Analysis on Variation of Dot Size Printed by Offset Flexography and Electrophotography

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Abstract

In printing, the reproducibility of printed dot size is important. The reproducibility of dot printed by electrophotography printing, offset printing, and flexography is investigated. It is found that the variation of dot by flexography is 0.046 in the mid range density level, on the other hand the variation of offset printing is 0.023. The variation of dot by electrophotography printing is 0.043. The relation between the variation of the dot size and quality of uniform density shows that human can detect the quality of uniform density on produced by flexography and electrophotography easier than offset printing.

Introduction

The reproducibility of printed dot size depends on the printing technology,the characteristics of the ink or toner and the properties of printed media. In this context, the printed dot is the smallest unit of an image and important. Electrophotography printing reproduces dot size by fusing toner. The Ink for electrophotography may be powder or liquid toners, which may vary in structure according to their composition, and contain the colorant in the form of pigments. Offset produce printed dot by indirectly transforming to printed media. In the conventional offset printing process, ink is prevented to transform onto non-image areas by dampening solution. The printed dot reproduced by flexography is transfer directly to printed media. The conjunction of low viscosity ink and resilience of the flexography printing plate enable the printing on the non-absorbent and rough printed media. Flexography requires only a slight contact pressure to enable reliable ink transform from printing plate to printed media [1].

Recent research shows the observation about the shape of printed dot by comparison between electrophotography printing and ink jet printing [3]. The results show that the uniformity of the shape of the dot printed by electrophotography printing increased in proportion to the cluster size. Ink jet, on the other hand, the increase of the uniformity was comparatively less obvious. Another research establishes the correlation between image quality parameters and measured attributes focusing on electrophotography. The measured attribute is defined by printed dot size. The variations of dot size printed by offset, flexography, and electrophotography were observed [6]. The result show that the variation of dot tends to decrease when the cluster of dot increase. In addition to that, the results provide the way to decide which printing technology should be selected by describe the coefficient of variation against the quality of uniform density.

By the consideration about the fundamental printing of dot size and a survey of related work, this paper aims to investigate the reproducibility of printed dot size in various printing technology and the relation between its and the quality of uniform density.

Experimental

The halftone dot were generated by image processing software and then output by various printing methods. The dot patterns were created in eleven patterns with square dot shape. They were an isolated dot a cluster of 1x1 = 1 dot, a cluster of two horizontally adjacent dots a cluster of 1x2 = 2 dots, and a cluster of 2 x 2 = 4 dots, a cluster of 3 x 3 = 9 dots, a cluster of 4 x 4 = 16 dots, until a cluster of 10 x 10 = 100 dots. The 100 different halftone dot data were made for each dot patterns and then print them out.

The printed halftone dots are produced by three different printing technologies. The printing technologies, which were selected for this experimental, are flexography, offset, and electrophotography printing. The printing specifications are following.

-Offset press: Compute To Plate (CTP) technology (Laser Diode), Proofing machine (SCREEN).

-Flexography press: CTP technology (Laser Diode), Proofing machine (JM Heaford)

-Electrophotography: Typical electrophotography printer

Each printed dot is measured as digital dot by image processing software. We use CCD scanner in order to transform printed dot to digital dot into a computer. The dots size and shape are then measured.

Results and Discussions

We report the results of the research in mean of halftone dot quality and human perception on dot noise in halftone image. The halftone dot quality was evaluated by considering the dot reproduction based on three kinds of printing technologies and the variation of dot. The dot noise was evaluated based on human perception.

Halftone dot quality

The halftone images for printed dot produced by 3 printing technologies are shown in Figure 1, 2 and 3. We found that the measured device cannot detect the isolated dot in Flexography technology printing. In some printing technology, it seems to be that their edges are vague when the cluster is small size and the shape of printed dots does not form in rectangular cluster.

According to Figure 1, 2 and 3. the printed dots are measured in pixels for each printing technologies. We found that the dot size reproducibility of electrophotography and offset tends to increase approximately whereas flexography produces dot size bigger than another in the same cluster. The results of halftone dot pattern against pixel can be shown in Figure 4.

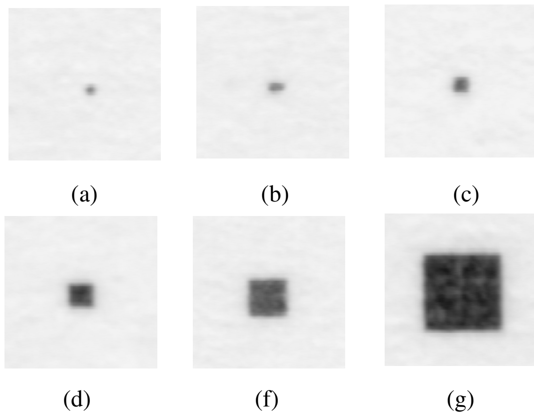


Figure 1. Printed dot by offset (a) isolated dot a cluster of 1x1 = 1 dot (b) cluster of two horizontally dot a cluster of 1x2 = 2 dots (c) a cluster of 2 x 2 = 4 dots (d) a cluster of 3 x 3 = 9 dots (f) a cluster of 5 x 5 = 25 dots (g) a cluster of 10 x 10 = 100 dots.

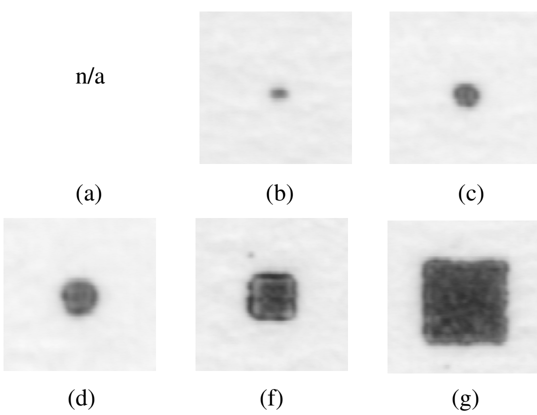


Figure 2. Printed dot by flexography (a) isolated dot a cluster of 1x1 = 1 dot (b) cluster of two horizontally dot a cluster of 1x2 = 2 dots (c) a cluster of 2 x 2 = 4 dots (d) a cluster of 3 x 3 = 9 dots (f) a cluster of 5 x 5 = 25 dots (g) a cluster of 10 x 10 = 100 dots.

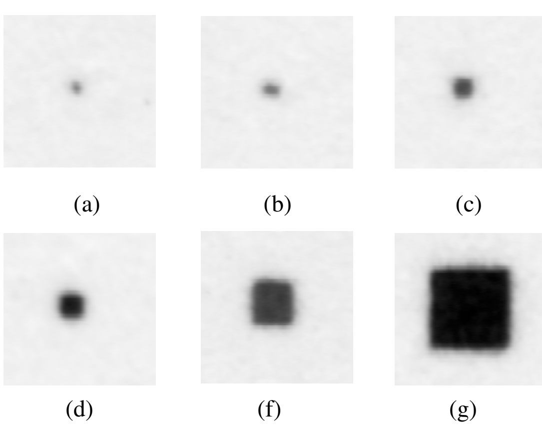


Figure 3. Printed dot by eletrophotography (a) isolated dot a cluster of 1x1 = 1 dot (b) cluster of two horizontally dot a cluster of 1x2 = 2 dots (c) a cluster of 2 x 2 = 4 dots (d) a cluster of 3 x 3 = 9 dots (f) a cluster of 5 x 5 = 25 dots (g) a cluster of 10 x 10 = 100 dots.

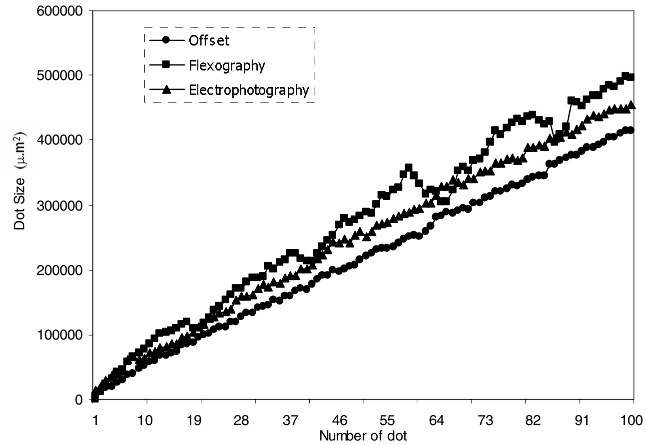


Figure 4.Dot size reproduction by offset, flexography, and electrophotography.

We also consider the relationship between area coverage of the original file and the area coverage in the printed media in the characteristic of dot gain. The result can be shown in Figure 5.

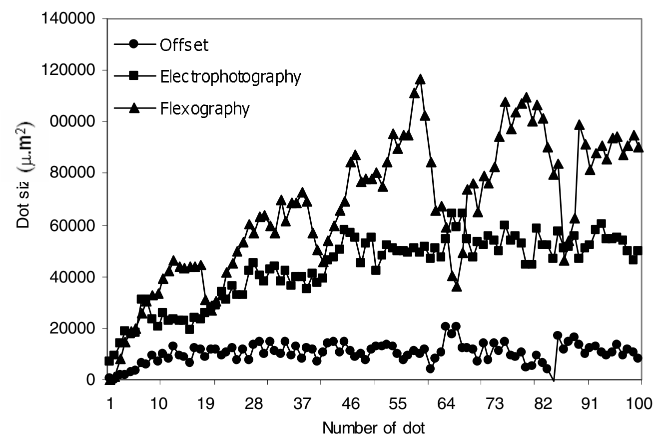


Figure 5. Dot gain values of offset, flexography, and electrophotography.

According to Figure 5, dot gain values of offset are nearly constant whereby dot gain values of flexography and electrophotography tend to increase while percent of halftone dot size increase.

According to Figure 4, the average size for each halftone dot pattern and its variance can be calculated as (1) and (2).

$$\overline{x} = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad (1)$$

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}\left(x_i - \overline{x}\right)^2 \qquad (2)$$

The average size can be denoted by $\bar{x}$ whereas its variance can be denoted by σ^2. N is the number of images and x_i is the cluster size of i^{th} image. The coefficient of variation V that indicates relative uniformity of the cluster size can be calculated as (3).

$$V = \frac{\sigma}{\bar{x}} \tag{3}$$

Table 1 show the values of average area x, (standard deviation) σ, and the coefficient of variation V of halftone dot patterns where $N = 10$. From Table 1, the coefficient of variation can be shown in Figure 6.

The results from Table 1 show that the variation of dot by flexography is 0.046 in the mid range density level. On the other hand, the variation of offset printing is 0.023. The variation of dot by electrophotography printing is 0.043. From the results of the experiments, it seems that halftone dots printed by offset technology have the least value of variation of dot. That means it can provide the better tone reproducibility than another

Table 1. Observation results of halftone dot patterns in average area, standard deviation, and coefficient of variation.

Offset

Halftone dot pattern	avg	SD	variation
1	479.3	42.60	0.089
2	726.4	51.80	0.071
2x2	1283.3	73.39	0.057
3x3	3025.7	122.48	0.040
4x4	4667.0	112.64	0.024
5x5	7062.8	224.11	0.032
6x6	10154.8	207.59	0.020
7x7	13186.8	276.55	0.021
8x8	17877.4	311.68	0.017
9x9	21573.8	222.24	0.010
10x10	26265.7	425.25	0.016

Flexography

Halftone dot pattern	avg	SD	variation
1	n/a	n/a	n/a
2	796.1	156.36	0.196
2x2	2087.1	181.34	0.087
3x3	4537.3	212.38	0.047
4x4	7023.4	454.07	0.065
5x5	9718.5	591.17	0.061
6x6	13685.6	588.46	0.043
7x7	17648.0	732.49	0.042
8x8	20322.2	830.17	0.041
9x9	27735.8	2344.03	0.085
10x10	31456.3	556.20	0.018

Table 1. Observation results of halftone dot patterns in average area, standard deviation, and coefficient of variation. (continue)

Electrophotography

Halftone dot pattern	avg	SD	variation
1	877.4	125.46	0.143
2	1305.1	265.14	0.203
2x2	2374.1	67.80	0.029
3x3	3913.7	346.08	0.088
4x4	5478.3	124.63	0.023
5x5	8661.6	626.40	0.072
6x6	11858.7	87.95	0.007
7x7	16052.5	1312.41	0.082
8x8	20041	354.51	0.018
9x9	24709.7	1285.04	0.052
10x10	28904.9	248.29	0.009

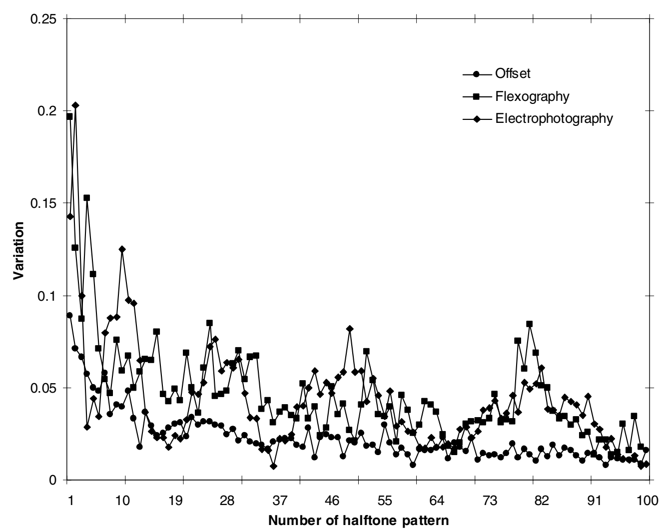


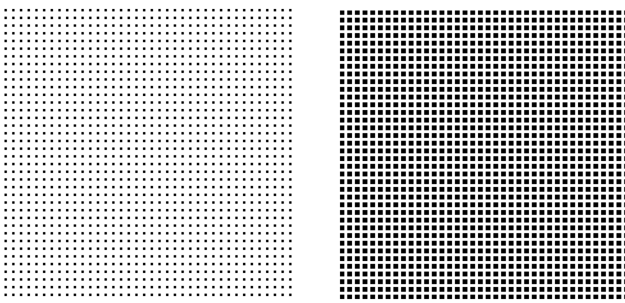
Figure 6. Comparison of coefficient of variation of dot size; offset, flexography, and electrophotography.

According to Figure 6, the dependence of the coefficient of variation of halftone dot patterns and the values of average area show that of electrophotography become decrease when the cluster of dot increase. The coefficients of variation in offset and flexography tend to provide the results in the same way.

It could be said from Figure 6, that the quality of uniform density increases in proportion of the cluster size. Offset technology can reproduce the halftone dot with less variation of dot than other technologies. These results can be used for considering which printing technology we should select for the quality of halftone image.

Human perception on dot noise in halftone image

We have particularly interested in the human perception according to noise in halftone image. A major challenge to develop the advance in printing technology is to reduce dot noise [5]. The noise in this study is the visual noise caused by uniform dot structure. In order to investigate the effects of noise in halftone image, we adapted a noise evaluation method based on the subjective perception. The halftone images were generated in order to evaluate the effects of noise with a cluster of 5 x 5 = 25 dots and a cluster of 10 x 10 = 100 dot as Figure 7. The distances between each dot were generated in 3 distances as Figure 8.



(a) (b)

Figure 7. Explanation the cluster of dot (a) The cluster of 5x5 dots, (b) The cluster of 10x10 dots.

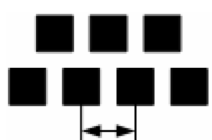
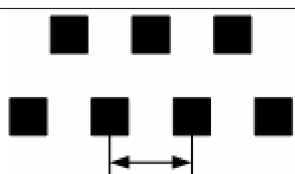
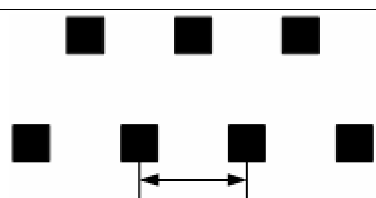
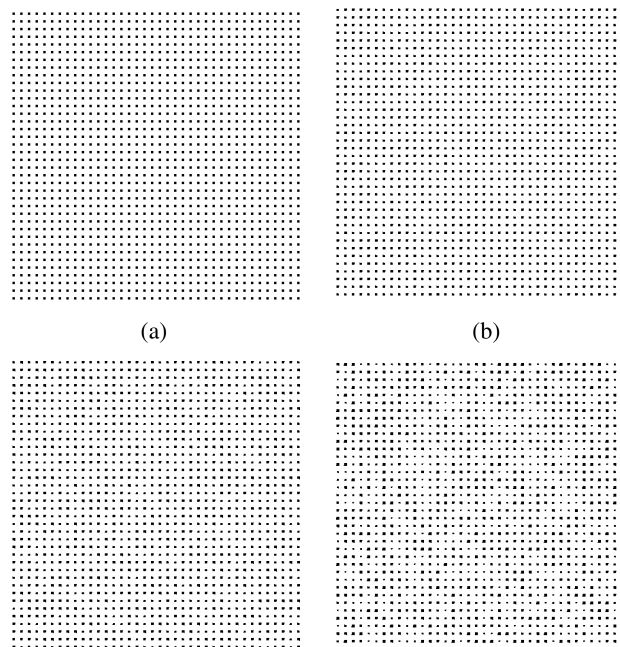
	Distance between dot
1	
2	
3	

Figure 8. The distance between halftone dots.

The percentage of noise for this evaluation can be classified into 6 levels: 2%, 4%, 6%, 8%, 10%, and 12%. The noise appearances were randomly generated according to these levels. In addition to that, the observation conditions were free and 1 m. distance. Figure 10 shows the percentage of dot noise for the evaluation according to the description.



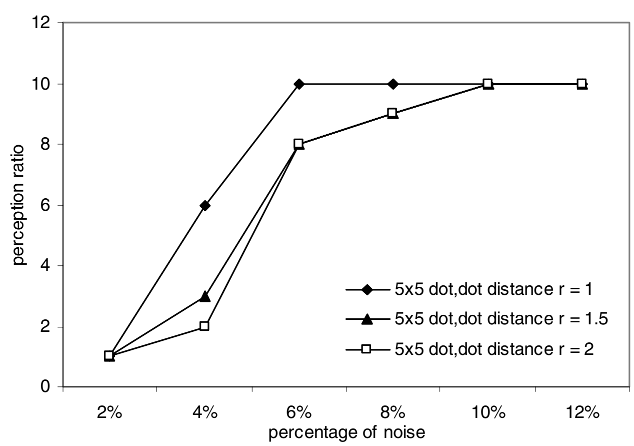
(a) (b)

(c) (d)

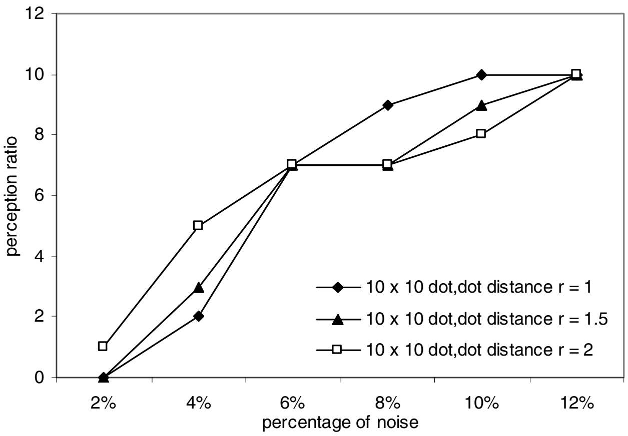
Figure 9. Test samples of the percentage of dots noise for evaluation (a) original (b) 4 % of noise (c) 6% of noise (d) 12 % of noise.

Effect of % of dot noise on human perception

Figure 10 shows the perception ratio against percentage of noise. The result shows that the perception ratios of noise at 5x5 dots increase while the percentage of dots increases. Although the perception ratios of noise at 10x10 show in the same way, the ratio is less than the perception ratio of noise at 5x5 in the same percentage of dots. The result also shows that the perception ratio decreases while the dots distance increase.



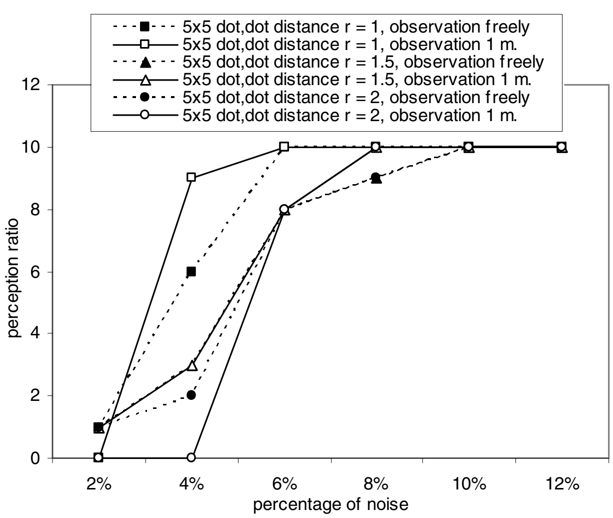
(a)



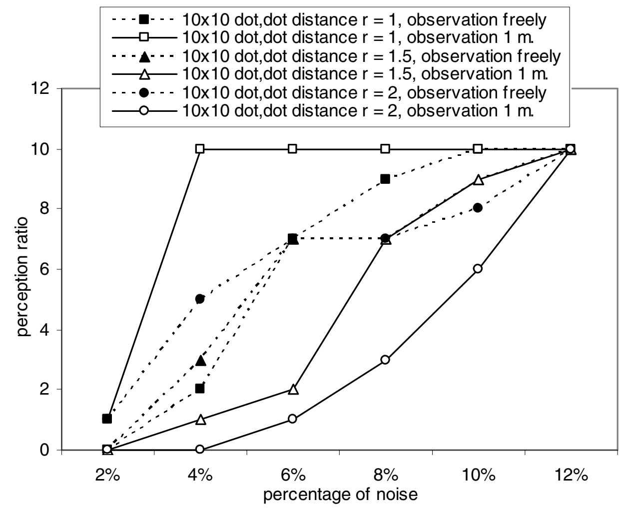
(b)

Figure 10.The perception ratio against percentage of noise (a) show perception ration of noise at 5x5 dots (b) show perception ration of noise at 10 x 10 dots.

Figure 11 shows the comparison of perception ratio between 2 observation distances, free condition and 1 m. The results show that perception ratio of noise at 5x5 dots with observation distance 1 m. is higher than the perception ratio with free observation distance. The results of perception ratio of noise at 10x10 dots also show in the same way. The perception ratio decreases when the distance between halftone dots increases.



(a)



(b)

Figure 11. The comparison of perception ratio between 2 observation distances (a) noise at 5x5 dots (b) noise at 10x10 dots.

Summary

The variations of dot size printed by offset, flexography, and Electrophotography and the effect of noise in halftone dot were investigated. The variation of dot tends to decrease when the cluster of dot increase. The reproducibility of dot printed by Electrophotography printing, offset printing, and flexography is investigated. It is found that the variation of dot by flexography is 0.046 in the mid range density level, on the other hand the variation of offset printing is 0.023. The variation of dot by Electrophotography printing is 0.043. In addition to that, the results of experimental provide the way to decide which printing technology should be selected by describe the coefficient of variation against the quality of uniform density. According to the result of dot noise on human perception, this is generated as uniformly in halftone image, human can detect noise from 4% and increase when the percentage of noise increases. The perception ratio of noise can be detected easily when the dot size decrease. By consideration the percentage of dot variation related with the human perception of dot noise, it seems to be that the human can detect the dot noise produced by flexography and electrophotography easier than offset printing.

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Author Biography

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