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A Enhancement of Message Capacity Pixel Value Differences (PVD) Steganography Using Filtration

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Abstract

Steganography is a widely used technique for securing confidential information by embedding secret messages into digital media, particularly images, in a manner that is imperceptible to human vision. One of the most effective image-based steganography methods is Pixel Value Difference (PVD), which determines embedding capacity based on the pixel intensity differences within each pair of non-overlapping pixels in a cover image. However, in smooth image regions where pixel differences are small, the embedding capacity becomes limited. To address this limitation, several modifications of the PVD technique have been proposed, mainly by increasing the difference values between adjacent pixels before the embedding process. In this research, a simple and practical enhancement approach is introduced by applying image filtering operations to the cover image prior to message insertion. The proposed method utilizes three commonly used filters, namely blur, emboss, and sharpen, with the objective of altering pixel characteristics so that larger pixel value differences can be generated. These filters are selected because they can modify image texture and edge intensity in different ways, which directly influences the data hiding capacity of the PVD algorithm. Experimental results demonstrate that the application of preprocessing filters can significantly improve the performance of PVD steganography in terms of embedding capacity. Furthermore, despite the increased payload, the visual quality of the stego-image remains acceptable, as indicated by favorable Peak Signal-to-Noise Ratio (PSNR) values. This confirms that the sharpen-based enhancement method can improve data hiding efficiency without causing noticeable image distortion. Therefore, the proposed filtering approach offers a simple yet effective solution for increasing the capacity of PVD steganography while preserving image quality.

Keywords: Algorithm, Filtration, Peak Signal Noise Ratio, Pixel Value Differences, Steganography

I. Introduction

Image processing is often applied to modify visualization of an image. This process will change the pixel's intensity value of an image. One of image processing operation is filtration. The effect will change the pixel's intensity values which owned by an image [1]. In this research, filtration is applied to the cover of

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steganography. The term of cover is used in steganography whose meaning is a media where secret messages are hidden inside it [2], [3] . A cover that has been inserted the message is termed stego image. Steganography applies the techniques to hide the existence of messages in a cover so that they cannot be detected and does not arouse suspicion for unauthorized parties [4], [5], [6]. Steganography is known as a security technique for sending confidential messages. Research shows that steganography with large amounts of message hiding would distort the cover so that the resulting stego image looked suspicious [7], [8]. Therefore steganography requires the right technique to be able to produce a natural stego image and have sufficient message capacity [9].

The improvement of steganography technique was carried out by Wu et al. [10] with the Pixel Value Differences (PVD) technique which divides the cover in blocks of two adjacent pixels that are not overlapping (non-overlapping pixel blocks). Then the difference of each pixel block is calculated. So that the number of message bits to be inserted follows the difference in values of the two pixels. Therefore, the bigger the difference, the bigger the pixel inserted. One way that can be done to change pixel values is to carry out image processing on the image [11]. So it will change the value of the difference between adjacent non-overblocked pixels and will improve PVD performance [12]. Filtration is an image processing process applied in this research. So that found the type of filter that can increase the difference of two pixel blocks on the cover which will also make the capacity of the cover message increase. This research succeeded in applying filters on steganographic covers. The result is a type of sharpen filter and blur gives the greatest influence in increasing the capacity of the message on a cover. Therefore the filter treatment of the cover of steganography becomes an alternative that can be used to increase the capacity of the message in steganography image.

II. Related Work

Image steganography has evolved with various methods to increase message-carrying capacity while preserving image quality [13]. One widely used technique is Pixel Value Differencing (PVD), which utilizes differences in pixel values to determine the number of bits to be embedded. This method is effective because it strikes a balance between message capacity and visual image quality. The development of the PVD method has been approached through various strategies, such as the use of pixel blocks, additional functions to handle overflow, and combinations with other techniques like edge detection. Compared to other methods like LSB and MSB, PVD is considered superior in preserving image quality while offering better embedding capacity. Additionally, adaptive quantization approaches are employed to optimize the method's performance.

On the other hand, image filtering techniques such as blur, sharpen, and emboss can alter pixel intensity values, thereby affecting the differences between pixels [14]. This has the potential to enhance PVD performance in terms of message insertion capacity. However, the direct application of filtering to the PVD method remains limited; therefore, this study proposes applying filtering to the cover image to increase capacity without compromising image quality.

III. Research Method

3.1 Embedded Proces

This research attempts to increase the message capacity that has been achieved using the PVD technique by applying filtration to the cover. Some software, for example: Adobe Photoshop and Gimp, provide several filter features that can be applied to images easily. An image kernel is a small matrix used to apply effects like the ones you might find in Photoshop or Gimp, such as blurring, sharpening, and embossing. In this research, the PVD Steganography process is preceded by applying a filter to the cover. Figure 3 is the steganography technique proposed in this research. The cover is filtered first before inserting the message using the PVD technique, the output of which is a stego image file.

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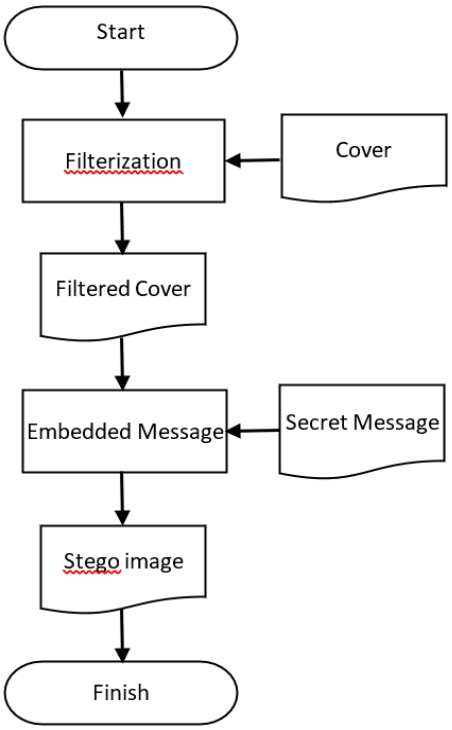

Fig. 1. Flowchart of the proposed technique

There are three types of filters applied, namely: Blur, Emboss, and Sharpen with Gimp software. All filters used are convolutions matrix which is called “kernel” as follows:

Blur:

1	1	1	1	2	1
1	1	1	2	4	2
1	1	1	1	2	1

Sharpen:

-1	-1	-1	0	-1	0
-1	9	-1	-1	5	-1
-1	-1	-1	0	-1	0

Emboss:

-2	-1	0
-1	1	1
0	1	2

Experiments were carried out with four bitmap files as covers and four other bitmap files as messages. Meanwhile, Figure 4 and 5 shows an application that has been previously developed with a Matlab script to perform PVD steganography. The application is also designed with a feature to calculate the number of bits that can be inserted by a cover.

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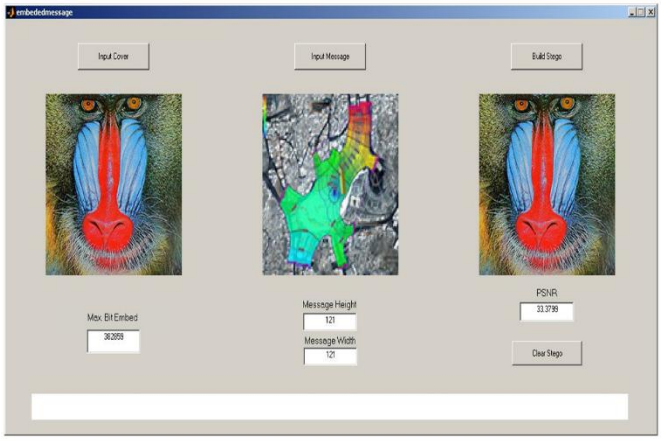

Fig. 2. Screen capture PVD Steganography application.

3.2 Extraction Process

After the stego image file is generated from the message insertion process, the next step is to carry out the message extraction process: extracting the secret message that is stored in the cover. This process is also carried out using the same application used to insert the message, measurements are needed to determine the similarity between the inserted message and the extracted message, which is called the robustness aspect. Except message capacity, the robustness is also the goal of implementing a steganography technique. PSNR (Peak Signal Noise Ratio) measurements are used to measure it.

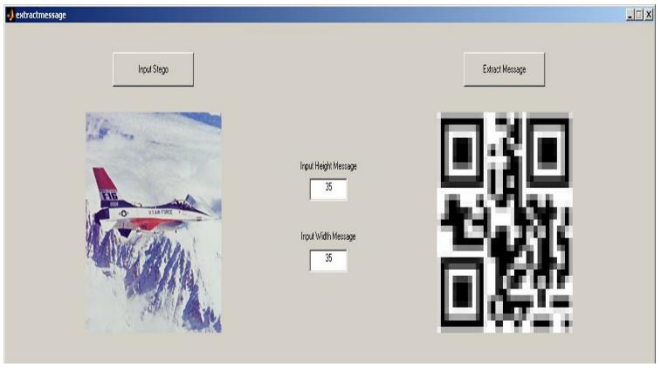

Fig. 3. Screen capture of message extraction from stego image

The cover filtration applied in this research aims to increase the capacity of the message, but in line with this the quality of the cover must be maintained so as not to arouse suspicion. Therefore, PSNR measurements are also a consideration so that it remains within the threshold limit [15].

IV. Result

In this study, four cover image (Airplane.bmp; Baboon.bmp; Fractal.bmp; Pepper.bmp) used in this research is 256x256 pixels with a size of 192 Kilobytes (KB) and a cover of 512x512 pixels with a size of 769 KB. The filters used on the covers are 5 types. The figure 5 shows the screen capture of filtered covers (512x512 pixels) which in the human visual system do not show much difference with the original.

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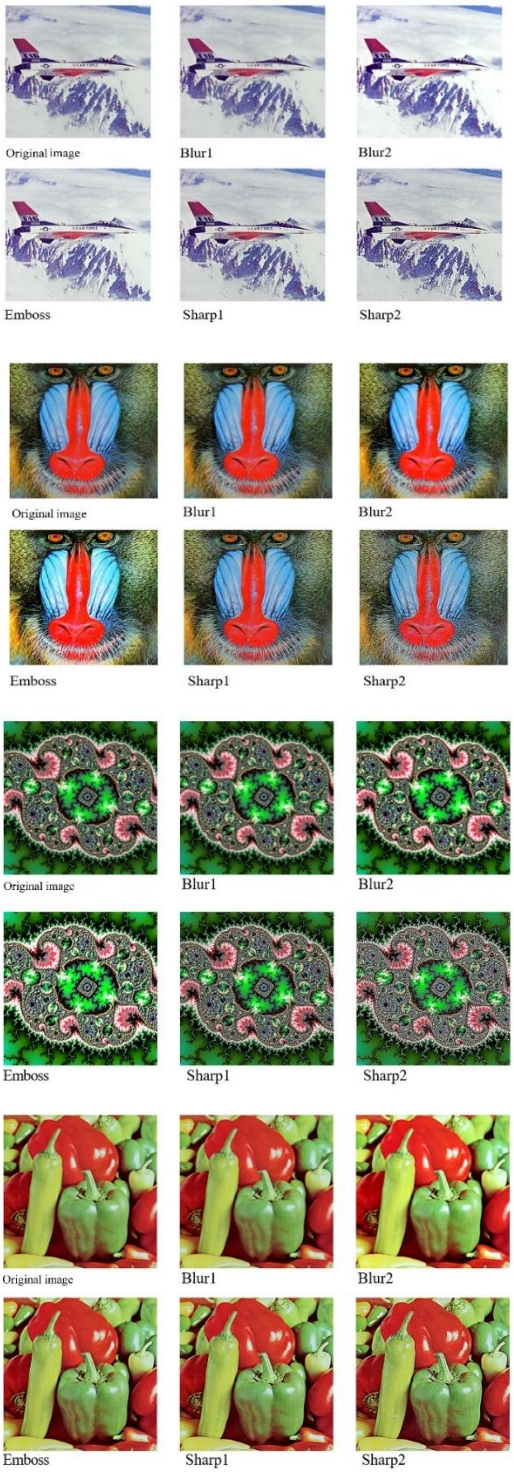

Fig. 4. visualization of filtered image

The first experiment was carried out using a cover size of 256x256 pixels. Sharp1 filter is a type of filter that can increase the message capacity of a cover to the maximum. As on the cover: airplane.bmp the initial capacity of 313905 bits can increase up to 392955 bits, an increase of 79050 bits in accommodating messages. Meanwhile sharpen and emboss filters can increase the message capacity on all four covers. The most is sharp1

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filters. On the 192 KB cover, the average message capacity increased by 4% by using the Sharp1 filter. On the other hand, with the blur filter, the message capacity is decreases. With a larger cover size of 512x512 pixels or a file size of 756 KB, the filter is also able to increase the message capacity by an average of 7%. However, this does not happen with the blur filter. The diagram in figure 6 and 7 shows the message throughput achieved by each filter can increase the capacity of a cover message.

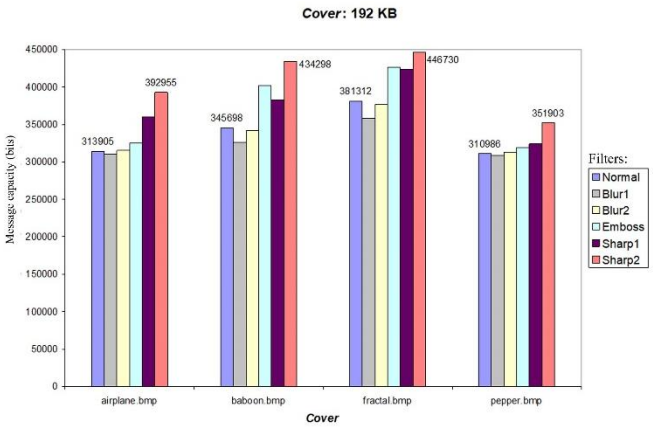

Fig. 5. The message capacity on the cover is 256x256 pixels

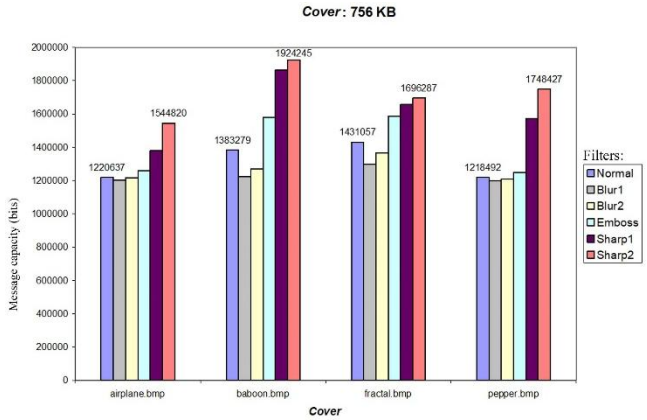

Fig. 6. The message capacity on the cover is 512x512 pixels

V. Conclusion

Based on the results of the discussion and research that has been done, namely implementing one of the image processing operations with the hypothesis that image filtration will affect the difference in the values of two adjacent pixels. This study tries to improve the achievement of PVD steganography, so the study produces several conclusions as follows: 1. Filtration can be used to increase the capacity of the cover message while maintaining the PSNR value above the threshold of 20., 2. The Sharp1 filter is able to increase the largest cover message capacity compared to other types of filters used in this study. However, this is not the case with the blur filter which has decreased. The author acknowledges that research on steganography still needs to be improved, especially PVD steganography. Given this, several aspects are considered for further research: Several types of range tables need to be used to find larger capacities, Algorithm design to speed up processing time, and Pixel values that are out of range need to be addressed by designing an appropriate algorithm.

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REFERENCES

[1] R. Amirtharajan, R. Akila, Deepikachowdavarapu, "A Comparative Analysis of Image Steganography," *International Journal of Computer Applications* , Vols. Volume 2 – No.3, May 2010, pp. 41-47, 2010.

[2] A.K. Sahu, G. Swain, M. Sahu, J. Hemalatha, "Multi-directional block based PVD and modulus function image steganography to avoid FOBP and IEP," *Journal of Information Security and Applications,* vol. 58, 2021.

[3] B. Vishnu, L. V. Namboothiri, S. R. Sajeesh, L. V. Namboothiri, "Enhanced Image Steganography with PVD and Edge Detection," *Proceedings of the Fourth International Conference on Computing Methodologies and Communication (ICCMC 2020),* vol. 4, pp. 827-832, 2020.

[4] A.O. Modupe, A.E. Adedoyin, A.O. Titilayo, F.O. Deborah, "A Comparative Analysis of LSB, MSB and PVD Based Image Steganography," *International Journal of Research and Review* , vol. 8, pp. 373-377, 2021.

[5] A. M. Hambal, Z. Pei, F.L. Ishabailu, "Image Noise Reduction and Filtering Techniques," *International Journal Science and Research,* vol. 6, 2015.

[6] D.C. Wu, Z.N. Shih, "Image Steganography by Pixel-Value Differencing Using General Quantization Ranges," *Computer Modeling in Engineering & Sciences,* vol. 141, pp. 353-382, 2024.

[7] N. Provos & P. Honeyman, "Hide and seek: An introduction to Steganography," *IEEE Security and Privacy,* vol. 1 no. 3, pp. 32-44, 2003.

[8] P. N. Andono. &. D. R. I. M. Setiadi, "Quantization selection based on characteristic of cover image for PVD Steganography to optimize imperceptibility and capacity," *Multimedia Tools and Applications,* p. pages 3561–3580, 2022.

[9] S. A. Laskar, K .Hemachandran "High Capacity data hiding using LSB Steganography and Encryption," *International Journal Database Management Systems,* vol. 4 no. 6, pp. 57-68, 2012.

[10] N. Hamid, A. Yahya, R. B. Ahmad, and O. M. Al-Qershi, "Image steganography techniques: an overview," International Journal Computer Science Security, vol. 6, no. 3, pp. 168–187, 2012.

[11] Z. Liu, G. Li, G. Mercier, Y. He and Q. Pan, "Change Detection in Heterogenous Remote Sensing Images via Homogeneous Pixel Transformation," in IEEE Transactions on Image Processing, vol. 27, no. 4, pp. 1822-1834, April 2018, doi: 10.1109/TIP.2017.2784560.

[12] M. B. O. Medeni and E. M. Souidi, "A novel steganographic method for gray-level images with four-pixel differencing and LSB substitution," 2011 International Conference on Multimedia Computing and Systems, Ouarzazate, Morocco, 2011, pp. 1-4, doi: 10.1109/ICMCS.2011.5945688.

[13] Abdullatif FA, Abdullatif AA & al-Saffar A (2018) Hiding techniques for dynamic encryption text based on corner point. J Physics: Conf Series (Vol. 1003, no. 1, p. 012027). IOP Publishing

[14] Gutub A, Al-Shaarani F (2020) Efficient implementation of multi-image secret hiding based on LSB and DWT steganography comparisons. Arab J Sci Eng 45(4):2631–2644

[15] Cole E. Hiding in Plain Sight Steganography and the Art of Covert Communication. Indiana: Wiley. 2003