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DIGITAL IMAGE STEGANOGRAPHY USING USING EIGHT DIRECTIONAL PVD WITH ADD-SUB ARITHMETIC

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Abstract

RS analysis detects least significant bit (LSB) replacement of methods and pixel value difference histograms (PDH) analysis detects traditional PVD methodologies. The employing the sides in numerous orientations, PVD steganography can throw off PDH analysis. This work presents a steganography technique that uses LSB substitution to resist both PDH and RS analysis by utilising the sides in eight directions. By using a modified LSB replacement approach, the middle pixel of each 33 pixel block is embedded with 3 or 4 bits of information. The central pixel's new value is then used to compute eight difference values with eight nearby pixels. These eight difference values have a tendency for conceal information. There were two of them. Regarding two separate range tables, there are two different types. Kind 1 employs range table 1 and 3 bit modified LSB replacement. In terms of two different range tables, the type 2 types. Kind 1 employs range table 1 and 3 bit modified LSB replacement. Type 2 employs range table 2 and 4 bit modified LSB replacement. Kinds 1 and 2 are referred to as variant 1 and variant 2, respectively. Kind 1 has a greater PSNR, whereas Kind 2 has a high in concealing capacity.

Keywords - PVD, LSB substitution, QVD, Steganalysis, PVC

I. INTRODUCTION

One of the most well-known and successful data-hiding schemes is the LSB replacement. RS analysis is used to detect this most basic approach. The sting areas of a picture may conceal more information than the smooth sections, according to Wu and Tsai [1]. They developed pixel value differencing (PVD) steganography to support this notion. The image's elements should all be 12 pixels wide. The difference between two pixels in a block is calculated and transformed to a new value by adding data. To increase embedding capacity, the PVD approach with a block size of 22 has been proposed [2, 3]. Edges in three directions are evaluated in blocks of size 22. The values of two, three, and four surrounding pixels were used by Chang & Tseng [4] to determine the differences in pixel values However, they made a blunder when it came to the autumn issue (FIEP). Yang et al. [5] defined four types of pixel value discrepancies for data concealment in fourpixel blocks. To enhance PSNR, Hong et al. [6] used diamond encoding with pixel value differencing. The embedding capacity of LSB replacement techniques is higher, but the imperceptibility of PVD approaches is higher. PVD and LSB techniques are used to boost hiding capacity and imperceptibility.

(7) and (8)Chen [9] suggested a PVD steganography that randomises the information embedding by employing two reference tables. In a 13-pixel block, Khodaei&Faez [10] developed a hybrid technique that used LSB substitution and PVD. It was definitely expanded to a 22 size block in [11] to get better performance. Adaptive LSB replacement based on pixel value disparities has been done in [12], [13]. During a block, Sahu& Swain [26] presented a steganography approach that combined the LSB and PVD concepts. They stated that their method is impervious to a variety of attacks. Swain [30] introduced a PVD-based approach called quotient value differencing, in which he applied PVD to higher bit planes (QVD). On lower bit planes, he used LSB substitution as well. As a result, concealment capacity has decreased.A static range table is used in traditional PVD steganography processes. As a result, certain unwanted steps appear in the stego-images' pixel difference histograms. Two methods will be used to prevent the step effects: I leveraging the perimeters in several directions, and (ii) employing an adaptive range table. Luo et al. [14] also presented a three-pixel block adaptive PVD steganography that is not affected by step effects. Swain suggested two adaptive PVD steganography algorithms that do not suffer from step effects and use vertical, horizontal, and diagonal edges.pixel blocks of size 22 are used in the first technique, and pixel blocks of size 33 are used in the second technique. Adaptive picture steganography systems have a lesser hiding capacity in general. Some prediction functions will anticipate the perimeters, and

hiding capacity will be determined by this prediction. If we hide in smooth areas, the distortion increases. Adaptive embedding will be used to support the amount of complexity in the sting regions [16]. As a result, capacity will be raised while the risk of detection will be reduced. PVD methods with 33 size pixel blocks were published by Balasubramanian et al. [17] to achieve greater concealing capacity. Multi-directional edges are used in [18] to avoid identification from pixel difference histogram (PDH)analysis.PVD steganography employing eight directions PVD was also proposed by Darabkh et al. [19], which is an expansion of Wu & Tsai's original PVD. PDH analysis should be used to verify a PVD steganography technique that is an extension of Wu and Tsai's PVD approach. To achieve better embedding capacity, Gulve& Joshi [20] employed PVD with LSB in six pixel blocks. LSB substitution was used in one of the six pixels. Then, using the PVD technique, five differences were estimated and supported. Pradhan et al. [27] suggested an adaptive PVD technique that used a 6 pixel block size and used edges in multiple orientations to improve efficacy. Sonar and Swain [28] combined adaptive PVD with the notion of pixel value correlation (PVC), resulting in increased efficacy.Swain and Pradhan [29] proposed a hybrid technique that included adaptive PVD with the correlation notion, as well as ensuring the integrity of the information at the receiver.

Steganography based on modification direction was proposed by Zhang and Wang [21]. (EMD). The most crucial objective is to

use (2n+1)-ary writing to convert a group of secret bits into a digit, where n is the pixel block size. This secret digit can be buried within the pixel block by adding 1 to just one pixel. When adopting this method, the hiding capacity is weak. Using a basis vector, Kim [22] refined the EMD technique. as well as (2n+x 1)-ary writing, where n and x are user-defined variables. PVD and EMD were employed by Shen & Huang [23] to adjust a block's hiding capacity, resulting in a higher hiding capacity and better PSNR. Nguyen et al. [24] used multiple bit planes and a pixel block complexity metric to perform adaptive embedding.In this strategy, high textured sections hide a greater number of bits than low textured regions. The steganography algorithm in [25] generates pseudo random integers that identify the embedding places using a public key and a personal key. Pradhan and his colleagues [33] a combination of EMD and PVD to improve efficacy. In classic PVD, we compute a replacement difference based on the pixel value difference to cover data. We employ the residual of the modulus operation instead of the difference in MF-based PVD. MF PVD with LSB was proposed by Swain [34]. The literature [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [50], [50], [50], [50], [Reversible steganography is defined as the ability to recover the ciphertext and thus the original image from the stego-image. Reversible steganography has a wide range of applications. Reversible approaches provided by Sahu and Swain [39,40] supported the principles of LSB and PVD.In 33 pixel blocks, this work proposes a combination of

modified LSB substitution and eight directional PVD. It has been thoughtfully built in such a way that neither RS nor PDH analysis can discover it. Furthermore, the PVD principle proposed by Wu and Tsai is not used.
detected by PDH analysis. Furthermore Wu & Tsai'sPVD principle isn't used.

II. Proposed System

The embedding algorithm works with pixel blocks of 33 pixels. The blocks are arranged in such a way that they do not overlap. Let's use Fig. 1 to represent a typical block (a). Pc is the central pixel, and q1,q2,q3,q4,q5,q6,q7,q8 are the surrounding pixels. T bit Least Seqficient Bit substitution is used in the centre pixel. The t value for type 1 for 3 and the range table is Table 1. The t value for type 2 is 4, and range table in Table 2.

Table 1. Range table 1 (for type 1)

Range	R1 =[0,7]	R2 =[8,15]	R3 =[16,31]	R4 =[32,63]	R5 =[64,127]	R6 =[128,255]
capacity	3	3	3	3	4	4

Table 2. Range Table 2 (for type 2)

Range	R_1 =[0,7]	R_2 =[8,15]	R_3 =[16,31]	R_4 =[32,63]	R_5 =[64,127]	R_6 =[128,255]
capacity	3	3	4	5	6	6

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After completing t bit LSB substitution inpc, the stego-value is p'c. Assume that the value of t LSB bits in Pcis is decold and that the value of t LSB bits in P′c,Pc′ is dec new. Determine the deviation, dev =decold-

decnew. As illustrated in equation, calculate a modified value of P′c′. (1).

$$P'_c = \begin{cases} P'_c + 2^t, & \text{if dev} > 2^{t-1} \text{ and } 0 \le P'_c + 2^t \le 255 \\ P'_c - 2^t, & \text{if dev} < -2^{t-1} \text{ and } 0 \le P'_c - 2^t \le 255 \\ P'_c, & \text{otherwise} \end{cases} \tag{1}$$

Calculating eight difference values di di for i= 1 to 8 using this adjusted value P′c, as shown in equation (2).

di =|P′c Pi| di =|P′c Pi| di =|P′c Pi| di (2)

One of the six ranges contains the difference value d1. For the range of d1, let's call the lower bound L1 and the concealing capacity t1.

belongs to one of the six ranges. Suppose the lower bound is denoted as L1 and hiding capacity as t1for the range ofd1 . Similarly,L2,L3,L4,L5,L6,L7,L8 are the lower bounds and t2,t3,t4,t5,t6,t7,t8 are the hiding capacities of the ranges of d2,d3,d4,d5,d6,d7 and d8 respectively. Now take t1,t2t3,t4,t5,t6,t7 and t 8 bits of data separately and convert to their decimal values S1,S2,S3,S4,S5,S6,S7 and S8 respectively.

Now for i=1 to 8, calculate new difference values d′i

using equation (3).

d′i=Li+Si(3)

For i = 1 to 8 a pair of new values for eachPi is calculated as in equations (4) and (5).

P''i = P′c - d′i (4)

P'''i = P′c + d′i (5)

Now out of two new values P''i and P'''i , one value is chosen for P′i using equation (6).

$$P'_i = \begin{cases} P'''_i, & \text{if } P''_i < 0 \\ P''_i, & \text{if } P'''_i > 255 \\ P''_i, & \text{if } |P_i - P''_i| < |P_i - P'''_i| \text{ and } P''_i \ge 0 \text{ and } P'''_i \le 255 \\ P'''_i, & \text{otherwise} \end{cases} \tag{6}$$

Thus, the stego-pixel block after hiding t, t1,t2,t3,t4,t5,t6,t7 and t8 bits of data in pixels

Pc,P1,P2,P3,P4,P5,P6,P7and P8 respectively is as shown in Fig.1 (b).

P_1	P_2	P_3
P_4	P_c	P_5
P_6	P_7	P_8

(a)

P'_1	P'_2	P'_3
P'_4	P'_c	P'_5
P'_6	P'_7	P'_8

(b)

Fig.1 (a) original block, (b) stego-block

As with the embedding process, the extraction algorithm works with 33 pixel blocks. The blocks are arranged in such a way that they do not overlap. Figure 1 depicts a typical stego-block (b). P′c should be used to get the t LSBs. Find eight different values for i=1 to 8 as shown in the equation (7).

Each d′i is part of a range with a ti embedding capacity and a Li lower bound. Finding the decimal value of the embedding secret bits stream using equation for i=1 to 8. 8Now convert S_1,S_2,S_3,S_4,S_5,$S_6$$S_7$,$S_8$ and t_1,t_2,t_3,t_4,t_5,t_6 binary bits respectively.

III.Result

In MATLAB, the embedding and extracting techniques are simulated. For testing, standard RGB colour photographs from the SIPI image data base are used. A pixel's R,

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G, and B (each 8 bits) components are considered as a single unit. The results are reviewed and averaged for eight sample photos. Figure 4 depicts the original photos, while Figure 5 depicts type 1 stego images and Figure 6 depicts type 2 stegoimages.Each of these stego-images has seven lakhs (7,00,000) bits of data. I concealing capacity, (ii) bit rate (BPB), (iii) PSNR, and (iv) quality index are the evaluation criteria

(Q). The entire amount of bits that an image can conceal is known as its hiding capacity.
The bits per bytes (BPB) value represents the original image average concealing capacity per byte. PSNR is used to measure stego-image distortion. It is calculated using Equation (9).
Where Pij is a pixel from the cover image and qij is the stego-pixel for that pixel.
Another indicator that measures structural The quality index is the degree of resemblance between the original image and the stego image (Q). Equation is used to calculate it (11). The greatest value of Q is 1 if the original image, p, and the stego-image, q, are the same.
Where q denotes the original image's mean pixel value, q denotes the stego-mean image's pixel value, 2x denotes the original image's standard deviation of pixel values, y 2 denotes the stego-standard image's deviation of pixel values, and xy denotes the covariance between the initial images and the stego-images.
calculate it.

$$PSNR = 10 \times \log_{10} \frac{255 \times 255}{MSE} \qquad (9)$$

Where MSE denotes the mean square error and can be computed using equation (10)

$$MSE = \frac{1}{m \times n} \sum_{i=1}^{m} \sum_{j=1}^{n} (p_{ij} - q_{ij})^2 \qquad (10)$$

Where, Pij is a pixel of cover image and qij is the corresponding stego-pixel.

The quality index (Q) is another parameter to measure the structural similarity between original image and stego image. Equation (11) is used to compute it. The maximum value of Q can be 1, if original image, p and stego-image, q are the same.Q = 4 σxy p̅ q̅(σx

2+ σy 2)[(p̅)2+(q̅)2] (11) Where, p̅ stands for the mean pixel value of the original image, q̅ stands for the mean pixel value of the stego-image, σ 2x stands for the standard deviation of pixel values of original image, σy 2 stands for the standard deviation of pixel values of stego-image, and σxy is the covariance between original image and stego-image. Equations (17), (18), (19),(20), and (21) are used to calculate these values.
p̅=1m×n ∑mi=1 ∑nj=1 pij,
q̅=m1×n∑mi=1∑nj=1qij(12)

$$\bar{p} = \frac{1}{m\times n}\sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij}\, , \; \bar{q} = \frac{1}{m\times n}\sum_{i=1}^{m}\sum_{j=1}^{n} q_{ij} \qquad (12)$$

$$\sigma_x^2 = \frac{1}{m\times n-1} \sum_{i=1}^{m}\sum_{j=1}^{n}(p_{ij}-\bar{p})^2\, , \; \sigma_y^2 = \frac{1}{m\times n-1} \sum_{i=1}^{m}\sum_{j=1}^{n}(q_{ij}-\bar{q})^2 \qquad (13)$$

$$\sigma_{xy} = \frac{1}{m\times n-1}\sum_{i=1}^{m}\sum_{j=1}^{n}(p_{ij}-\bar{p})(q_{ij}-\bar{q}) \qquad (14)$$

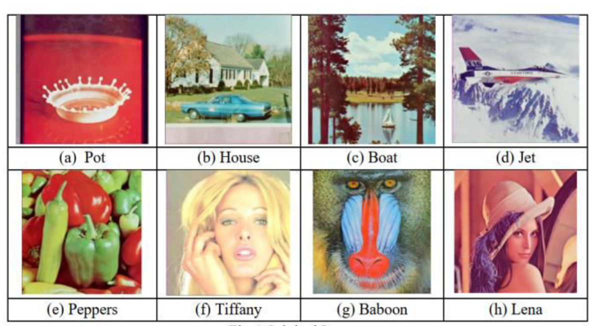

Fig.4 Original Images

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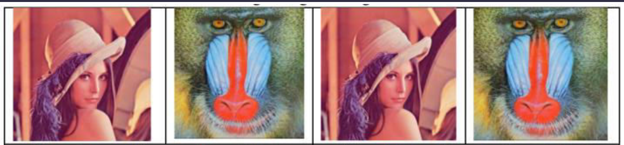


Stego-images of proposed type 1 (t=3, range table 1)	Stego-images of proposed type 2 (t=4, range table 2)

Fig.5 Stego-images of proposed technique

The results of a seven-way PVD [18] technique, which is an extension of Wu and Tsai's [1] method, are shown in Table 3. Table 4 shows the results of Khodaei&Faez's technique [10], whereas Table 5 shows the results of the proposed technique. The proposed technique provides a greater PSNR and capacity than seven-way PVD (both

types 1 and 2). Both the bit rate and the Q have improved. When compared to Khodaei and Faez's technique, the PSNR is not raised, but the hiding capacity is. The proposed technique has a substantial advantage over Khodaei&Faez's technique in that it is not detectable by PDH analysis, but Khodaei&Faez's technique is.

The major advantage over Khodaei&Faez's technique is that the proposed technique is resistant to PDH analysis, but Khodaei&Faez's technique is detectable by PDH analysis. This is made possible by exploiting the edges in eight directions.Now let us observe the results of proposed technique and compare the type 1 and type 2. We can observe that the capacity is higher in type 2 as compared to type 1. This is because of the 4 LSBs substitution in type 2 at the central pixel i.e. the t value is 4. On the other hand, the PSNR of the type 1 is better than that of type2.

Table 3. Results of proposed eight directional PVD technique .

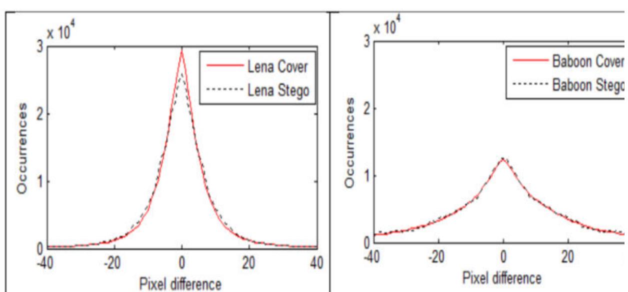
Images 512×512×3	Proposed- type1 (t=3, Range Table 1)				Proposed- type2 (t=4, Range Table 2)			
	PSNR	Capacity	Q	BPB	PSNR	Capacity	Q	BPB
Pot	41.15	2354240	.9996	2.99	37.11	2475977	.9988	3.15
House	39.69	2358575	.9988	3.00	38.39	2625804	.9984	3.34
Boat	37.25	2364685	.9987	3.01	34.08	2659795	.9973	3.38
Jet	42.21	2356828	.9989	3.00	40.38	2538801	.9985	3.23
Peppers	37.81	2356645	.9988	3.00	34.69	2544392	.9975	3.24
Tiffany	41.46	2353505	.9987	2.99	40.53	2511139	.9984	3.19
Baboon	34.26	2392573	.9961	3.04	32.09	2939376	.9937	3.74
Lena	42.62	2353892	.9995	2.99	40.48	2533551	.9992	3.22
Average	**39.55**	2361368	.9986	3.00	37.22	**2603604**	.9977	**3.31**

Table 4. Comparison with existing techniques

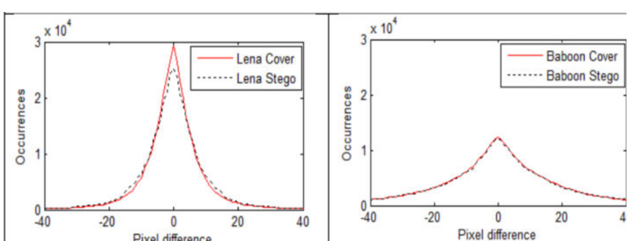
Techniques	PSNR (in dB)	Capacity (in bits)	Q	BPB
Seven-way PVD [18]	39.81	1868551	0.9986	2.37
Seven way+ one way PVD [18]	39.78	1885371	0.9985	2.39
Khodaei & Faez- type1 [10]	40.11	2385386	0.9988	3.03
Khodaei & Faez- type2 [10]	38.57	2466275	0.9984	3.13
Proposed Type 1	39.55	2361368	.9986	3.00
Proposed Type 2	37.22	2603604	.9977	**3.31**

IV.Security Analysis

The LSB substitution techniques suffer from RS analysis and PVD techniques suffer from PDH analysis. The proposed technique uses the concepts, modified LSB substitution and PVD, so it must be analyzed by both RS analysis and PDH analysis. The PDH analysis is performed by calculating the difference value between every pair of pixels. A pair comprises of two consecutive pixels. This difference values are from -255 to +255 including 0. The frequency of every of these difference values is counted. A graph is plotted, with the pixel difference value on X-axis and frequency on Y6 axis. The curve obtained is named because the PDH. The PDH of original image are going to be a smooth curve. If the PDH of stego image is additionally a smooth curve then steganography isn't detected. If the PDH of stego-image shows step effects, then steganography is identifie Fig.7 is that the PDH analysis of type 1 and Fig.8 is that the PDH analysis of type 2 of the proposed technique. The analysis is carried over all the eight test images. for every image the PDH of the first image is represented by solid line And the PDH of the stego-image is represented by line. The solid line curves are going to be obviously freed from step effects as they're of the initial images. The line curves altogether the sixteen cases don't show any step effects. This justifies that the proposed technique is proof against PDH analysis.



Type 1



Type 2

If the stego picture's Pixel Differencing Histogram is also a smooth curve, steganography isn't detected. If the PDH of the stego-image displays step effects, steganography has been detected. The PDH analysis of type 1 using the suggested technique is displayed in Fig.7, and the PDH analysis of type 2 is given in Fig.8. The analysis is performed on all eight test photographs. In each image, the PDH of the first image is represented by a solid line. The image of stego-PDH is shown by lines. The solid lines curve will be devoid of step effects because they are from the beginning photographs. In any of the sixteen situations, there is no step effect in the line curve.

This proves that the proposed method is impervious to PDH analysis.

These four parameters are used in the RS analysis. If Rm R-m >Sm S-m is true, then RS analysis and pvd are unable to detect the steganography approach. However, if R-m - S-m >Rm - Sm is true, the RS analysis is successful in detecting the steganography technique. The proposed technique's RS analysis is shown in Figure 9. RS analysis of Lena and baboon photos of method 1 is shown in Figs. 9(a) and (b). Similarly, RS analysis of the Lena and baboon photos in method 2 is shown in Figs. 9(c) and (d).

$$R_m = \frac{\text{No of blocks satisfying the condition } f(F_1(G)) > f(G)}{\text{Total number of blocks}},\ S_m = \frac{\text{No of blocks satisfying the condition } f(F_1(G)) < f(G)}{\text{Total number of blocks}} \quad (23)$$

$$R_{-m} = \frac{\text{No of blocks satisfying the condition } f(F\_1(G)) > f(G)}{\text{Total number of blocks}},\ S_{-m} = \frac{\text{No of blocks satisfying the condition } f(F_{-1}(G)) < f(G)}{\text{Total number of blocks}} \quad (25)$$

(25).

Fig.9 represents RS analysis for the proposed technique. Figs. 9(a) and (b) stands for RS analysis over Lena & baboon images respectively of type 1. Similarly, Figs. 9(c) and (d) stands for RS analysis over Lena & baboon images respectively of type 2. In all the four cases the condition **Rm≈R−m >Sm≈S−m**

is true, so we can conclude that RS analysis could not detect the proposed technique.

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Because the criteria Rm R-m >Sm S-m is valid in all four situations, we may infer that RS analysis failed to discover the proposed process. The Lena image has more smooth areas, while the Baboon image has more edge regions; the six photos in between are smooth. As a result, establishing a conclusion based on RS analysis using these four elements is sufficient.

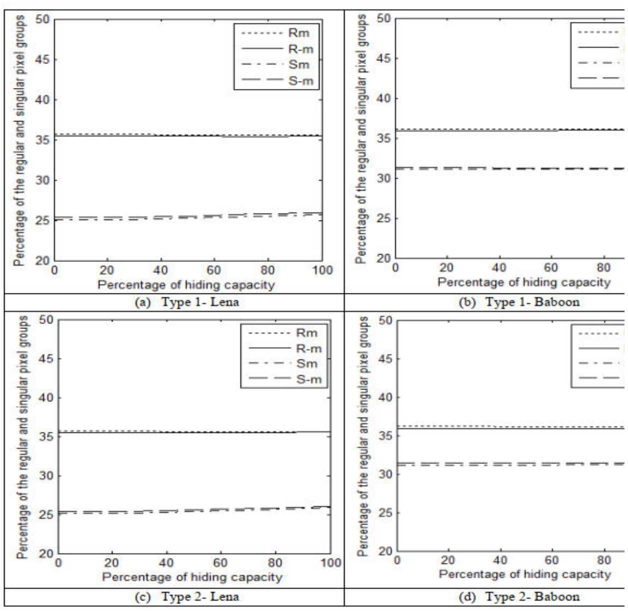
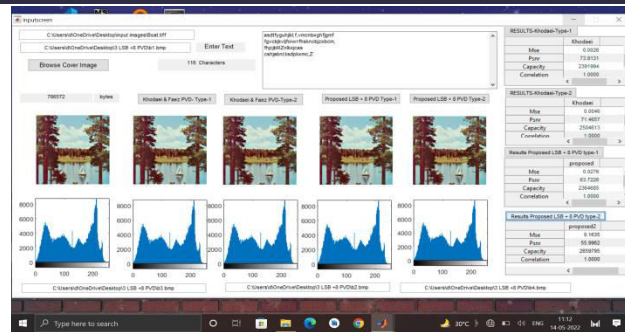
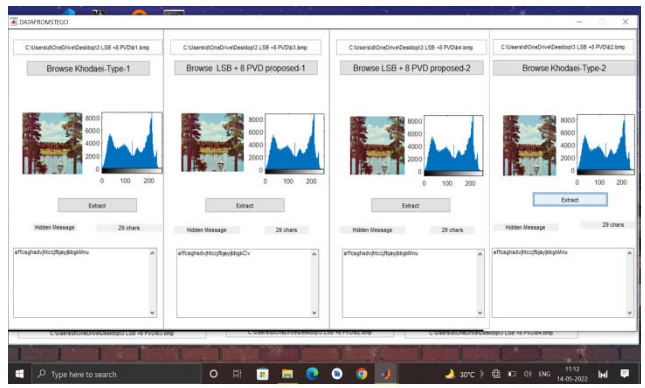


Fig.9 RS Analysis for type 1 and type 2 of the proposed technique

Embedding process



Exacting process



V. Conclusion

A static range table is used in traditional PVD steganography processes. As a result, certain unwanted steps appear in the stego-images' pixel difference histograms. By utilising edges in eight distinct directions, the step effect might be avoided. This research provides a steganography technology that combines Ingenious LSB substitution with eight directional PVD. RS analysis is unable to detect the Least Significant Bits substitution since it occurs in just one pixel out of every nine in a block.. The PDH analysis is unable to detect it since the edges are used in numerous directions. With regard to two different quantization tables, there are two types of the proposed technique. The kind 1 has a higher PSNR, but the type 2 has a greater concealing capacity. This proposed process outperform competing PVD process when utilized to confirm their identification in terms of hiding capabilities and PSNR.

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