halloran, B. Comprehensive survey of image steganography: Techniques, Evaluations, and trends in future research. Neurocomputing 2019, 335, 299–326.

[2] Girdhar, A.; Kumar, V. Comprehensive survey of 3D image steganography techniques. IET Image Processing 2018, 12, 1–10.

[3] Kusuma, E.J.; Indriani, O.R.; Sari, C.A.; Rachmawanto, E.H.; et al. An imperceptible LSB image hiding on edge region using DES encryption. In Proceedings of the 2017 International Conference on Innovative and Creative Information Technology (ICITech). IEEE, 2017, pp. 1–6.

[4] Piras, L.; Giacinto, G. Information fusion in content based image retrieval: A comprehensive overview. Information Fusion 2017, 37, 50–60.

[5] Wang, X.; Li, X.; Pei, Q. Independent embedding domain based two-stage robust reversible watermarking. IEEE Transactions on Circuits and Systems for Video Technology 2019, 30, 2406–2417.

[6] Ernawan, F.; Kabir, M.N. An improved watermarking technique for copyright protection based on tchebichef moments. IEEE Access 2019, 7, 151985–152003.

[7] Chen, W.J.; Chang, C.C.; Le, T.H.N. High payload steganography mechanism using hybrid edge detector. Expert Systems with applications 2010, 37, 3292–3301.

[8] Tseng, H.W.; Leng, H.S. High-payload block-based data hiding scheme using hybrid edge detector with minimal distortion. IET Image Processing 2014, 8, 647–654.

[9] Adi, P.W.; Rahmanti, F.Z.; Abu, N.A. High quality image steganography on integer Haar Wavelet Transform using modulus function. In Proceedings of the 2015 International Conference on Science in Information Technology (ICSITech). IEEE, 2015, pp. 79–84. Version October 31, 2023 submitted to Future Internet 21 of 22

[10] Sun, S. A novel edge based image steganography with 2k correction and Huffman encoding. Information Processing Letters 2016, 116, 93–99

[11] Swain, G. Adaptive pixel value differencing steganography using both vertical and horizontal edges. Multimedia Tools and Applications 2016, 75, 13541–13556.

[12] Khan, S.; Ahmad, N.; Ismail, M.; Minallah, N.; Khan, T. A secure true edge based 4 least significant bits steganography. In Proceedings of the 2015 International Conference on Emerging Technologies (ICET). IEEE, 2015, pp. 1–4.

[13] Hussain, M.; Wahab, A.W.A.; Javed, N.; Jung, K.H. Recursive information hiding scheme through LSB, PVD shift, and MPE.IETE Technical Review 2018, 35, 53–63.

[14] Al-Dmour, H.; Al-Ani, A. A steganography embedding method based on edge identification and XOR coding. Expert systems with Applications 2016, 46, 293–306.

[15] Bai, J.; Chang, C.C.; Nguyen, T.S.; Zhu, C.; Liu, Y. A high payload steganographic algorithm based on edge detection. Displays 2017, 46, 42–51.

[16] Vanmathi, C.; Prabu, S. Image steganography using fuzzy logic and chaotic for large payload and high imperceptibility. International Journal of Fuzzy Systems 2018, 20, 460–473.

[17] Lee, C.F.; Chang, C.C.; Xie, X.; Mao, K.; Shi, R.H. An adaptive high-fidelity steganographic scheme using edge detection and hybrid hamming codes. Displays 2018, 53, 30–39.

[18] Gaurav, K.; Ghanekar, U. Image steganography based on Canny edge detection, dilation operator and hybrid coding. Journal of Information Security and Applications 2018, 41, 41–51.

[19] Setiadi, D.; Jumanto, J. An enhanced LSB-image steganography using the hybrid Canny-Sobel edge detection. Cybernetics and Information Technologies 2018, 18, 74–88.

[20] Kumar, S.; Singh, A.; Kumar, M. Information hiding with adaptive steganography based on novel fuzzy edge identification. Defence Technology 2019, 15, 162–169.

[21] Setiadi, D.R.I.M. Improved payload capacity in LSB image steganography uses dilated hybrid edge detection. Journal of King Saud University - Computer and Information Sciences 2019 Feb, 34, 104–114.

[22] Vishnu, B.; Namboothiri, L.V.; Sajeesh, S.R. Enhanced image steganography with PVD and edge detection. In Proceedings of the 2020 Fourth International Conference on Computing Methodologies and Communication (ICCMC). IEEE, 2020, pp. 827–832.

[23] Jan, A.; Parah, S.A.; Malik, B.A. A novel Laplacian of Gaussian (LoG) and chaotic encryption based image steganography technique. In Proceedings of the 2020 International Conference for Emerging Technology (INCET), Belgaum, India, 5–7 June 2020; IEEE: Piscataway, NJ, USA, 2020; pp. 1–4.

[24] Chakraborty, S.; Jalal, A.S. A novel local binary pattern based blind feature image steganography. Multimed. Tools Appl. 2020, 79, 19561–19574.

[25] Sultana, H.; Kamal, A. Image Steganography System based on Hybrid Edge Detector. In Proceedings of the 2021 24th International Conference on Computer and Information Technology (ICCIT), Dhaka, Bangladesh, 18–20 December 2021; IEEE: Piscataway, NJ, USA, 2021; pp. 1–6.

[26] Ghosal, S.K.; Chatterjee, A.; Sarkar, R. Image steganography based on Kirsch edge detection. Multimed. Syst. 2021, 27, 73–87.

[27] Kamal, A.; Islam, M.M. Uses of Local Binary Pattern Codes for Enriching the Embedding Performance. In Proceedings of the 2022 IEEE Delhi Section Conference (DELCON), New Delhi, India, 11–13 February 2022; IEEE: Piscataway, NJ, USA, 2022; pp. 1–7.

[28] Kamal, A.; Islam, M.M. Boosting up the data hiding rate through multi cycle embedment process. J. Vis. Commun. Image Represent. 2016, 40, 574–588.

[29] Lee, C.F.; Chen, H.L. Adjustable prediction-based reversible data hiding. Digit. Signal Process. 2012, 22, 941–953.

[30] Sultana, H.; Kamal, A. An Edge Detection Based Reversible Data Hiding Scheme. In Proceedings of the 2022 IEEE Delhi Section Conference (DELCON), New Delhi, India, 11–13 February 2022; IEEE: Piscataway, NJ, USA, 2022; pp. 1–6.

[31] Hassan, F.S.; Gutub, A. Novel embedding secrecy within images utilizing an improved interpolation-based reversible data hiding scheme. J. King Saud Univ. Comput. Inf. Sci. 2020.

[32] Sahu, A.K.; Swain, G. High fidelity based reversible data hiding using modified LSB matching and pixel difference. J. King Saud-Univ. Comput. Inf. Sci. 2019.

[33] Lee, C.F.;Weng, C.Y.; Chen, K.C. An efficient reversible data hiding with reduplicated exploiting modification direction using image interpolation and edge detection. Multimed. Tools Appl. 2017, 76, 9993–10016.

[34] Sahu, M.; Padhy, N.; Gantayat, S.S.; Sahu, A.K. Local binary pattern-based reversible data hiding. CAAI Trans. Intell. Technol. 2022, 7, 695–709.

Citation: Habiba Sultana and A.H.M. Kamal, Reversible Image Steganography Based on Edge Detection and MPVD, International Journal of Computer Engineering and Technology (IJCET), 15(5), 2024, pp. 152-163

Abstract Link: https://iaeme.com/Home/article_id/IJCET_15_05_015

Article Link:
https://iaeme.com/MasterAdmin/Journal_uploads/IJCET/VOLUME_15_ISSUE_5/IJCET_15_05_015.pdf

✉ **editor@iaeme.com**