

Anti-Counterfeit Technology of Halftone Image Watermarking by Digital Screening

Qifeng Chen, Guangxue Chen*, Shuangshuang Wen, Jinglei Tai

State Key Lab of Pulp & Paper Engineering, Guangdong Province, South China University of Technology, China

*Corresponding author, e-mail: guangxuech@yahoo.com.cn

Abstract

From the point of view of the digital printing, this paper focused on researching the anti-counterfeit print technology of halftone images and directly detecting techniques combined with digital image processing technology, thereby enhancing the security features of the printed mater. The grating has converged effect on light in the corresponding direction, which makes it compress and isolate images. According to this feature of grating, the variable angle algorithm of screening anti-counterfeit technology was proposed, and in accordance with the algorithm, the experiment of grating extracting the watermarking of halftone image was studied in this paper. In this experiment, we designed other screening angles to hide the information, we called it the variable angle screening security technology. When detecting the hidden information, only at the same angle could we observe the security effect with corresponding lines of the grating. The experimental results showed that the variable angle algorithm of screening anti-counterfeit technology had nice security effect, and could be used in practical application.

Keywords: halftone image, digital screening, digital watermarking, anti-counterfeit

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1. Introduction

Through the printing process, digital image is the best carrier to save the anti-counterfeit information. Then a special mark, the digital watermark, came into being. It can hide the information, which can distinguish the authenticity from the false embedded into digital image. It can also guarantee the information integrity and reliability by detecting and analyzing. It gets a nice security effect. Anti-counterfeit print technology of halftone image is based on digital image transmission. Compared with other anti-counterfeit technologies like RFID and Dongle, it costs very little and it has a nice security effect [1]. The digital watermark technology plays an important role in digital copyright protection and communication security areas [2]. Academic institutions and enterprise have studied a lot, but it isn't enough. From the appearance of printing press, halftone image is the important route of information transmission. It widely used in advertising, newspapers, magazines, packing, currency, notes and other areas, halftone image is of great value and amount. Halftone image anti-counterfeit is an effective way, which costs little besides the cost of anti-counterfeit material [3].

We hide the information, such as images, words, codes, etc. into the printing image by embedding watermark, and we cannot change the printing image visual effects. Figure 1 shows the embedding watermark procedure of halftone image watermark technology, which is similar with the general digital image watermark technology [4].

In the digital screening process, a halftone image is produced by digital screening algorithm from a continuous digital image, which greatly affects and even destroys the hidden watermark information. In the printing and storage section, paper, cloth, plastic and other print substrates may be deformed and fuzzy. After printing and scanning process, the graphic geometry and tone of images on the substrates may be changed, which greatly influent the extraction of hidden information quality. In order to avoid the limit above, this study focused on researching the anti-counterfeit print technology of halftone images and directly detecting techniques. In this paper, we improved the algorithm and enhanced the security performance through researching the super performance information hiding technology, and finally applied it into the grating anti-counterfeit technology. It will provide the research thought for digital printing screening, and play a positive role in digital image anti-counterfeit technology.

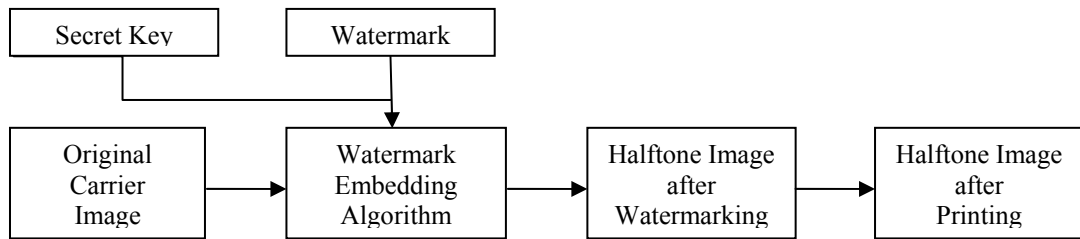


Figure 1. Embedding Watermark Procedure

With the development of digital information, the protection of digital image becomes more and more important. As one of the digital image method, digital watermark technology embeds the hidden information into digital image, and gets it after transmission, compressing and being malicious attacks to distinguish the true from the false. In the digital printing process, the digital image may pass a halftone process before turning into the print one as it shows in Figure 2. So we call the digital watermark technology for printing image as halftone process [5].

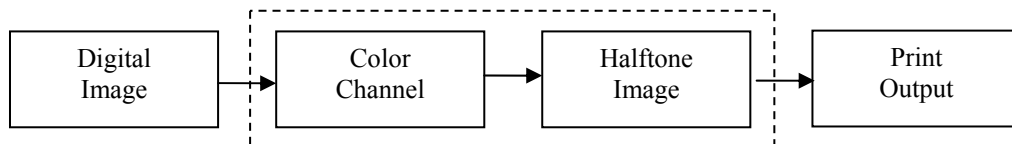


Figure 2. The Flow Chart of Digital Printing Process

In the digital screening process, a halftone image is produced by digital screening algorithm from a continuous digital image, which greatly affects and even destroys the hidden watermark information. Previous had studied a lot about halftone digital watermark technology [6-8]. And they provided many halftone digital watermark technology algorithms. According to the watermark embedding methods, it can be divided into space domain watermarking and transform domain watermarking, this study is about the space domain watermarking based on the Moiré fringe. Moiré fringe is the interference visual outcome of two lines or objects with fixed angle and frequency. When eyes cannot tell the two lines or objects, they see the interference fringe, which calls Moiré fringe in optical. In printing industry, Moiré fringe is called Moiré, which should not occur in printing image. Moiré fringe has a nice security effect on anti-counterfeit printed matter. It can form through multiple printing. It can also be observed under the magnifier with some decoding tool after once printing. It can have a better security effect by using the decoding tool and special professional design to change the Moiré fringe on printed matter.

The experiment used the grating watermark halftone security technology as well as the optical interference. When the grating plate covers the printed matter, the column lens grating lines interfere with the discontinuity dots, and Moiré fringe forms. Only when the direction of outlets lines the same as the column lens grating ones, can not form Moiré fringe. So we hide the watermark information in these dots, in order to use it in the security of printed matter. We call this detecting method the grating watermark halftone security technology for its using of grating extraction.

2. Research Method

Using the light refraction of grating, the optical path of the image formal dots and the hidden information dots will separate. This will make the difference between the hidden information dots and the image formal dots, so the hidden information will appear. In the practical application, setting the dots of halftone image regularly can embed information in halftone image, which will have an anti-counterfeit effect [9].

2.1. Improved Halftone Image Watermarking Data Hiding Algorithm

In this experiment, we can design other screening angles to hide the information, we call it the variable angle screening security technology. When detecting the hidden information, only at the same angle can we observe the security effect with corresponding lines of the grating. Therefore, screening angle design is the core of variable angle screening security technology. Firstly, we illustrate the variable angle screening security technology according to traditional screening angle. The data hiding algorithm based on correlation error diffusion (DHCED) algorithm considers pixels transformed artificial texture noise when it embeds watermark into two or multiple halftone images, so it can improve the quality of watermarking halftone images [10, 11].

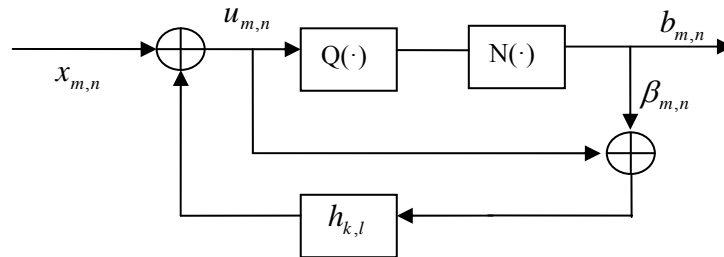


Figure 3. The Algorithm Structure of DHCED

The DHSED algorithm provides the original continuous grayscale images as X , X uses standard error diffusion method to generate the halftone image as Y_0 (See from the Figure 3). The embedded binary image must be the same size as the continuous tone image, if the binary image is smaller than the continuous tone image, we may fill binary images by white filled to obtain the same size image. We can calculate the black areas H_B, Y_B of the halftone image Y_0 , the white areas H_W, Y_W , of the halftone image Y_0 , the embedded binary image H . At the same position, when the pixel values of halftone image Y_0 and embedded binary image H are same as white or black, the raw grayscale image X is still passed using a standard error diffusion method; When the pixel values of halftone image Y_0 and embedded binary image H are different, we will use the error diffusion Equation(1):

$$\begin{aligned} x'_{m,n} &= x_{m,n} + \Delta x_{m,n} \\ u'_{m,n} &= x'_{m,n} + \sum h_{k,j} e_{m-k,n-j} = u_{m,n} + \Delta x_{m,n} \\ b'_{m,n} &= Q(u'_{m,n}) = Q(u_{m,n}) + \Delta x_{m,n} \end{aligned} \quad (1)$$

In the DHCED, if $|\Delta x_{m,n}| < T_1$, T_1 is an appropriate threshold, The parameter T_1 gives the balance on the visual quality, T_1 is the greater, the original image pixels of the hidden watermark image are more, but T_1 is too large, it will generate poor image effect [12, 13].

2.2. Experimental Principles and Methods

As Figure 4 shows, (a) is an image, whose gray scale is uniform. The image can be divided into different digitals, characters and Figures, which can become the watermark image while others become the background. The watermark of image is the number "2". The screening angle of watermark image and background image are different. As (b) and (c) shows, the screening angle of watermark image is 45° , while the one of background image is 18.4° . Then put (b) and (c) together, (d) with watermark image is formed. The gray scale of (d) is still 200. In the embedded image (d), the boundary of the watermark image and the background image is very tidy compared with the variable angle screening security technology. Eyes cannot distinguish the differences between the watermark image and the original one. So the concealment of watermark is guaranteed.

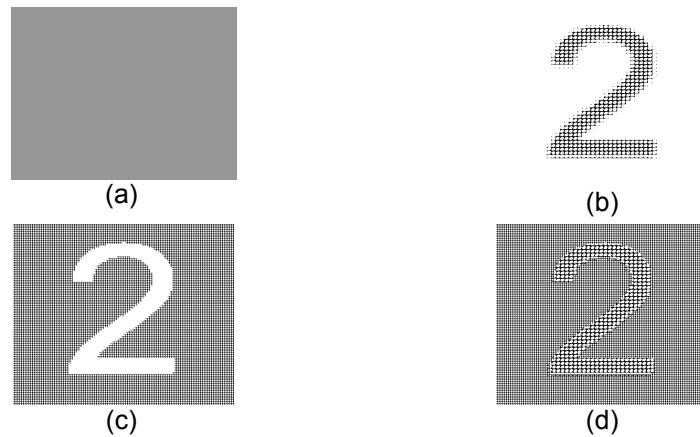


Figure 4. (a) The Uniform Image (b) Watermark Image (c) Background Image (d) The Embedded Image

Using the principle of minimum threshold matrix can achieve the changing of screening angle of FM screening. As Figure 5 shows, set screening angle as θ , then $\tan \theta = \frac{a}{b} = \frac{mp}{mq}$, m , p and q as integer, p and q are co-prime to each other. The grid number $N = a^2 + b^2$, then $L = \frac{1}{m}(a^2 + b^2) = m(p^2 + q^2)$, $K = m$. The $L \times K$ rectangular forms the basic unit of threshold matrix, which called the minimum threshold matrix. The variable angle screening can be realized according to certain rules of distribution threshold.

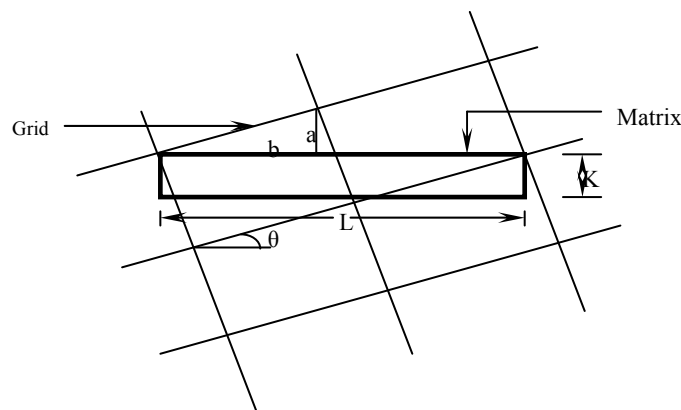


Figure 5. The Sketch of Minimum Threshold Matrix Theory

After determining the threshold matrix, the shape and property of the dots will be influenced, while the area ratio will not. The area ratio is dependent on the pixel value of the gray scale of the original image. The AM dots are point state, start from one dot of the grid, distribute according to the request of dots shape in the increasing or decreasing rules. Dots grow gradually with the pixel value of the original image, and form the aggregate state AM screening. The dot can start from the middle of the grid. It can also start from the corner. The gather of the four grids is called the center of the grid. The research of this paper starts from the corner, and the design of the threshold matrix is based on the spiral growth method [9].

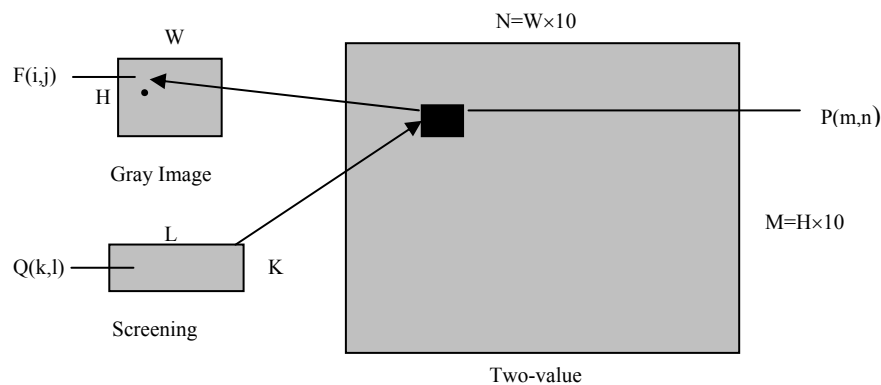


Figure 6. The Procedure of Screening for Gray Images by Minimum Threshold Matrix

As Figure 6 shows, set the pixel value of the original gray image is $(W \times H)$, the number of the grid is 10, then the two-value image size of screening is $N(10 \times W) \times M(10 \times H)$. The pixel of the original gray image is scanned one by one, we can use (i, j) to show its position in the two-value image. A dot in a 10×10 pixel matrix is expressed by $P(m, n)$. Work out the threshold coordinates (k, l) of the threshold matrix, and we can get the screening threshold matrix $Q(k, l)$. Compared with the pixel value (F) of original gray image, the gray scale of the screening image can be ensured. When the grid is 10×10 , the grid size respectively is 100, 90, 98. The number of threshold value is less than 255. We must make comparison the threshold value and the pixel value of the origin image, and establish the conversion (mapping) when screening. The Matlab programming simulates the screening process of the minimum threshold matrix, the function is computed as:

$$F_c = \text{Fix} \left(\frac{F_o}{255} \times Q_{\max} \right) \quad (2)$$

3. Results and Analysis

This experiment is based on the optical refraction phenomenon, embedding the hidden image at the different screening angle which is different from the background one and will not affect the whole visual of the watermark image. When laminating the grating with the corresponding screening lines, we can see the watermark image, so the feasibility of the variable angle screening security technology is proved. According to the screen angle algorithm, we can get a nice visual effect of extracting watermark.

3.1. Threshold Matrices for Different Screen Angles

The shape and angle of outlets is influenced by the distribution of the threshold. Even though the shape and angle are the same, the distribution of the threshold matrix may be different. The Figure 7 shows the threshold matrices for different screen angles. Here are the threshold matrices for the angles at 0° , 18.4° , 45° . The threshold matrices for the angles at 71.6° is the transposed matrix of 18.4° , so it isn't list below.

3.2. Experimental Results

Experiment parameter: the grating density (p) of column lens is 100 lpi, the screening line (L) is 100 lpi. If the level resolution is 100, then set the printing resolution as 1000 dpi. Build a gray image with the resolution as $100\text{dpi} \times 100\text{dpi}$ and the gray scale of 200. Use Matlab to simulate the screening at the four angles (0° , 18.4° , 45° and 71.6°) After screening, the two-value image which is made up of white and black dots formed. The four images is the four channel of Matlab programming. Set '2' as the watermark information, screening the hidden image at 0° , while the background image at 18.4° , and the original image at 45° and 71.6° . Laminating the four images together to form the mixture halftone image, and get an image like Figure 8(a). When detecting by the grating, we can see the hidden image '2' in (b) clearly after laminating the grating at 0° like Figure 8(b).

95	96	66	67	68	69	70	71	73	97
94	63	64	65	37	38	39	41	72	74
62	61	35	36	18	19	20	40	42	75
60	34	16	17	7	8	21	22	43	76
59	33	15	6	1	2	9	23	44	77
58	32	14	5	4	3	10	24	45	78
57	31	30	13	12	11	25	46	79	80
56	54	52	29	28	27	26	47	81	82
92	55	53	51	50	49	48	84	83	98
93	91	90	89	88	87	86	85	99	100

(a) The threshold matrices for the angles at 0°

57	30	11	2	3	8	26	42	62	77	50	28	34	48	54
61	38	20	6	10	16	22	36	60	89	52	67	71	79	81
73	46	23	14	18	32	40	44	56	83	86	88	68	64	53

(b) The threshold matrices for the angles at 18.4° (the left 3*30)

65	69	82	85	84	55	43	39	31	17	13	24	45	76	74
78	70	66	51	90	59	35	21	15	9	5	19	37	72	87
47	33	27	49	80	63	41	25	7	1	4	12	29	58	75

(c) The threshold matrices for the angles at 18.4° (the right 3*30)

45	41	31	33	37	48	55	53	58	68	66	62	51	47
28	21	16	17	23	25	42	71	78	83	82	76	74	57
29	12	8	5	6	18	38	70	87	91	94	93	81	61
35	13	7	1	2	11	34	64	86	92	98	97	88	65
39	19	9	4	3	10	27	60	80	90	95	96	89	72
43	24	22	15	14	20	26	56	75	77	84	85	79	73
54	49	36	32	30	40	44	46	50	63	67	69	59	52

(d) The threshold matrices for the angles at 45° (7*14)

Figure 7. The Threshold Matrices for Different Screen Angles



(a)



(b)

Figure 8. Examples of Varied Angles Anti-counterfeit Embedded Images

4. Conclusion

The variable angle screening security technology is based on the principle that human being can not tell the differences from changed screening line of the image, using different screening lines on the screening of the hidden image and the background image, then we can see the watermark information clearly after the watermark image laminating at the same angle

and the same lines of grating. This paper studied the anti-counterfeit technology of halftone image watermarking by digital screening and realized the variable angle of screening at 0° , 18.4° , 45° and 71.6° through Matlab and Photoshop software. The experimental results showed that the variable angle algorithm of screening anti-counterfeit technology had nice security effect, and could be used in practical application.

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