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Edge Enhancement Effect of Vision on X-Ray Radiographs Made Using a Dual Screen-Film System

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INTRODUCTION

The edge enhancement effect of a radiographs is useful for the detection of a diseased part in medical imaging. A step edge image is enhanced by vision. This is called the Mach effect.

In an x-ray radiograph, made using a screen-film system, the edge image is enhanced by vision and blurred by the screen-film system. In this paper, theoretical and experimental approach for edge enhancement effect of vision on x-ray radiographic images was carried out. Psychophysically enhanced portions in density unit at the both sides of a step edge image were derived from MTF's of vision and a dual screen-film system. Experimental values were obtained using our new method, in which a step edge image was compared with a standard film having continuous density change. Experimental values distributed around theoretical values, and their qualitative behaviour was similar to that of theoretical values.

The broken line in Figure 1 shows the physical density distribution without the enhancement and blurring, and the solid line shows the psychophysical density distribution with the enhancement and blurring. The abscissa is the position on a film along the line perpendicular to the step edge, D_o and D_u are the densities at the both sides of the step edge, measured by a densitometer, and S_o and S_u are the psychophysical density-peak and -valley enhanced by vision.

THEORY

The edge enhancement effect is caused by the MTF of vision, since the MTF has a maximum at non-zero spatial frequency.

The threshold contrasts c_t under steady state adaptation, as functions of the spatial frequency, have been presented by Ozaki et al. for various average luminous exitances at the spatial frequencies of 0.3 to 4 mm^{-1}.[1,2] The inverse of c_t gives the MTF of vision.[3] These curves were extrapolated at the frequency range of 0 to 0.3 mm^{-1} and that higher than 4mm^{-1}.

The screen-film system degrades the sharpness of edge image. The screen HGM and the film UR2 were combined in the experiment. Dual system was used. The system MTF was obtained by the slit method of Doi et al.[4] The product of system MTF and MTF of vision was Fourier transformed to obtain the LSF (line spread function). The integral of the LSF gave the upper half of the edge response in luminous exitance unit.

In order to compare with experimental values of Psychophysically enhanced portions in density unit, theoretical values were transformed into density unit.

EXPERIMENTS

To make sample films having step edge images, aluminium step edges were radiographed using the screen-film system stated before. Tube voltage (kV) and mAs values were changed widely to obtain wide variety of D_o , D_u and ΔD. These densities were measured using a densitometer.

No physical edge enhancement effect caused by film development[5] and scattered x-rays[6] was found in microdensitometric traces of all sample films. Therefore only psychophysical enhancement effect was treated in this paper.

An aluminium wedge having continuous thickness change was radiographed to make standard films having continuous density change. Densities were measured using the densitometer in every 1-cm interval.

The luminous exitance of viewer was 4000 lm•m^{-2}. The viewer was covered by a black paper having an window of 2-cm square to prevent the effect of glare.

An edge image having density change and a standard film having continuous density change were arranged in the window, and then the standard film was moved along the edge image to find the same densities as psychophysically enhanced densities appearing at the both sides of the edge. This is our new method.

Inspection was conducted in a dark room to eliminate reflected light from the film surfaces. The observers eyes were focused on the two films until steady state adaptation prevailed.

Distances between psychophysically enhanced peak and valley were measured using a slide vernier calliper.

RESULTS AND DISCUSSION

Typical results are shown by solid lines in Figures 2, 3, 4 and 5. In these figures, experimental results are shown by dots. In each figure, parameter of theoretical curve is single value, and that of experimental values distribute ± 0.5 density unit from that of the theoretical curve.

Theoretical values of ΔS_o and ΔS_u become larger with the increase of ΔD and almost flat with D_o and D_u . Experimental values were larger than theoretical values, but the qualitative behaviour was similar to that of theoretical values.

CONCLUSION

Psychophysically enhanced portions in density unit ΔS_o and ΔS_u were theoretically obtained from MTF's of vision and the system MTF. Experimental values were obtained by our new method. The qualitative behaviour of experimental values was similar to that of theoretical values.

REFERENCES

1. Y. Ozaki, H. Kubota, M. Matsumoto and H Kanamori, Journal of Photographic Science,**41**, 59-62 (1993).
2. Y. Ozaki, H. Kubota, M. Matsumoto and H Kanamori, Journal of Photographic Science,**41**, 96-97 (1993).
3. A. S. Patel, Journal of the Optical Society of America, **56**, 689-694 (1996).
4 K. Doi, G. Holje, L. N. Loo, H. P. Chan, J. M. Sandric, R. J. Jennings and R. F. Wagner, "MTFs and Wiener Spectra of Radiographic Screen-Film Systems", pp. 6-14, BRH, Rockville, MD, U. S. A. (1982).
5 R. S. Barrows and R. N. Wolfe, Photographic Science and Engineering, **15**, 472 (1971).
6 H. Inatsu, M. Ueda, K. Kariya and S. Uchida, Medical Imaging and Information Sciences, **10**, 89-95 (1993).

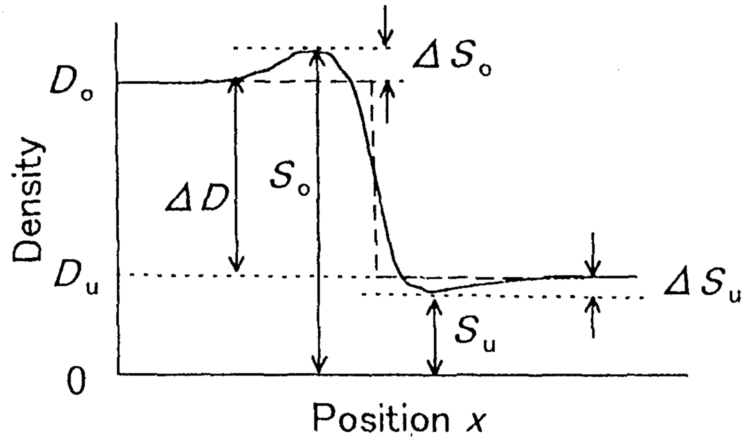

Figure 1: Physical (broken line) and Psychophysical (solid line) density distribution.

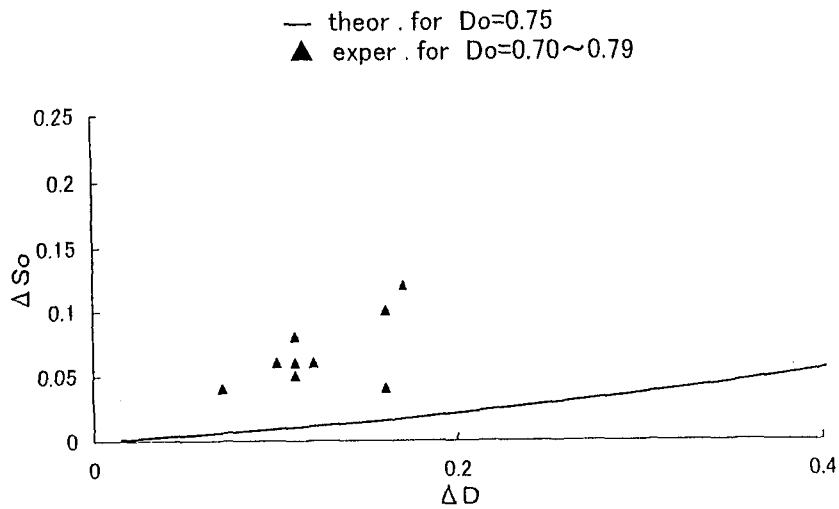

Figure 2: Relation between ΔS_o and ΔD.

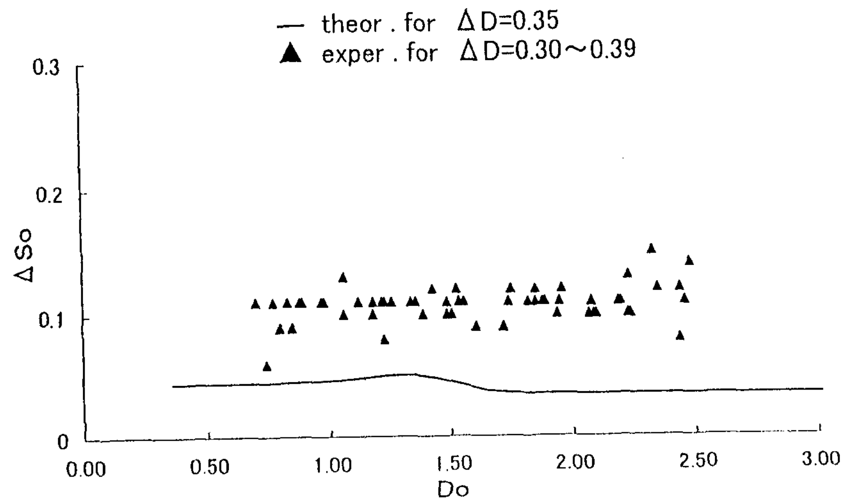

Figure 3: Relation between ΔS_o and D_0.

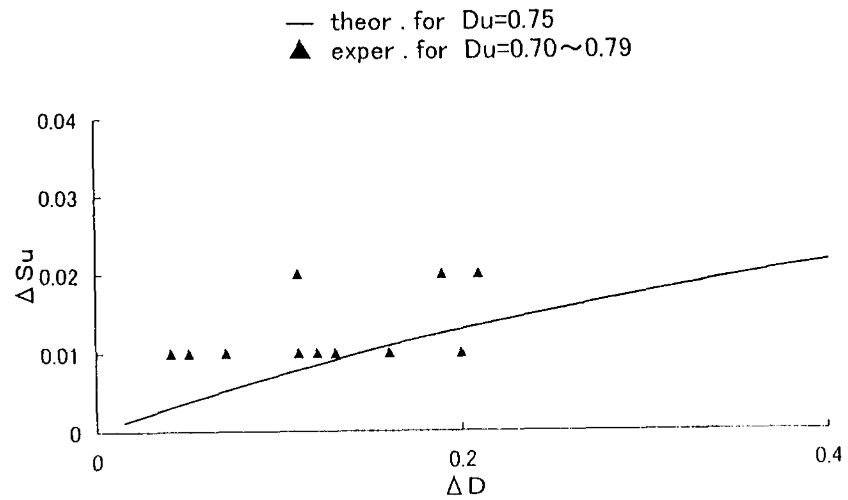

Figure 4: Relation between ΔS_u and ΔD.

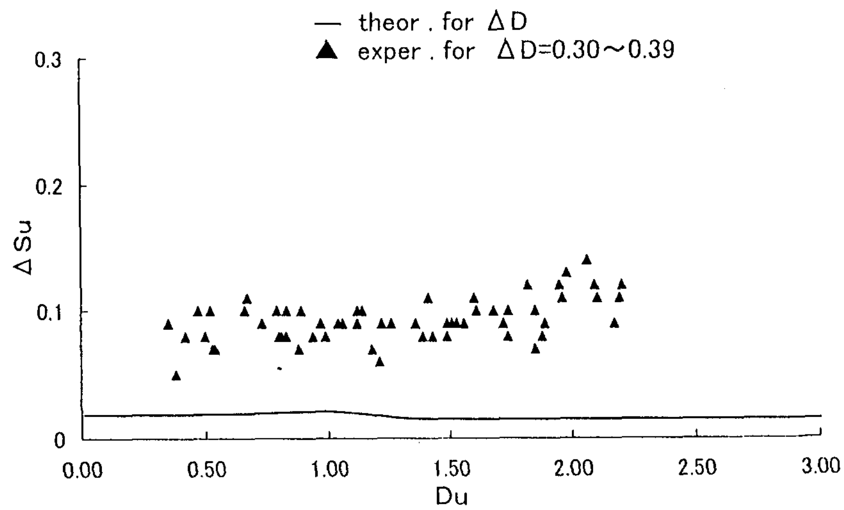

Figure 5: Relation between ΔS_u and D_u.