A COMPARISON OF SUBJECTIVE PICTURE QUALITY WITH OBJECTIVE MEASURE USING SUBJECTIVE SPATIAL FREQUENCY

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ABSTRACT

Recently, not only still pictures but also moving pictures are displayed on the PDAs or cellular phones. When we take a look such pictures, the picture quality seems to be better than those on the CRTs or the large LCDs. In order to clarify the reason, we have investigated the relationship between the subjective quality of different size of pictures with keeping the viewing distance 6H. After three kinds of pictures (Girl, Mandrill, Milkdrop) are subjectively tested, the MOS using the small sized pictures with several distortions is better than that of the middle and large sized pictures by the psychophysical factors.

In this paper, after discussing the effect of picture size on the MOS, we show the experimental results obtained by subjective evaluation with 20 observers. And, the relationship between the MOS and the Weighted SNR compensated by the subjective spatial frequency are given.

1. INTRODUCTION

In designing better picture coding and decoding system, it is necessary to consider the total system including cameras, coding and decoding schemes, displays, and human visual system. The human visual characteristics have been investigated by many researchers for establish better objective measure for evaluating coded picture quality automatically [1-3]. And, we have proposed some objective measures considering not only spatial contrast sensitivity but also masking effect and the observation area [4]. Some studies are focused on the high definition TV system with middle or large sized displays and not on small sized displays used for PDA or cellular phones.

On the other hand, recent digital picture coding schemes such as MPEG2 and MPEG4 have scalable features which adapt to the display size, the network bandwidth, and so on. This means that the actual viewing condition can be changed individually. Therefore, such viewing conditions should be taken into account for the scalable coding design.

In order to find effects of the display size on the subjective picture quality, we examine the subjective evaluation using various sized displays with keeping the viewing distance 6H. In this paper, we show the experimental results, and discuss the psychophysics factors using the Subjective Spatial Frequency region

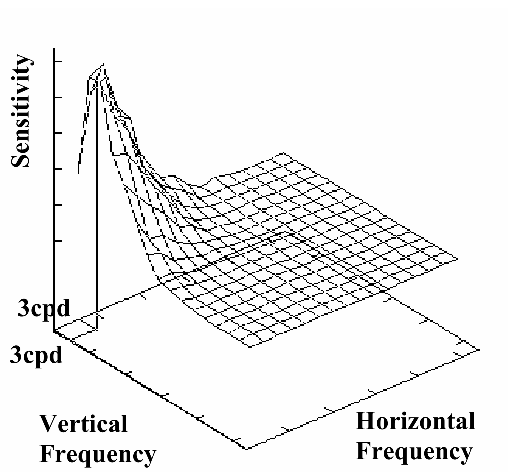

Fig.1 Experimentally Derived Contrast Sensitivity

2. EFFECTS OF PICTURE SIZE ON MOS

It is well known that the human visual MTF (Modulation Transfer Function) has a maximum at around a few cycles per degree. Fig.1 shows the human contrast sensitivity in the spatial frequency domain [4]. This was derived from the detectable noise level after subjective evaluations, and used for weighting the coding noise in spatial frequency domain objectively by the AWSNR.

On the other hand, it was reported that the subjective spatial frequency was affected by both of the viewing distance and the picture size. In case of binocular observation, the subjective spatial frequency (SSF) and the physical spatial frequency (PSF) had a relationship as shown in Fig.2. The figure shows that the subjective spatial frequency becomes higher than the physical frequency in case the viewing distance Dv becomes shorter. As this tendency was appeared in case of binocular observation, it was estimated that an observer detects the viewing distance to act the homeostasis of sizing psychophysically.

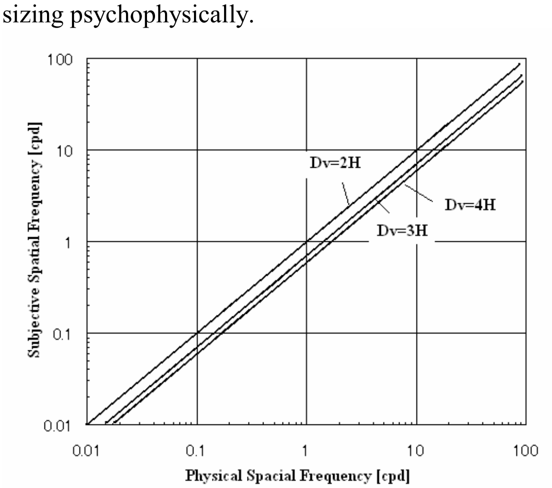

Fig.2 Relationship between SSF and PSF[5]

Fig. 3 shows another relationship between the subjective spatial frequency and the picture size ratio, when the physical spatial frequency on the display was fixed. From this figure, the subjective spatial frequency goes down as the picture size ratio becomes smaller even if the viewing distances are same.

From Fig.2 and Fig.3, when we observe a small picture with short viewing distance, we feel its spatial frequency higher, because the psychological effect caused by shortening the viewing distance is greater than that by making the picture size smaller. This means that, in objective picture evaluation of small sized pictures using human visual MTF under standard viewing conditions, the noise should be treated after spatial frequency shift or equivalent gain shift.

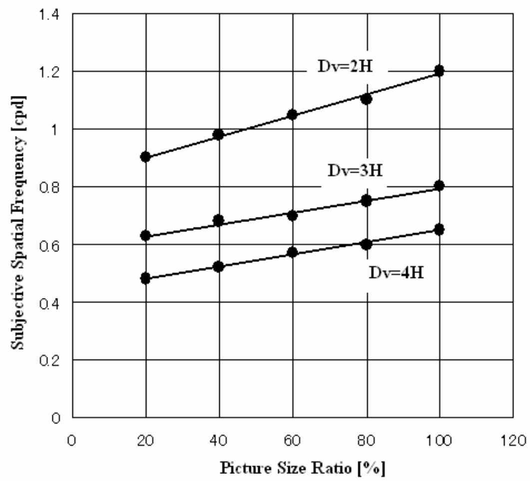

Fig.3 Relationship between SSF and Picture Size[5]

3. EXPERIMENTAL

3.1 Subjective Evaluation

In order to find the correlation between the MOS and the picture size, we made a subjective evaluation test.

Table 1 shows the evaluating conditions.

Table 1 Evaluating Conditions

Viewing Distance	6H
Display	17 inch LCD
Test images	Girl, Mandrill, Milk drop
Noise	Block(JPEG), Random
Number of Observers	20
Evaluation Method	DSIS

The height H of a small picture is 67.5mm, a middle picture is 135mm, and a large picture is 270mm, respectively.

3.2 Experimental Results

Fig.4 shows the correlation of MOS values with 5 level of random noise, when the picture size is small and middle. And, Fig.5 shows the correlation of MOS values with 5 levels of block noise. In both case, regardless of tested images, MOS of small picture is better than that of middle picture. The result of analysis of variance also shows MOS differences between small and middle pictures. Fig.6 and Fig.7 show the correlation of MOS values with random noise and block noise respectively, when the picture size is large and middle. From these results, there is no significant difference between MOS values of large and middle pictures statistically, even if the kinds of noise are different.

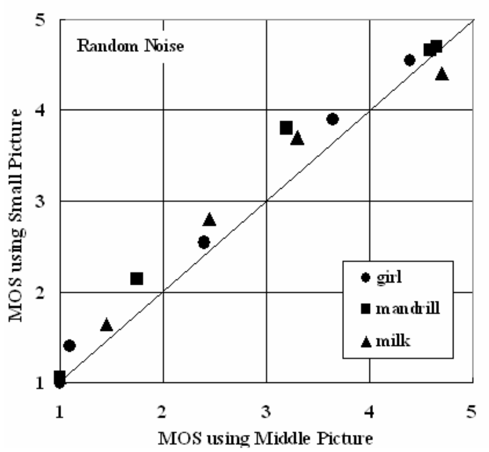

Fig.4 MOS between Small and Middle Pictures in case of Random Noise

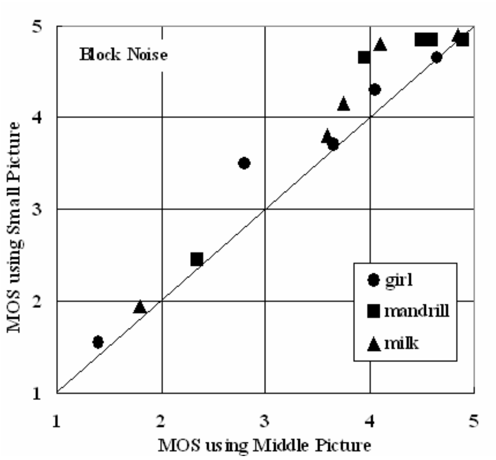

Fig.5 MOS between Small and Middle Pictures in case of Block Noise

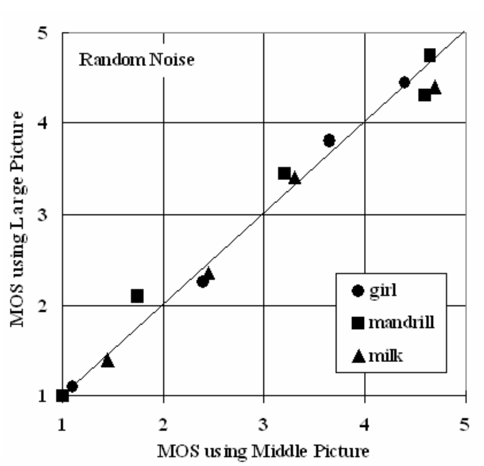

Fig.6 MOS between Large and Small Pictures in case of Random Noise

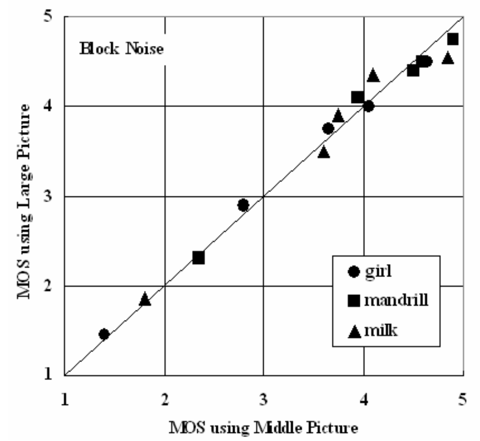

Fig.7 MOS between Large and Middle Pictures in case of Block Noise

3.3 Discussion

We think that the reason of difference of MOS value between small and middle picture is the frequency shift described in the chapter 2. Fig. 8 shows the relative contrast sensitivity versus the PSF considering the frequency shift of the SSF with different viewing distances. When viewing distance becomes closer, the sensitivity in high PSF decreases. On the other hand, according to Fig.6 and Fig.7, there is no difference between middle and large pictures. It is inferred that the additional psychological factor conceals degradation of image.

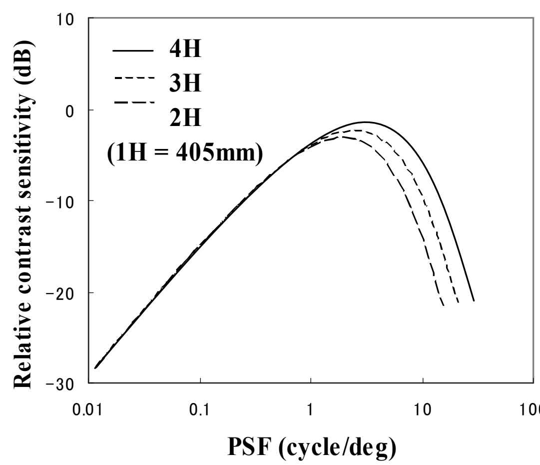

Fig.8 Contrast Sensitivity considering Viewing Distance

4. OBJECTIVE EVALUATION

From the discussion of the previous section, it is found that the spatial frequency compensation using the SSF is effective on the MOS difference caused by the picture size.

Fig.9 shows the relationship between the MOS obtained from experimental results and the WSNR proposed in previous studies [4]. From this figure, it is difficult to make a new objective measure only by the weighting function, which is similar to the human visual MTF. Fig.10 shows the relationship between the MOS and the WSNR compensated by the SSF. In comparison with Fig.9, it is cleared that the dispersion of data becomes small. This means that the SSF considering the viewing distance is good for making the objective measure. Table.2 shows the correlation coefficient between the MOS and the WSNR in each test image. By using the SSF, the sensitivity decreases uniformly and is not concerned with physical spatial frequency, when the distance becomes shorter. This means that objective evaluated score is expressed with the following simple formula that is proportion to logarithm of ratio of viewing distance.

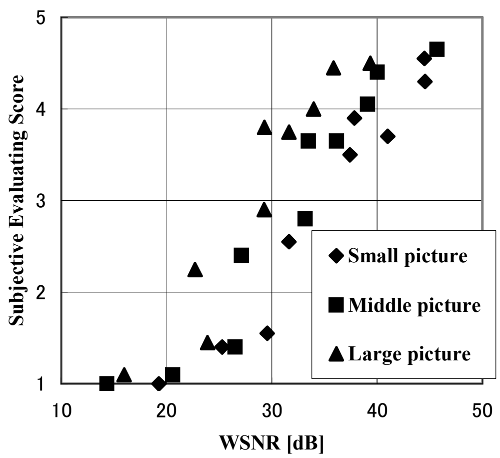

Fig.9 Relationship between MOS and WSNR

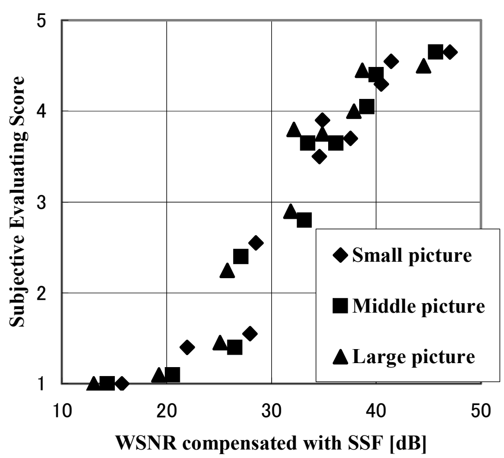

Fig.10 Relationship between MOS and WSNR after compensated by SSF

Table 2 Correlation coefficient

Test Image	WSNR without SSF	WSNR with SSF
Girl	0.84	0.93
Mandrill	0.74	0.89
Milk drop	0.84	0.96

$$S(r) = S_D - a\log(\frac{r}{D})$$

where, ***S(r)*** is the compensated objective evaluation measure in dB, ***r*** is the viewing distance, S_D is the WSNR derived from the weighting function with the standard viewing distance ***D*** (6H: H is the height of display) and ***a*** is proportional constant (According to our experiments, this is about 5dB). In the case of small and middle picture, it is inferred that above formula can apply to changing picture size with fixed view distance, as viewing distance replaced with picture size in formula.

5. CONCLUSION

In this study, in order to find the correlation between the MOS and the picture size, we made a subjective evaluation test using 3 sizes and 3 kinds of pictures with 10 different noise, i.e., five levels of random and block noise. From the results, the picture quality of the small sized is better than those of the middle and the large sized even if the viewing distance is fixed as 6H. It is also shown that the results agree with the previous research, in which the subjective spatial frequency was derived.

We also apply the frequency shift caused by shortening the viewing distance into the calculation of the weighted SNR. According to the correlation coefficient between the MOS and the frequency compensated SNR, the compensation is effective to develop a new objective measure.

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