Influence of noise on contour perception

ZiQing Jiang, HongMei Cheng, Phichit Kajondecha, Yasushi Hoshino
Nippon Institute of Technology, Miyashiro, Saitama, Japan

Abstract

Recognition of object is usually carried out from the contour of the object. It is important to find an influence of noise on image recognition. Half-toning is essential processing for digital printing of continuous tone. The Sine density pattern which is the most basic picture change is treated with half-toning and adds random noise. Contour perception conditions are studied experimentally on various noise conditions, density difference, Sine wave's cycle, and observation distance for the image. It is found that the contour perception is disturbed as the stimulus of the noise increases. The influences of noise are discussed form the viewpoint of HVS (Human Visual System).

1. Introduction

Human perception is the most important way to recognize an image. A number of factor influence the perceived quality of an image is the determining of contour. Contour contains some characteristics for image recognition. It is the boundary of two different densities, colors, or texture areas. It can be said that human eye has ability to recognize the contour in an image. The ability of determining contour in the image is necessary for image recognition area in imaging system.

Since digital halftone is essential process in digital printing [1], the contour expression characteristics is important factor for obtaining image quality. Digital halftone is the processing technique transferring continuous tone image to binary image. Digital halftone [2] process does not only produce image with binary value, but also generate noise. The noise generated by digital halftone process influence contour perception for a halftone image. In this regards, it should be considered the relation between noise and contour in order to evaluate the influence of noise on image recognition.

This study aims to investigate the contour perception condition based on various noise conditions, density differences, Sine wave's cycle, and observation distances. The Sine density pattern which is the most basic picture change is treated with halftone and adds random noise.

2. Experiment

2.1 Image Preparation

In this study, the original images is generated by the structure of Sine density pattern as Fig. 1 with resolution 300 dpi and then printed at 2048 x 2048 pixels. In Fig.1, b is the difference of the density level that is the grayscale of digital image. There are the density difference cycles in the original images. The difference of the density level is changed as 4, 8 and 12, and *n* is changed as 3, 16 and 30 for experimental images. The original images are made by Eq. 1 and then processed by halftone method with dot distance 1 mm and screen angle at 0 degree. The halftone images are added the size of halftone dot noise [3] according to Eq. 2. α is the value of the halftone dot noise. We generate halftone dot noise value from 20% to 60% for halftone images. *R* is the random halftone dot noise coefficient with value 0 until 1.

Fig.2 shows the pattern of halftone image generated by the description as above. Fig.2 (a) is the original Sine density pattern with 0% of halftone dot noise and Fig.2 (b) is the Sine density pattern with halftone dot noise value.

$$I(x) = 192 + b * \sin(2 * n * 3.14 * x / width) \qquad (1)$$

$$N = \alpha(R - 0.5) \qquad (2)$$

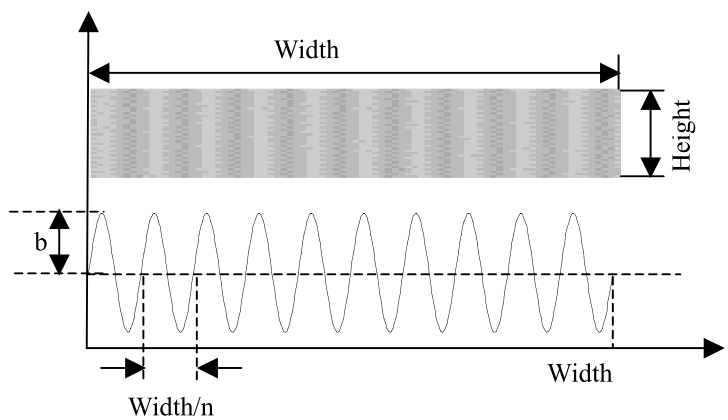
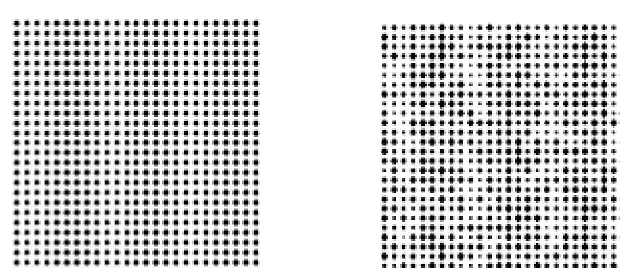


Fig.1. Pattern of observation.



(a) (b)

Fig.2. Example of Sine density pattern.
(a) Sine pattern of Halftone,
(b) Sine pattern of Halftone with noise.

2.2 Experimentation

The observation experiments are carried out as shown in Fih.3. The observers are 10 students of Nippon Institute of Technology. The condition of an illumination level is 500Lux. There are observation distances between the sample picture and observer from 0.5m to 3m. Their perceptibility of the density level in noised images is examined.

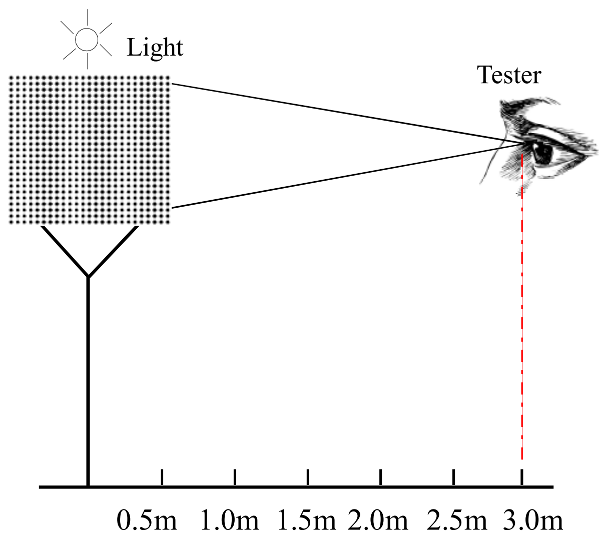


Fig.3 Contour perception experiment.

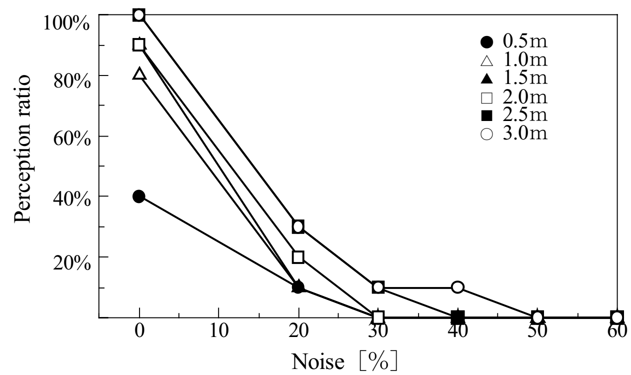
3. Results

3.1 The influence of a dependence on the density level difference.

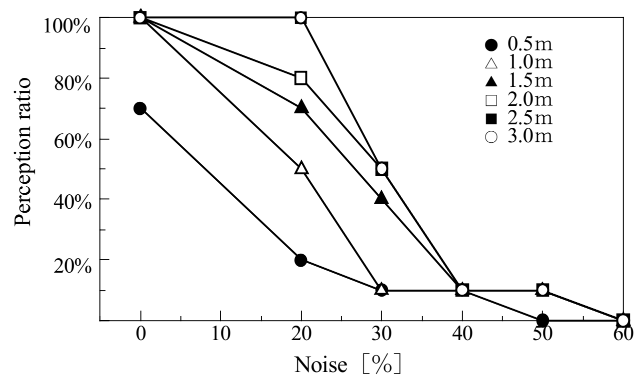
Fig.4 shows the relation between the perception ratios against halftone dot noise value. The density level was greatly perceived in the halftone dot noise ratio of 0% at observation distance since 1m. The perception ratio of Sine density pattern tends to decrease when the halftone dot noise value increases. In addition, the difference of Sine density level affects the perception ratio of halftone dot noise. Fig. 4(a) and (c) shows the effect of density level as the considering the perception ration at 20% of halftone dot noise. The result shows that perception ratio increases when the Sine density level increases. The perception ratio tends to increases when the observation distance increases as well as perception ration tens to decreases when % of halftone dot noise increases.

3.2 The influence of a dependence on the density cycles difference.

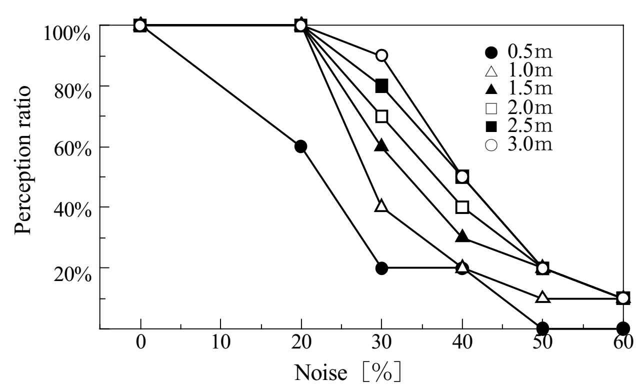
Fig.5 shows the relation between the perception ratios against Sine density cycle patterns. The result shows that the observation distance influences perception ratio when the Sine density cycle pattern at 3. The perception ratio at observation distance 0.5 m is the lowest at all % of halftone dot noise. The perception ratio tends to decrease when % of halftone dot noise increases at Sine density cycle 30. On the other hand, the density cycles 16 have a peak of perception.



(a)

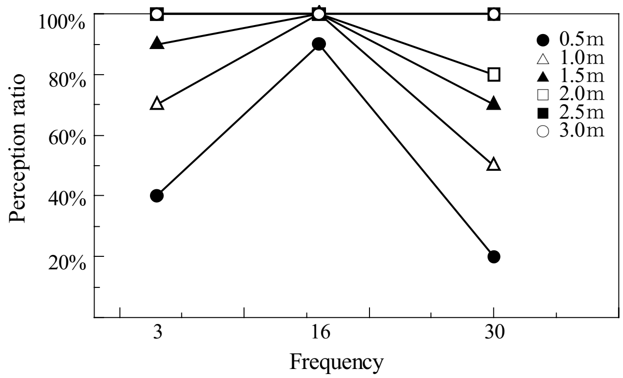


(b)

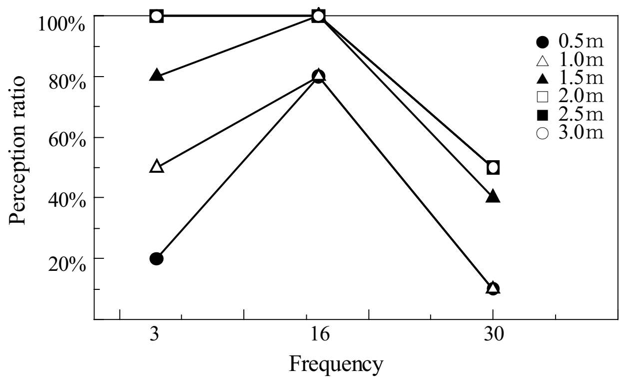


(c)

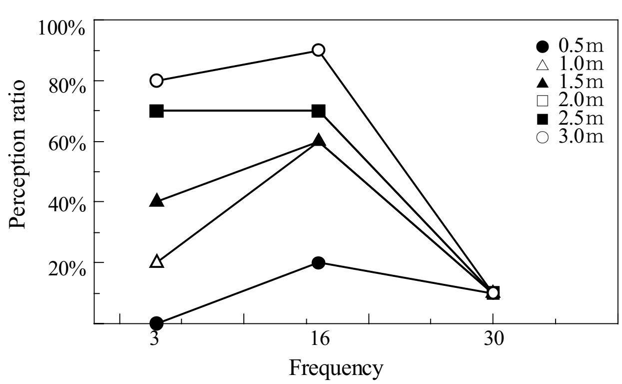
Fig.4. Perception ratio dependence on noise.
(a) Condition of frequency 30 and density difference 4,
(b) Condition of frequency 30 and density difference 8,
(c) Condition of frequency 30 and density difference 1.2.



(a)



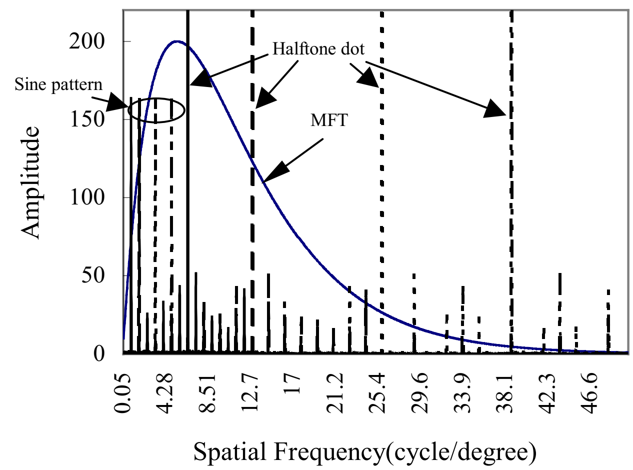
(b)



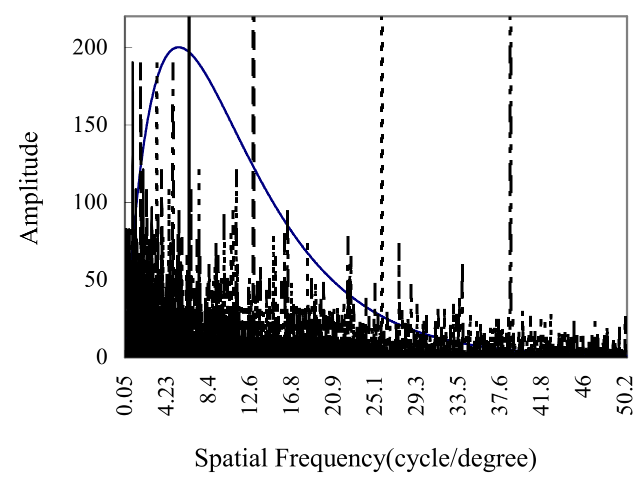
(c)

Fig.5. Perception ratio dependence on frequency.
(a) Condition of density difference 8 and noise 20%,
(b) Condition of density difference 8 and noise 30%,
(c) Condition of density difference 8 and noise 40%.

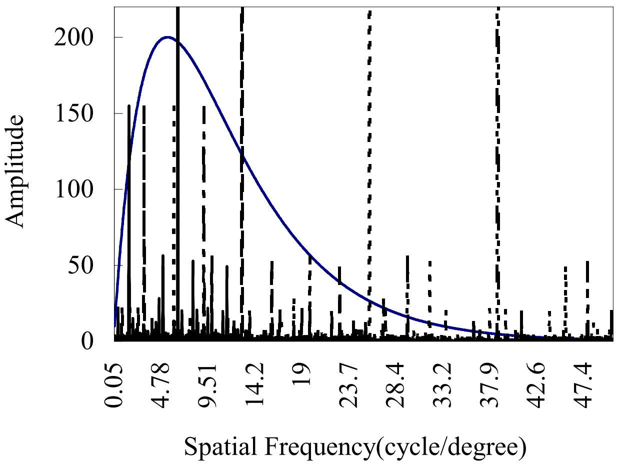
Fig.6 shows the relation between Discrete Fourier Transform of halftone frequency and Modulation Transfer Function of HVS. It shows the peak of respective of sine and halftone frequencies and MTF curve of HVS (human visual system) on the horizontal axis of the scale of cycle/degree from the eye. MTF curve is for understanding the stimulus strength of sine and half-tone dots. Fig. 6 (a) shows the halftone frequency at the density difference at 8 and Sine density cycle pattern at 16 with 0% of halftone dot noise. It is forecasted that halftone dots have certain stimulus strength in the observation distance of less than 2 m, and in more than 2 m the dot stimulus strength become week. Fig. 6 (b), which shows the result with 20% of halftone dot noise, shows the influence of halftone dot noise for the dot stimulus strength. Fig. 6 (c) and (d) shows the results in the same way. Fig.6 (a) and (c) contributes the evidence about Sine density cycle patterns from Fig.5 that the peak of perception from Sine density cycle pattern at 16 greater than the peak of perception from Sine density cycle pattern at 30.



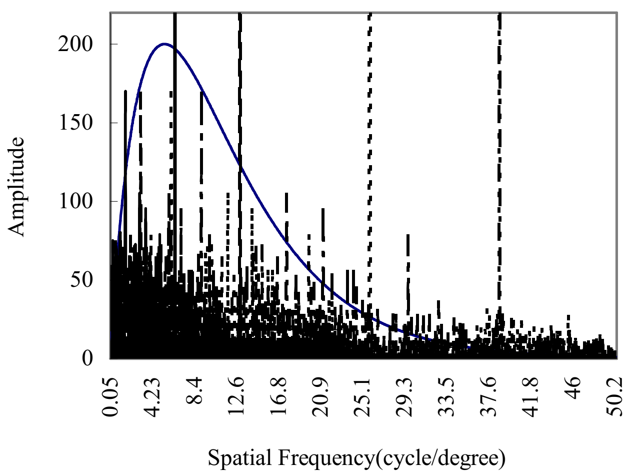
(a)



(b)



(c)



(d)

Fig.6. Relationships between DFT of halftone frequency and MTF of HVS.

0.5m *(a) Original at Sine density cycle pattern 16,*

1.0m *(b) Sine density cycle pattern 16 with noise,*

2.0m *(c) Original at Sine density cycle pattern 30,*

3.0m *(d) Sine density cycle pattern 30 with noise.*

4. Discussions

Spatial frequency response of visual property of the human has low-pass filter quality. MTF generally, as for contrast sensitivity function, becomes the band pass type which at bright place vision level has maximum of sensitivity near 3~5 cycle/degree being frequency characteristic of the output amplitude for the input of the Sine wave signal of fixed amplitude. In this research, as for the MTF curve, halftone it is thought perception ratio of the Sine density fluctuation which processed. Then, from the aspect of visual property of the human, influence of the noise in image recognition is investigated.

Fig. 6 (a), (b), (c), and (d) are the halftone amplitude of the Sine density cycle patterns at 16 and 30 respective DFT and MTF. According to the result, irregular components arise in DFT spectrum when the halftone dot noise increase.

5. Conclusions

The relation between human perception and the influence of halftone dot noise has been investigated by utilizing the Sine density patterns [4]. The results show that the density difference tends to increase when the halftone dot noise increases. In addition, the perception ratio tends to increases when the observation distance increases as well as perception ration tends to decreases when percentage of halftone dot noise increases. The relation between DFT and MTF of HVS provides the finding that halftone dot noise influence the dot stimulus strength.

6. References

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7. Author Biography

ZiQing Jiang is a Master degree student in Hoshino Laboratory, Systems Engineering Department, Nippon Institute of Technology. She had learned Computer and Information Technology from Gui Zhou Institute of Technology in background. Her research interest influence of noise and image processing.

