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A COMPLETE SURVEY ON WATERMARKING IN HALFTONE IMAGES

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Abstract - This paper reviews various techniques that are available for watermarking in halftone images. Halftone images are two tone images that are generally used in printing and display. It is often necessary to hide data in halftone images such as owner information, creation date and time and possibly information for copyright protection and authentication purposes. This hiding of data is useful in many printing and publishing applications. Due to this need digital watermarking came into existence and became very popular. This paper first discusess the various dithering techniques and then watermarking schemes. Even though there are many techniques like Error Diffusion, Self Toggling, Pair Toggling, Smart Pair Toggling etc which are preferred to embed information in a halftone original image, have their own limitations. This paper also presents the future scope where the resolution and quality of the embedded information is much improved. And also presents the merits and demerits of various existing techniques under Inference section.

Keywords- Halftoning, Digital watermarking, information hiding, Error Diffusion, Toggling.

I. Introduction

Halftoning is the process in which image is represented using dots of varying sizes. The area of the dots is directly proportional to the intensity in the image. Traditional halfoning methods (classical halftoning) has lesser resolution; inorder to increase tha resolution dithering is introduced in halftone images. Dithering is the process of introducing various errors in the images. This results in reduction of spatial integration in our eye thus increasing the display range of perceptible intensities. Different types of dithering techniques are: random dither, ordered dither and error diffusion dither [1], [22]. In random dither technique the errors introduced appears as noise. It will also randomize the quantization noise. For example, if we consider an image, for each value in the image generate a random number from 1 to 255; thus if the value generated is greater than the original value of the image plot that point as white otherwise black. Even though this technique adds a lot of high frequency noise to the image, it is useful in reproduction of low frequency images where the absence of artifacts is more important than noise.

Ordered dithered technique is generally implemented where it is require continuous image of higher color dots with relatively lower depth [16], [18]. It is carried out by applying a threshold map on the each value of the image that is being displayed. The threshold map used is called as Bayer's matrix. The matrix can be generated by first filling the slot with successive values and then rearranging it in such a way that the average distance between two values is as high as possible. Because the algorithm operates on single pixels and has no conditional statements, it is very fast and suitable for real-time transformations. Additionally, because the location of the dithering patterns stays always the same relative to the display frame, it is less prone to jitter than error-diffusion methods, making it suitable for animations. Because the patterns are more repetitive than error-diffusion method, an image with ordered dithering compresses better. Ordered dithering is more suitable for line-art graphics as it will result in straighter lines and fewer anomalies.

In error diffusion technique quantization error is spread over to neighbor pixels. Its main aim is to convert a multilevel image into binary image. Unlike other methods, in this technique operation at one location affects its neighboring areas and buffering is required. The algorithm used for this is called as Floyd and Steinberg algorithm, named after the scientists who discovered it [1], [13].

II. Watermarking In Halftone Images

In this rapid growing world, people are more into discovering new things. In this process, a no of unauthorized and unofficial techniques have been developed and devised to crack and access data [14]. As a result data has become less private. In this scenario protection of data is very much necessary. This data can be a video, speech, text, image etc. here in this paper we concentrate on image protection. To protect image we should know about the various types of images. One of the most effective types of images known is a halftone image. Halftone is the reprographic technique that simulates continuous tone imagery through the use of dots, varying either in size or in spacing, thus generating a gradient-like effect. With this technique one can represent the picture with reduced size without losing the outline content of the image. Now to protect this image we can go with several protection techniques available. The most common, and possibly strongest, image protection technique is to place a visual copyright watermark on the image. Image watermarks come in a range of styles: from a full copyright symbol across the image to simply small text in the corner of an image containing the copyright symbol,

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date, and name of the copyright holder [21], [20]. There is a trade off with watermark size: the larger the watermark the less likely one is to download or steal the image, but the larger the watermark the more of a visual distraction it becomes.

III. Existing Algorithms

In 2002, Ming Sun Fu et. al proposed the technique called self toggling. In this technique one halftone pixel is used to store one bit data, and an N data bits are added at N pseudo random location by forced toggling. Thus if the value at particular location in the image is deviating from original value is toggled. As a result a series of pixels of same color some black and white, which are visually very disturbing. The set of black and white dots is called as the "salt and pepper artifacts". This is called self toggling because only one pixel is toggled. It is considered as advantageous because it is very simple. This process requires random generator and error correction coding. It's not preferred because of low perceptual quality and the problem of image alignment during decoding [2], [12]. In the same paper author also explained about a technique called pair toggling, in which instead of toggling one pixel value, a complementary pair of pixels is toggled when ever toggling is needed. The complementary pixel is generally chosen from its 3x3 neighborhood is toggled. Although two values are toggled and thus two errors are introduced the complementary errors tends to cancel each other, thus protecting its local intensity and reducing salt and pepper artifacts. It is more complex than self toggling because two values have to be changed.

The author also mentioned about the technique called smart pair toggling, this technique improves over pair toggling because of its smart technique to choose the complementary location that is to be toggled. A quantity called connection is calculated [12] for complementary pair and the one which is largest is chosen before toggling. The neighboring pixels that are connected before toggling goes unconnected after toggling hence reduce the formation of clusters and thus reduce the artifacts increasing the visual quality. The computation of this technique is more complex than pair toggling and self toggling.Researcher also proposed another efficient technique called error diffusion. In this technique self toggling is first applied and then modified using normal error diffusion method [2]. But the complexity of this method is very high.The author also explained about the modified error diffusion process. Even though there is good visual quality in error diffusion still there are some more artifacts. These can be reduced using this technique. Here in this DHST (Data Hiding and Self Toggling) is normally performed on the image but the error diffusion process varies. Here the error diffusion is applied to future values rather than the past values as in DHED (Data Hiding and Error Diffusion) [2]. It is more complex than DHED. But DHED and MDHED (Modified Data Hiding and Error Diffusion) can be carried out even when the original image is not available.

In 2005, Soo-Chang Pei et. al proposed a technique called paired sub matching ordered dithering. This technique includes bit intervealing process. Bit intervealing is the process that gathers all the pixels of same threshold value and puts together to construct the image. Then sub image intervealing is done by dividing the picture into sub images and thus pairing them. This not only increases the quality but also reduces the noise [3].

In 2006, Jeng-Shyang Pan et. al discussed a lossless watermarking scheme.in this technique the has sequence is embedded as a fragile watermark. To know about the restored image we should compare the hash sequence of restored image with the original image.if there are same there is no alteration in the image.here in this technique no information is stored unless the secrect key [4].

In 2013, Liu Ping Feng et. Al proposed a technique for watermarking using phase modulation. The watermarking and original is mixed by rotating at various screen angles. Mean filtering and median filtering is carried out that improve the appearance, and further pre-processing of watermarking is done using Arnold transformation to eliminate the edges in the border ofthe watermark [15].

In 2015, Jing Ming Juo et.al explained about Watermarking for position mapping based halftoning. In this paper the technique proposed by the author requires less computation and it's more efficient to provide security to the information embedded. The encoder in this technique consists of a reference table that is generated using EDBS (efficient direct binary search) which ensures that the generated image is a halftone image. And also a number of optimized compressive tables with various texture angles are established for the subsequent look up table. LMS in decoder enlarges the differences that exist between phenotypes of the embedded angles and also the required no of dimensions for each angle. And at last naive Bayer classifier is used to collect the possible information for each angle. using this navie bayer classifier helps us to improve CDR [5].This paper mainly focuses about embedding a multi-scale image in the given host image without compromising in quality and also the storage space required for the resultant image is also very less. This is more efficient because it reduces the processing of the application as size is comparatively reduced when compared to other techniques [5].

In 2016, Pedro Garcia Freitas et.al projected a technique for hiding color images into original image [19]. It is a technique through which one can embed a color water mark into a black and white image. In order to maintain the quality of the image, this method uses

homogeneous dot patterns to embed an image and these patterns have a different binary texture arrangement. To reduce the associated noise with the halftone image maximization problem is solved that prevents image from degradation. This maximization problem's objective is to measure the similarity between original half tone image and a set of randomly generated patterns. But this optimized problem has to be solved for each dot in a halftone image, thus increase the processing speed. So in order to reduce the processing speed parallel processing is introduced. This method is advantageous because there is no color restriction and also has higher embedding capacity when compared with other existing techniques. Moreover the computation speed is also less because of the parallel processing [17]. Future works include implementing the proposed algorithms with multiple GPUs and additional CUDA cores. Architectures with distributed memory can also be used to exploit the parallelism of the problem [6].

In 2016, Yuanfang Guo et.al illustrated about the halftoning processes on theoretical basis. A general optimization framework for Halftone Visual Watermarking (HVW), which is a certain category of halftone image watermarking technique, is proposed. Then two specific HVW problems, Single-sided Embedding Error Diffusion (SEED) and Double sided Embedding Error Diffusion (DEED) are presented and solved by applying the proposed framework. Data Hiding by Conjugate Error Diffusion (DHCED) and Data Hiding by Dual Conjugate Error Diffusion (DHDCED) are special cases of SEED and DEED respectively that are further implemented in this paper [7].

In 2016, Wang et.al described about an approach called DBS (Direct Binary Search). This method tries to minimize the mean squared error between the original continuous image and halftone image. This method is very flexible and efficient too. But to detect the water marking original continuous tone image is still required which is major drawback for this method. Here the image is divided into three sets one for embedding the other for synchronization and one more for complementary set. All the pixel pairs in embedded set are correlated according to embedded bits and all pixels used for synchronization are assumed to be black. During pixel by pixel scanning the error between original and halftone is minimized by changing the values in complementary set (here two methods are used: toggle and swap& pair toggle).Thus this process is iteratively repeated until no trail change are accepted during complete pass through the image [8].

In 2017, Po-Chyi Su et.al discussed about a new secret sharing scheme in halftone images based on multi scale error diffusion. During the transformation of several gray-level images to halftone ones, a secret halftone image is embedded in these images by controlling the number of white dots in each position. The modified MED sees that the resultant pixels satisfy the conditions required, so that when retraced back can obtain the embedded information correctly. This method can be considered as more efficient as it sees the error free transmission and also at the same timing maintaining the quality of the image [9].

In 2017, Yung-Yao C et.al suggested an efficient way to embed a large amount of information through watermarking. ET (embedded toggle) is used to embed information at particular location of the host image. While this technique has a disadvantage of poor image quality and knowledge of toggled positions. So this can be overcome by random toggle to embed information and further shifting the position of the toggled ones that enhances the image quality. Furthermore a technique called SOBB (Swap-Only Block-Based) is also proposed in this paper. This strategy when mixed with DBS can improve the image quality [10].

IV. Inferences Drawn From Survey

The pros and cons of few halftoning schemes are tabulated from the above technical survey as shown in table 1.

Table 1: Pros & Cons of existing halftone watermarking schemes

Technique used	advantages	disadvantages
Self Toggling	Simple to construct	Low perceptual noise and problem of image alignment
Pair toggling	More complex in construction when compared to self toggling	Reduced artifacts
Smart pair toggling	Computation is more when compared to self and pair toggling	Much improved technique that reduces noise and artifacts
Error diffusion	Increased quality	Few artifacts
Paired submatching orederd dithering	Increased quality and reduced noise	Not efficient
Loss less watermarking scheme	Efficient	Secrect key has to be stored to recover the image
Position mapping based halftoning	Less computation required and more security	-
DBS	Flexible and efficient	Requires original image to recover

		watermarking

V. Performance Metrics

In some of papers, which are referred by different authors used few parameters to compare the results and thus derive a conclusion out of the experiments conducted by them. They are PSNR (Peak Signal to Noise ratio). It is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Another parameter used by the writers is MPSNR (Modified peak signal to noise ratio). It is the PSNR between the original multitone image and the lowpass filtered halftone images. CDR (Correct Decode Rate), it is also another important parameter mentioned by researches which gives the effieciency of information decoded.

$$\text{CDR} = \frac{\sum_{m^l=1}^{M}\sum_{n^l 1}^{N} w^t_{m^l,n^l} \Theta w^{rt}_{m^l,n^l}}{M \times N} \times 100\%$$

Θ indicates XOR operation and $w^t_{m^l,n^l}$ and

$w^{rt}_{m^l,n^l}$ denotes original and decoded watermark images.

VI. Conclusion

In this paper, a complete review on various existing techniques of watermarking in halftone images is given. There are many existing techniques in which watermarks can be embedded into halftone image and can be restored without any loss. Nowadays still researchers are working to improve the image quality after embedding the watermark into an original halftone image. They also trying to reduce the size and time required for processing the watermarked image, so that the watermarked image can be well fitted in printing process. From the survey it has been observed that there is lot of scope to improve the efficiency of watermarking algorithms to work upon the issues faced during watermarking that is color printing issue and alignment issue through which the quality of an image can be improved and thus make watermarked halftone image more attractive and clear.

References

[1] Thomas Funkhouser, "Image Quantization, Halftoning, and Dithering", Princeton University C0S 426, Fall 2000.

[2] Ming Sun Fu and Oscar C Au, "data hiding water marking for halftone images", IEEE transactions on image processing, vol. 11, no. 4, 2002.

[3] Soo-Chang Pei, Jing-Ming Guo and Hua Lee, "Novel Robust Watermarking Technique in Dithering Halftone Images", IEEE signal processing letters, vol. 12, no. 4, 2005.

[4] Jeng-Shyang Pan, Hao Luo and Zhe-Ming Lu, "A Lossless Watermarking Scheme for Halftone Image Authentication", IJCSNS International Journal of Computer Science and Network Security, VOL.6 No.2B, 2006.

[5] Jing-ming guo, Guo-Hung lai, Kokshik Wong and Li Chung chang, "progressive halftone watermarking using multi-layer table lookup strategy", IEEE Transactions on Image Processing, 2013.

[6] Pedro Garcia Freitas, Mylene C.Q.Farias and Aleteia P.F.Araujo, "Hiding color watermarks in halftone images using maximum- similarity binary patterns", ISRME, 2015.

[7] YuanfangGuo, Oscar C.Ac, JiantaoZhou, KetanTang and XiaopengFan, "Halftone image watermarking via optimization", IEEE transactions on image processing, 2015.

[8] Fuping Wang and Jan P.Allebach, "printed image watermarking using direct binary search halftoning", ICIP, 2016.

[9] Po-Chyi Su,Tzung-Fu Tsai and Yu-Chien Chien, " Visual secret sharing in halftone images by multi-scale error diffusion", Springer, 2017.

[10] Yung-Yao Chen and Wei-Sheng Chen, "High-quality blind watermarking in halftones using random toggle approach", Springer, 2017.

[11] Farisa M.Y and D. Gnana Jebadas, "halftone image multilayer watermarking using look up table", International Journal of Engineering Science and Computing, 2016.

[12] Ming Sun Fu and Oscar C Au, "improved halftone image data hiding with intensity selection", IEEE, 2001.

[13] Ming Sun Fu and Oscar C. Au, "A Robust Public Watermark for Halftone Images", IEEE, 2002.

[14] Zifen He and Yinhui Zhang, "watermarking hiding in haltoning images", ISRME, 2015.

[15] Liu Ping Feng, Ai Hua Wen and Ya Li Qi, "clustered dot halftone watermark using phase modulation", Applied Mechanics and Materials Vols 416-417 (2013) pp 1205-1209, 2013.

[16] Satvik Sachdev, Aparna Nayak and Tribikram Pradhan, " Data Hiding in Halftone Images using Mathematical Morphology and Conjugate Ordered Dithering", IEEE 2014.

[17] GUO Qian, CHEN Guangxue, LUO Jian, CHEN Qifeng and HE Zhengguo, "A Hybrid SVD-DCT Watermarking Method Used for Halftone Image",

Applied Mechanics and Materials, Vols. 644-650 (2014), pp. 4473-4476, 2014.

[18] Chao-Ting Su and Hsi-Chun Wang, "Self-authentication watermark by digital halftoning", ICCST, 2015.

[19] Pedro Garcia Freitas, Mylene C.Q. Farias and Aleteia P. F. de Arajuo, " Embedding Color Watermarks into Halftoning Images using Minimum-Distance Binary Pattern", SIBGRAPI Conference on Graphics, Patterns and Images, 2015.

[20] Donald E .knuth, "digital halftones by dot diffusion", standsford university, 1987.

[21] Yun-Fu Liu and Jing-Ming Guo, "Dot-Diffused Halftoning with Improved Homogeneity", 2015.

[22] Jing-Ming Guo and Jyun-Hao Huang, " Data Hiding in Halftone Images with Secret-Shared Dot Diffusion", Taiwan university, 2010.