IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 18, Issue 3, Ver. IV (May-Jun. 2016), PP 102-109
www.iosrjournals.org

Different Method Used in Pixel Value Differencing Algorithm

Tripti Dhruw[1],Dr. Namita Tiwari[2]
[1](Computer Science and Engineering, MANIT Bhopal (M.P.), India)
[2](Computer Science and Engineering, MANIT Bhopal (M.P.), India)

Abstract: *Steganography is the art of hiding information inside a multimedia. The basic idea is to hide data inside carrier medium such as text, image, audio, video and networks in such a way that attacker cannot detect it. Image steganography is the major part of steganography which is divided into spatial and frequency domains. Pixel value differencing is one of the spatial domain techniques. In this paper, we would review various pixel value differencing steganography techniques and also the changes in these techniques. This paper concludes with the need of better steganography techniques for color images and edge based images.*
Keywords: *Steganography, pixel value differencing , PSNR, modulus function, hiding capacity.*

I. Introduction

The utilization of internet is increasing and the transmission of information through it is also increasing. Therefore the security of that information is also necessary. Encryption is the most effective way to provide security. But during encryption, message is changed therefore it become suspicious and attacker may easily suspect about the presence of confidential information. Steganography is the art of secret communication. Its main objective is to hide the important information in to an innocent media in such a way that no one can extract the information. Different steganographic techniques have been introduced. The spatial domain steganography, the secret data are directly embedded into pixels of cover images. There are several methods of spatial domain (LSB) steganography available such as least significant bit(LSB), pixel value differencing(PVD), Histogram shifting and pixel mapping. The PVD scheme uses the difference value between two consecutive pixels to determine how many secret bits can be embedded. PVD can be classified into basic PVD, PVD with LSB, Multi Directional (MD), Multi-Pixel Differencing (MPD), side matching, and Modulus Function (MF). This paper presents a literature review of PVD methods based on various parameter like hiding capacity, PSNR ratio and steganographic attack. In this paper all the method of pixel value differencing method will be explained with specific factor.

II. Literature Review

PVD method is one of the most important algorithm used for data hiding. This method changes a lot from 2003 to till now. This section represents current literature review of PVD methods based on various parameters.

2.1. Pixel Value Differencing:- In 2003,Wu and Tsai (2003) proposed a data embedding method based on pixel value differencing (PVD). In this method, the difference of two pixels in the cover image is calculated. The number of bits to be embedded into these two pixels is determined by their absolute difference and a pre-defined range table. Since pixel pairs with larger difference are often located in complex regions, PVD embeds more data into pixel pairs with larger differences.

Let us assume pi and pi+1 are two pixel of the considered block then difference d is given by (pi+1-pi). Suppose it lies in the sub range r1 with width w1 then number of bits to be embedded t can calculated by log(w1). The decimal value of t bits of secret data is taken and used to adjust d to get d'. This d' gives us new values pi ' amd pi+1' of pixels pi and pi+1. The embedding is explained using a block of [50,200] in figure below.

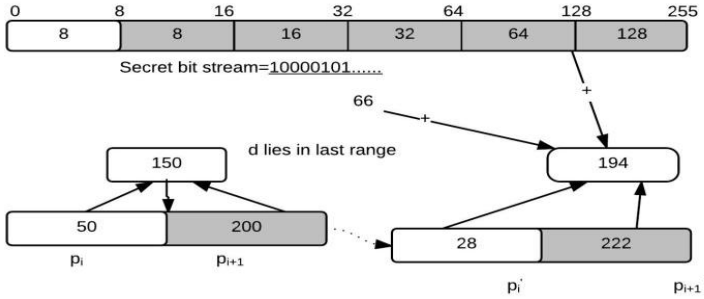

Fig 1 PVD embedding process

However, the PVD method may cause considerable distortion, leading to degradation in image quality. PVD method has been subsequently enhanced and combined with various other popular methods explained below.

2.1.1 Modified PVD approach- Wu et al. proposed this method. The partitioning and difference calculation steps were same as original PVD. The range table was controlled by user into lower division and higher division. If the pixel difference of a block was under higher level then original PVD was used for embedding otherwise 3 bit LSB substitution was employed. This method improved image quality.

2.1.2 Adaptive PVD- Weiqi Luo et al. proposed a secure content adaptive PVD scheme. In this approach, cover image was divided into small squares and rotated by any random angle of 0, 90,180, 270 . The processed image was then divided into non-overlapping embedding units with three consecutive pixels, and the middle one was used foe embedding. The number of embedded bits was dependent on the differences among the three pixels. In order to preserve the local statistical features, the sort order of the three pixel values was kept same after data hiding. Furthermore, the new method first used sharper edge regions for hiding adaptively, while preserving other smoother regions by adjusting a parameter. The experimental results evaluated on a large image database showed that this method achieved much better security as compared to the previous PVD-based methods.

2.1.3 Modulus PVD- Modulus PVD method was proposed by Wang et al. in which modulus function is used for data embedding. The difference of the two pixel block was used to modify the pixel values by applying the modulus process. This tackled the boundary falling off problem. But result of this method is same as original PVD.

2.2 Modified K-bit LSB- In this method k was decided by the range in which the block difference fell. In this method range table were divided into two section: lower and higher (l-h) division and lower, middle and higher(l-m-h) division. The hiding capacity increased from l to h and after the difference was calculated for a block, range was checked and secret data was hidden. Different divisions provide better results in terms of capacity as compared to previous method

2.3 Side Match Method-In order to provide larger embedding capacity and to minimize the distortion of the stego-image, a novel steganographic method using side information was presented by Chin-Chen Chang *, Hsien-Wen Tseng in jan 2004. The proposed method of side match information is most effective in VQ coding based quantization scheme at low bit rate. In this scheme we use the side information of neighboring pixel for each pixel to estimate the capacity. The correlation value determines whether the input pixel is located at edge area or not. The two sided method is used in this proposed method. The three sided and four sided method are also used to estimate the capacity of hiding and embedding. In order to provide more security to stego-image they used DES encryption technique is used to make it more difficult for attackers.

2.4 Method using information of neighbor pixel- In 2005, Park, Kang, Shin and Kwan proposed a steganographic method for digital image using th information of neighboring pixels. To increase the capacity, our scheme decides the number of bits to be inserted into a target pixel are decided by using the difference value between the other two pixels close to the target pixel. When inserting secret data into a target pixel, the modular operation is used to improve the quality of stego image. Therefore the proposed method is more effective than Chang's scheme because it not only provides a good quality stego image but also embeds more secret message. This method provide the accurate judgement for embedding bit of each pixel for both edge area and smooth area. Te time complexity is low because of simple embedding and extracting algorithm.

2.5 PVD with LSB-In 2005, a new steganographic method was proposed which combined both pixel value differencing method and least significant bit replacement method. In this method Firstly, the difference value between two consecutive pixels is calculated. If difference value small then located in smooth area using LSB replacement method and the large one is located in edge area using PVD method. It embed more secret data into edge region then smooth region and has better impage quality by using PVD alone. This method is used to improve the capacity of the hidden data and to provide an imperceptible stego-image quality.

2.6Multi Pixel Differencing:- In previous PVD method only two consecutive pixel were used as a pixel block for data embedding. The multi-pixel differencing is presented by neighboring pixels correlation to estimate the degree of smoothness or contrast of pixels. Various MPD methods are

2.6.1 Tri Pixel Value Differencing-To upgrade the capacity of hidden secret information and to provide an imperceptible stego-image for human visible system, a new approach was introduced in 2008 that uses tri pixel value differencing. In this approach three different directional edges are used to hide more secret data than the PVD method. To reduce the quality distortion of the stego-image an optimal selection approach is presented for the reference point. Experiment results demonstrate that the secret data embedded in the stego image is imperceptible for human vision while compared to the cover image. Furthermore, the proposed approach can achieve superior embedding capacity than the PVD method. After the detection test for the embedded data , the approach demonstrates the robustness to avoid the data detection and survival from dual statistical stego-analysis. the extraction of the embedded secret data can work correctly in stego-images even without the participation of original cover images.

2.6.2 Tri-Way Pixel Value Differencing With LSB Matching Revisited - In 2011 one more steganographic method was proposed which used tri-way pixel value differencing (TPVD) with adaptive LSB matching revisited algorithm for maximizing the embedding rate. According to this method, the LSB of first pixel carries one bit of information and the function of two pixel pair contain another information. The embedding phase of proposed system initializes some parameters, which are used for data preprocessing and region selection, and then the capacity of those selected region is estimated. If region is large enough then data hiding is performed only at some selected regions and it also performed postprocessing is also performed to obtain the stego-image. The side match information is also required for data extraction. Based on side information some preprocessing can be performed and also identifies the region where data in hidden. The absolute difference between two adjacent pixels is the criteria for region selection, and use LSBMR as the data hiding algorithm.

2.6.3 Four pixel differencing method with LSB substitution- Medeni et al. **[7**] proposed a four pixel differencing method with LSB substitution. In this the cover was partitioned into equal blocks of 4×4. After that, for each block M i.e. square root of median was calculated. Then average difference D was calculated. If $D \geq M$, embedding was performed as per MSB‘s. Each pixel was divided into two parts. MSB was checked for number of 1's. For 4 or 3 1‘s _b‘ bits could be embedded in LSB. For two 1‘s 2bits could be embedded. For zero or one 1‘s single bit would be hidden in one LSB. Thus it adaptively decided the number of secret data to be hidden. Also k –bit LSB substitution was used to hide the bits. This method was compared with PVD and established better values of PSNR and greater embedding performance.

2.6.4. Four Pixel Differencing With Modified Lsb- Again, to improve the embedding capacity and provide an unnoticeable visual quality , a new technique based on four pixel differencing and modified LSB was introduced. This method is similar to the multi-pixel differencing method. In this method a four-pixel block with three difference values is used to calculate how many secret bits will be embedded in a block and also used to distinguish between smooth area and edge area. Secret data is hidden into each pixel by the k-bit modified LSB substitution method, where k is decided by the average difference value of a four-pixel block. To extract secret data exactly readjustment of pixel will be executed and also it minimizes the perceptual distortion. This method considers the features of edge sufficiently, so the pixel in edge areas can tolerate much more changes without making noticeable distortion.

2.6.5. Five Pixel Differencing And Lsb Substitution- Gulve et al. proposed a PVD method utilizing 5 pixel blocks and LSB substitution. An average value is calculated and the pixel block is modified using the average value of the number of bits that can be embedded in the block. In this a common pixel is used to hide 3 bits of secret data. The proposed method yields better PSNR values in the range of 40 db .The original image is not required to regenerate the message. This method demonstrates imperceptible stego image even after full capacity embedding. Further in **[17]** they proposed to use PVD for embedding data into the frequency coefficients, thereby performing cross between spatial and frequency domains. It improved upon the robustness of basic PVD with acceptable levels of embedding and imperceptibility.

2.6.6. Nine Pixel Differencing and modified LSB substitution -**Swain [15]** proposed a steganographic technique with nine pixel differencing and modified LSB substitution .The image was partitioned into 3×3 pixel blocks and average difference was calculated using minimum value pixel. This difference could belong to any of the 4 levels viz. lower, lower- middle, higher-middle and higher for which n bit(n=2,3,4,5 respectively) LSB substitution was used. Also two LSB‘s of last pixel in the block were reserved as indicator for data extraction. Comparisons were drawn in terms of PSNR, MSE, embedding capacity and distortion rate between proposed method and Wu et al.‘s[2] method. Proposed method has significantly improved results in most cases.

2.6.7 Multi-Pixel Differencing With LSB -The important requirement in data hiding is that the attacker should not be able to detect the presence of hidden message in the cover image. Data can be hidden in many different ways in cover data. In 2008, Jung, Ha, Yoo proposed a method that yields a high capacity by improving the multi-pixel differencing method and uses the LSB substitution method in the smooth block. The proposed method divided the four pixel sub-block into a smooth block or an edge block. For a smooth block, secret data was hidden into the cover image by the LSB substitution method, while the MPD method was used for an edge block. And for an edge block, pixel values were optimized for minimizing the distance between pixel-pair for each sub-block. To solve the falling-off-boundary problem a new stenographic method was proposed in 2007 by Wang, Wu, Tsai and Hwang in which PVD method is used with modulus function to improve the quality of the image. In this paper a novel scheme was proposed to reduce the visibility of the hiding effect present in PVD method. This method utilized the remainder of the two consecutive pixels to record the information of the secret data which gains more flexibility, capable of deriving the optimal remainder of the two pixels at the least distortion.

2.7 Data Hiding Pixel Value Differencing (DHPVD)- Another data hiding scheme was proposed on 2011 by J.K.Mandal in which pixel value differencing method is applied on digital image. This data hiding scheme is called DHPVD(Data hiding pixel value differencing) . In DHPVD one host image and one hidden image is used. insertion is made by choosing 2*2 mask from the host image in row major order. Firstly the dimension of hidden image is extracted which is then embedded into host image. Two consecutive pixels from 2*2 mask are taken to determine the difference. This difference value may fall into four level lower level(d<=31), middle level 1(31<d<=63), middle level 2(63<d<=127), higher level(d>127). The basic idea of difference expansion isto utilize the high correlation of the cover data. This scheme use color image for secure messege transmission. This paper presents better PSNR ratio then other method used till now. In this method large amount of data can be embedded. It provide better visual quality and tough task for attackers to crack it.

2.8 Lsb Substitution & Pvd- Data hiding method can be implemented in three domains: frequency domain, vector-quantization based domain and spatial domain. In spatial domain data can be embedded directly in pixels of cover image. The spatial domain is basically focused on high embedding capacity but in three different aspect (i)Image quality, (ii) reasonable hiding capacity and (iii) slight distortion in quality of image. In 2011 M. Khodaei and K. Faez proposed a new adaptive steganopraphic method using LSB substitution and pixel value differencing. In this paper they basically focused on spatial domain approach with reasonable hiding capacity. This method has three phases. In the first phase, all possible differences are divided into lower level and higher level with the help of range table. The range table has two levels and five ranges R1=[0,15], R2=[16,31], R3=[32,63], R4=[64,127] and R5=[128,255]. In the second phase, the image is partitioned into some non overlapping blocks containing only 3 successive pixels and the second pixels of each block is selected as the base pixels. Then, k bits of secret data are embedded into k-rightmost LSBs of the base pixel using LSB substitution. After that, the differences of pixel values between the base pixel and other two pixel in each block is calculated and then applied PVD method to embed secret data bits into the two pixels. Optimal pixel adjustment process(OPAP) is also used to improve the quality of the embedded base pixel.

This method is different from other methods because it does not require readjusting phase, duw to which time complexity is low and over-flow problem does not take place. This method is also secure against regular or singular stegananlysis attacks. This method provide better image quality and larger hiding capacity then other method using PVD.

2.9 PVD with Color Image- until 2012, all the data hiding methods that used PVD algorithm were implemented in gray-value image. But in 2012 J.K. Mandal and Debashis Das proposed a method in which color image is used as secret data for data embedding. A color image is composed of red, green and blue components. Each component has range from 0 to 255 in 8 bit representation. So the proposed method called color image steganography is based on pixel value differencing in spatial domain. In this method firstly, each color component is separated from the pixel and three separate matrices are created for each component . Then apply PVD method is applied for data hiding to each matrix. In data embedding process, initially bits are embedded in 1^{st} pixel block of the red component then in first pixel block of green component and lastly in blue component. Sequencing manner is common for all the pixel blocks. If any pixel value exceeds the range(0 to 255) then the bit stream which is to is checked be hidden. If MSB of bit stream is 1 then discard it. And embed one less number of bits. This method gives more security than the original PVD used in gary images and also provides better visual quality of stego-image. This method extracts the hidden secret message efficiently without using the original cover image.

2.10 Predictive differencing- Weng et al. [12] proposed a method based on predictive differencing. In this method, the cover image was scanned in a raster scanned manner. Then using various predictors like horizontal, vertical, PV was calculated. Predictive error was computed as a difference of PV and input pixel. The range in which this lied was checked then embedding was done using k bit substitution. If after embedding PE and NPE were laying in different ranges the output pixel‘s value had to be readjusted. This method has been compared with earlier works of Chang and Tseng‘s two−side−match, Wu and Tsai‘s pixel−value differencing, Hang et al.‘s spatial domain hiding scheme. Comparatively this method has achieved better capacity and stego image quality.

2.11 LSB substitution and PVD algorithm for block based data hiding - In 2013, Yuan et al explore the LSB substitution and PVD algorithm for block based data hiding. The basic idea is opted from the adaptive data hiding technique proposed by Khodaei and Faez .Main purpose of introducing this algorithm is to hide secret data within a block instead of bit stream. This study introduces an adaptive data hiding towards adjustable embedding capacity for grayscale images. The proposed method applies dynamic block subdivision on the cover image to define the flaws present in previous algorithms.

This algorithm consists of three phases: the range division, data embedding and data extraction. The range division phase divides the gray levels [0,255] into five ranges and derives the region’s information. In data extraction phase, the cover image is divided into non overlapping blocks with m*n pixel. In this algorithm 3-LSB substitution and OPAP used to perform data embedding. Here secret data is embedded into the central pixel of each block and subsequently difference between each pixel within block and the data-embedded central pixel is calculated. For data extraction, the stego-image is first divided into non overlapping blocks and then 3-bit secret is derived from the central pixel. After that difference value for each block calculated and located range is obtained. The secret message can be obtained from the distance, which is derived from the calculated difference and the lower bound of the located region.

2.12 Block Based Pvd- From the above explained method Huang et al proposed partition scheme based on pixel value differencing to embed data in gray scale images. The main idea of this method is to find more edge areas so we can hide more secret data. Altering process is used to extract the hiding data correctly. In proposed method cover image is partitioned into adjacent four-pixel blocks. Then for each block, the hiding capacity of both horizontal and vertical mode is calculated and then the partitioning result according to the hiding capacity is decided. and secret data is embedded using Wang, C. M. et al.’s method. After that, new hiding capacity is calculated and if results are same then ll secret data is embedded otherwise same steps are performed again. The main aim of this method is to compare the difference values between the adjacent four pixels and find more edge areas in order to hide more secret data.

2.13 Modified LSB and Modulus function PVD- Swain [15] proposed a steganographic technique with nine pixel differencing and modified LSB substitution .The image was partitioned into 3×3 pixel blocks and average difference was calculated using minimum value pixel. This difference could belong to any of the 4 levels viz. lower, lower- middle, higher-middle and higher for which n bit(n=2,3,4,5 respectively) LSB substitution was used. Also two LSB‘s of last pixel in the block were reserved as indicator for data extraction. Comparisons were drawn in terms of PSNR, MSE, embedding capacity and distortion rate between proposed method and Wu et al.‘s[2] method. Proposed method has significantly improved results in most cases.

2.14 Modified PVD in biomedical- Hayat et al. [18] proposed a stenographic technique for inserting patient‘s data in biomedical images. A region of non interest (RONI) was separated and used to hide data using PVD. As in PVD, blocks were divided but only some were used for embedding. Selection of blocks was based on the threshold value. For secure embedding (7, 4) hamming code was used i.e. 3 secret bits have been hidden in 4 cover bits. The said method have been evaluated using MRI and Ultrasound images as cover at varied levels of threshold values and provided improved payload capacity and achieved PSNR more than 50dB.

2.15 Modified PVD with logistic chaotic map- El-Sayed et al. [19] proposed a modified PVD technique which is secured using logistic chaotic maps. It emphasizes on the security factor by defeating the histogram attack. Also additional security layer is added to make the extraction by unauthorized person more difficult. Here the image is divided into 2×2 block after a zigzag scan. Hereafter the blocks are rotated in either left or right direction. Two parameters: initial condition and control parameter act as the secret keys and provide for enhanced security. The proposed method is compared with Wu Tsai‘s original PVD and it performs better in terms of PSNR and embedding capacity. Also added security against histogram analysis makes comparatively superior. The said method is tested on gray images.

2.16 Chaotic ordering PVD with LSB- R. L. Tataru et al. [20] proposed an adaptive least-significant bit (LSB) approach clubbed with chaotic ordering and pixel-value differencing (PVD) .This was an improvement over Yang et al's method which used modified LSB insertion and PVD to hide data in gray scale images. A chaotic generator was used to assist random embedding in the cover and spread the secret data across the entire region. Yang et al's method has been modified using a chaotic generator.

III. Quality Parameters Of Pixel Value Differencing

The pre and post versions of image are compared on the basis of achieved and desired imperceptibility, robustness and security. The most widely used parameters are explained below

3.1 Mean Square Error (MSE) - It the most common estimation method used to check image fidelity. It takes into account full reference model. It is widely used as it is simple to implement and cheaper in execution. Let us consider two images, x (i, j) and y(i ,j) of M×N dimensions. The MSE is calculated as

$$MSE = \frac{1}{MN}\sum_{i=0}^{M}\sum_{j=0}^{N}\left(x(i,j) - y(i,j)\right)^2$$

3.2 Peak Signal to Noise Ratio (PSNR) - PSNR employs MSE to evaluate image quality and is inversely related to it .It is expressed as the ratio of original image against corrupted image and is measured in terms of logarithmic decibel (dB). Our aim is to achieve higher values of PSNR. Higher values indicate better reconstruction .These do not take into consideration the human visual system. It is calculated as

$$PSNR = 10\log_{10}\left(\frac{2^n - 1}{\sqrt{MSE}}\right) = 10\log_{10}\left(\frac{255^2}{\sqrt{MSE}}\right)$$

3.3 Embedding Capacity - The amount of data that can be inserted in a cover image while maintaining the statistical properties, determines the embedding capacity. Different methods provide different levels of capacity. Also the payload is directly proportional to size of cover image. Generally, if the host image has more smooth regions then lesser data may be hidden. On the other hand, complex images having frequent edge variations which provide comparatively greater insertion capacity. This is generally measured in bits per pixel (BPP).

$$Capacity = \frac{N_{bits}}{C}$$

These are the parameters are used to measure the quality of cover image and stego image after data embedding. These are the important factor for pixel value differencing.

IV. Summary Of Pixel Value Differencing

This section represents the results of various PVD with different parameters. Lena, baboon and peppers each having size 512×512.The comparisons have been drawn by conducting tests on gray scale images. PSNR and embedding capacity have been complied.

S No	Method Name	PSNR Value(dB)				Hiding Capacity (bits/bytes)				Attacks/Comments
		Lena	Baboon	Jet	Pepper	Lena	Baboon	Jet	Pepper	
1	PIXEL VALUE DIFFERENCING	41.79	37.90	40.97	41.73	50960	56291	51243	50685	Dual statistics attacks
2	Modified PVD	36.16	32.63	X	35.34	766040	717848	X	770248	RS Steganalysis
3	Adaptive PVD	37.93	34.84	X	38.78	807256	854096	X	800168	Not tested
4	SIDE MATCH Method	41.22	33.53	X	X	389004	660725	X	X	
5	Neighbor Pixel Method	38.82	34.33	X	X	115898	179255	X	X	
6	PVD with LSB	36.16	32.63	35.01	35.34	95755	89731	96320	96281	RS steganalysis
7	MULTI-PIXEL DIFFERENCING	36.92	X	X	35.90	590518	X	X	594241	

8	Four PIXEL DIFFERENCING WITH MODIFIED LSB	39.57	36.90	X	39.79	810564	903580	X	805492	Trade off between embedding capacity and attack resistance
9	TRI PIXEL VALUE DIFFERENCING	38.89	33.93	38.70	38.50	75836	82407	76352	75579	RS Steganalysis
10	Data Hiding Pixel Value Differencing (DHPVD)	49.44	46.54	X	48.78	X	X	X	X	
11	TRI-WAY PIXEL VALUE DIFFERENCING with LSB matching revisited	X	X	X	X	X	X	X	X	
12	4PVD + modified LSB	33.66	32.02	X	34.06	578716	701580	X	569512	Trade off between embedding capacity and attack resistance
13	LSB SUBSTITUTION & PVD	38.18	36.72	38.05	38.35	791253	810126	792617	789989	RS steganalysis Spam features
14	PVD with Color Image	42.26	38.44	42.60	42.28	145787	144916	145648	145995	Not tested
15	LSB substitution and PVD algorithm for block based data hiding	36.13	31.22	X	33.74	806527	877073	X	804382	
16	BLOCK BASED PVD	43.6	36.7	X	41.6	51574	61728	X	51659	
	Predictive differencing PVD	34.573	29.128	X	33.910	798478	946068	X	798478	Not presented
	Modulus + modified LSb	40.23	39.79	X	40.04	66064	66397	X	65889	Not tested
17	TRI PIXEL VALUE DIFFERENCING	38.89	33.93	38.70	38.50	75836	82407	76352	75579	RS Steganalysis
18	Data Hiding Pixel Value Differencing (DHPVD)	49.44	46.54	X	48.78	X	X	X	X	
19	TRI-WAY PIXEL VALUE DIFFERENCING with LSB matching revisited	X	X	X	X	X	X	X	X	
20	4PVD + modified LSB	33.66	32.02	X	34.06	578716	701580	X	569512	Trade off between embedding capacity and attack resistance
21	LSB SUBSTITUTION & PVD	38.18	36.72	38.05	38.35	791253	810126	792617	789989	RS steganalysis Spam features
22	PVD with Color Image	42.26	38.44	42.60	42.28	145787	144916	145648	145995	Not tested
23	LSB substitution and PVD algorithm for block based data hiding	36.13	31.22	X	33.74	806527	877073	X	804382	
24	BLOCK BASED PVD	43.6	36.7	X	41.6	51574	61728	X	51659	
	Predictive differencing PVD	34.573	29.128	X	33.910	798478	946068	X	798478	Not presented
	Modulus + modified LSb	40.23	39.79	X	40.04	66064	66397	X	65889	Not tested

Table 1. Summary on pixel value differencing

We observe from the above drawn comparisons that as the method flourished with time, more and more data capacity became available. In comparison to simple PVD [1] the capacity has nearly doubled in subsequent techniques. Also these new methods improved the image quality and yield better statistical results be it PSNR or MSE. This means a stego image is quite similar to original image Methods in latter times extended over colour images in addition to grayscale images.

V. Conclusion

PVD methods are the most popular method which were explored by(). It basically follows the theory that the edge areas can endure more changes than smooth areas. This paper presents the improvement of various PVD methods from 2003 to till now. PVD with LSB method provide good results in terms of capacity and PSNR. However, if PVD method is combined with other methods like MP and MPD then it is expected to provide better hiding capacity and PSNR. Since all methods used gray image as a cover media, we can use color image as cover media for data embedding process in PVD method. And if we can able to embed more data at edge area then we can increase the tolerance of steganalysis attacks.

References

[1]. Mamta. Juneja, and Parvinder S. Sandhu, An Analysis of LSB Image Steganography Techniques in Spatial Domain, *Journal of Computer Science and Electronics Engineering (IJCSEE)*,2013

[2]. Da-Chun Wu a, Wen-Hsiang Tsai, A steganographic method for images by pixel-value differencing, *Elsevier*,2003.

[3]. H.-C. Wu, N.-I. Wu, C.-S. Tsai and M.-S. Hwang, ―Image steganographic scheme based on pixel-value differencing and LSB replacement methods‖, *IEE Proceedings-Vision, Image and Signal Processing*, Vol. 152, No. 5,pp.611- 615,2005,doi:10.1049/ip-vis:20059022.

[4]. Weiqi Luo, Fangjun Huang and Jiwu Huang, ―A more secure steganography based on adaptive pixel-value differencing scheme‖, *Springer Science+Business Media*, LLC 2009, doi: 10.1007/s11042-009-0440-3.

[5]. C. M. Wang, N. I. Wu, C. S. Tsai and M. S. Hwang, ―A high quality steganographic method with pixel-value differencing and modulus function‖ ,*The journal of system and software*, Vol. 81, pp. 150-158,2008, doi:10.1016/j.jss.2007.01.049

[6]. Cheng-Hsing Yang, Chi-Yao Weng, Shiuh-Jeng Wang and Hung-Min Sun, ―Adaptive Data Hiding in Edge Areas of Images with Spatial LSB Domain Systems‖, *IEEE Transactions on Information Forensics and Security*, Vol. 3, No. 3,2008,doi: 10.1109/TIFS.2008.926097.

[7]. Chin-Chen Chang , Hsien-Wen Tseng, A steganographic method for digital images using side match, *Elsevier*,2004.

[8]. Young-Ran Park, Hyun-Ho Kang, Sang-Uk Shin, and Ki-Ryong Kwon ,A Steganographic Scheme in Digital Images Using Information of Neighboring Pixels, *Springer-Verlag Berlin Heidelberg* 2005.

[9]. Hsien-Chu Wuz Na-I Wux Chwei-Shyong Tsaiz Min-Shiang Hwang, An Image Steganographic Scheme Based on Pixel-Value Differencing and LSB Replacement Methods, *2004*.

[10]. Ko-Chin Changa, Chien-Ping Changa, Ping S. Huangb, and Te-Ming Tu, A Novel Image Steganographic Method Using Tri-way Pixel-Value Differencing, JOURNAL OF MULTIMEDIA, VOL. 3, NO. 2, JUNE 2008.

[11]. P. Mohan Kumar*a* and K. L. Shanmuganathan, Developing a Secure Image Steganographic System Using TPVD Adaptive LSB Matching Revisited Algorithm for Maximizing the Embedding Rate, *Journal of telecommunication and information technology*, 2011.

[12]. Ki-Hyun Jung, Kyeoung-Ju Ha, Kee-Young Yoo, Image Data Hiding Method Based on Multi-pixel Differencing and LSB Substitution Methods,*IEEE*,2008.

[13]. Xin Liao, Qiao-yan Wen and Jie Zhang,―A steganographic method for digital images with four-pixel differencing and modified LSB substitution‖, *Journal of Visual Communication and Image Representation*, Vol. 22, Iss. 1, pp. 1–8, 2011,doi:10.1016/j.jvcir.2010.08.007

[14]. Avinash K. Gulve and Madhuri S. Joshi**, "**A High Capacity Secured Image Steganography Method with Five Pixel Pair Differencing and LSB Substitution‖, *International Journal of Image, Graphics and Signal Processing*, 2015, doi: 10.5815/ijigsp.2015.05.08 .

[15]. Gandharba Swain, ― Digital Image Steganography using Nine-Pixel Differencing and Modified LSB Substitution‖, *Indian Journal of Science and Technology*, Vol. 7(9),pp. 1448–1454, 2014,doi: 10.17485/ijst/2014/v7i9/49029

[16]. Ki-Hyun Jung, Kyeoung-Ju Ha, Kee-Young Yoo, Image Data Hiding Method Based on Multi-pixel Differencing and LSB Substitution Methods,*IEEE*,2008.

[17]. J. K. Mandal, A. Khamrui, A Data- Hiding Scheme for Digital Image using Pixel Value Differencing (DHPVD), *IEEE*,2011.

[18]. M. Khodaei1 K. Faez, New adaptive steganographic method using least-significant-bit substitution and pixel-value differencing, *IET image processing*, 2011

[19]. J. K. Mandal and Debashis Das, Colour Image Steganography Based on Pixel Value Differencing in Spatial Domain, *IEEE*, 2012.

[20]. C.Y. Weng, H.K. Tso and S.J. Wang, ―Steganographic data hiding in image processing using predictive differencing‖, *Opto-Electronics Review* , Vol. 2 , Iss. 2, pp. 126-133, 2012, doi: 10.2478/s11772−012−0020−3.

[21]. Yuan-Yu Tsai, Jian-Ting Chen, and Chi-Shiang Chan, Exploring LSB Substitution and Pixel-value Differencing for Block-based Adaptive Data Hiding, *IEEE*, 2014.

[22]. Hsiao-Shan Huang*, Chin-Song Wu, Ming-Hsin Chang, and Gan-How Chang, An Image Steganographic Method Based on Block-wise Pixel-Value Differencing, *IEEE*, 2014

[23]. Chung-Ming Wang , Nan-I Wu , Chwei-Shyong Tsai , Min-Shiang Hwang, A hgh quality steganographic method with pixel-value differencing and modulus function, *Elsevier*,2007.

[24]. Hayat Al-Dmour, Ahmed Al-Ani and Hung Nguyen, ―An Efficient Steganography Method for Hiding Patient Confidential Information‖, *36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'14)*, 2014, doi: 10.1109/EMBC.2014.6943569.

[25]. El-Sayed M. El-Alfy and Azzat A. Al-Sadi , ―Improved Pixel Value Differencing Steganography Using Logistic Chaotic Map‖, *International Conference on Innovations in Information Technology (IIT)*, 2012,doi: 10.1109/INNOVATIONS.2012.6207716.

[26]. R. L. Tataru, D. Battikh, S. El Assad and H. Noura O. Deforges , ―Enhanced Adaptive Data Hiding in Spatial LSB Domain by using Chaotic Sequences‖, *Eighth International Conference on Intelligent Information Hiding and Multimedia Signal Processing*, 2012,doi:10.1109/IIH-MSP.2012.26.

[27]. Xin Liao a,⇑ , Qiao-yan Wena, Jie Zhang , A steganographic method for digital images with four-pixel differencing and modified LSB substitution, *Elsevier*, 2010

[28]. Zaidoon Kh. AL-Ani, A.A.Zaidan, B.B.Zaidan and Hamdan.O.Alanazi, Overview:Main fundamentals for steganography, *JOURNAL OF COMPUTING, MARCH 2010.*

[29]. Mehdi Hussain, Ainuddin Wahid Abdul Wahab, Nor Badrul Anuar, Rosli Salleh and Rafidah Md Noor, Pixel value differencing steganography techniques: analysis and open challenge, *ICCE-TW 2015.*