Image Quality Dependence on Pixel Number in High-Resolution Display
—Depth Feeling and Texture Feeling—

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Recently the pixel number of display and digital camera image sensor increases rapidly and the image quality including depth and texture feeling expression is paid attention to. In this study, focusing on the point of their pixel number/resolution, subjective estimation of image quality dependence on the pixel number is carried out. Two types images for 4K display (3840 × 2160 pixels) are prepared and resized to 1/4, 1/16 and 1/64. They are displayed at 4K display and subjective estimation is carried out by 25 peoples. It is obtained that the image quality increases as the pixel number increases within the range that pixel is distinguished by vision.

Keywords: Pixel number, Image quality, Subjective estimation, 4K display

1. Introduction

Pixel number of an image is a very important factor affecting its quality. Recent progresses of display and digital camera technology are remarkable. Their pixel number is especially increasing. High-resolution display which has 4 times pixels of full high vision has been launched and in the near future 16 times pixel number of full high vision display is also scheduled, and they are called 4K and 8K display, respectively. The 4K display has 3840 × 2160 pixel. Concerning a digital camera, the pixel number of its image sensor increases and optical low pass filter on its sensor is removed for high resolution image capturing in some types of cameras.

The increase of pixel number of their devices is thought to have effects on improving output image quality. According to the advertisements of 4K display, it can express high quality image as beautifullness, details, reality and more. Depth feeling is an important factor in 4K display. But the influence of pixel number increase on image quality is not studied enough.

In this study, 4 images whose pixel numbers are ranging from 3840 × 2160 pixels to 480 × 240 pixels are prepared by resizing and examined by subjective estimation. In addition to image quality, depth feeling and texture feeling which are factors of image quality are also estimated. The estimation is carried out at two typical distances of pixel recognizable distance and almost unrecognizable distance. In the pixel recognizable distance, as the pixel number increases, it is found that image quality increases.

2. Experiment

Two images are prepared by being captured by a digital camera (Canon EOS D600D). These images are shown in Figs. 1 and 2. Image quality and depth feeling is subjectively estimated on Fig. 1 and image quality and texture feeling is also subjectively estimated on Fig. 2. The display used in this

Fig. 1 Landscape image of MBK.

Fig. 2 Still life image of Thai silk tie.
experiment is a 4K display (Toshiba Regza 55X3), which display area is 1210 mm × 680 mm and pixel number is 3840 × 2160 pixels. The size of one unit pixel is 0.315 mm × 0.315 mm and one unit is composed of RGB strips. Concerning the pixel number, maximum pixel number is 3840 × 2160 pixel and is named as 4K, and 1920 × 1080 pixel, 960 × 480 pixel and 480 × 240 pixel are named as 2K, 1K and 0.5K respectively in this report. Original image is resized from 4K to 2K, 1K and 0.5K by bi-cubic processing.

Subjective estimation is carried out at two observation distances. The distances are determined from the visibility of the Landolt ring gap as a person of vision 1.0 can recognize the pixel size of RGB unit of the 4K display. Since the size of the pixel composed of RGB cell is 0.315 mm × 0.315 mm, the observation distances are obtained as 105 cm, which is the limit of recognition for vision 1.0.

Subjective estimation is carried out by 25 persons of wide range of age 10-60 years. The image of 4K, 2K, 1K and 0.5K image is estimated subjectively compared with 2K which is full high vision image (1920 × 1080 pixels) respectively and ranked in 5 levels of ‘better’, ‘rather better’, ‘same’, ‘rather worse’, ‘worse’. It is considered that more stable results are obtained by comparing with our familiar full high vision image (2K).

3. Result and discussion

Subjectively estimated values of image quality and depth feeling of Fig. 1 are shown in Fig. 3 (a) and (b), which show the results at the observation distance 1.05 m and 2.10 m, respectively. It is found that the values of image quality and depth feeling increases as the resolution of image increases in both observation distances. At the longer distance of 2.10 m, the change against the resolution is less than shorter distance 1.05 m, and especially, it is found that the difference between 2K and 4K is very small.

Concerning Fig. 2, subjectively estimated values of image quality and texture feeling are shown in Fig. 4 (a) and (b), which show the results at the observation distance 1.05 m and 2.10 m, respectively. Similarly it is found that the values of image quality and texture feeling increases as the resolution of image increases in both observation distances. At the longer distance of 2.10 m, it shows the same tendency of image quality and depth feeling as the change against the resolution is less than shorter distance, and especially, it is also found that the difference between 2K and 4K is very small.
Resolution dependence of subjectively estimated results is summarized as the estimated values increase as the resolution increases. This is mainly considered from the reason that the detail of the image is expressed and definition degree which is one of the important factors of image quality increases. It is said that the clues for depth feeling are line perspective, diminishing size, overlapping, shadow and dimness, and that those for texture feeling are color and light reflection. The clue of depth feeling and texture feeling becomes clear and the recognition becomes easier as the resolution increases.

Concerning the reason that the estimated values of 4K and 2K are not so different at the observation distance 2.10 m in Figs. 3 (b) and Fig. 4 (b), it is considered that the observers of vision 1.0 can distinguish the pixel 0.315 mm × 0.315 mm of the display at 1.05 m, but at the observation distance 2.10 m it is difficult to distinguish the pixel, so the difference between 2K and 4K is little.

It is obtained that the correlation between image quality and texture feeling dependence on resolution is good in Fig. 2, on the other hand, it is found that the value of depth feeling decrease gradually compared with image quality in Fig. 1. Image quality is controlled generally by various factor, however the depth feeling is controlled by restricted factors such as line perspective, size and so on.

The subjective estimations of the image quality, depth feeling and texture feeling of the same photo image as used in this report on hardcopy have been reported. According to the report, these estimated values increases as the resolution increases. It is considered that printed materials are watched at the arbitrary distance and position. On the other hand, we usually watch display at the fixed distance.

The 4K display has enough resolution for ordinary watching distance, so it is proposed that one of possible application of 4K display is to enjoy high quality photo image with arbitrary distance, in addition to enjoy 4K movie and TV broadcast.

4. Conclusion

At the two different observation distances, subjective estimation of image quality, depth feeling and texture feeling are carried out on two type images, line perspective image of Fig. 1 and texture image of Fig. 2. It is found that the estimated value of image quality, depth and texture feeling increase as the resolutions increase within the range that pixel is distinguished by vision.

Comparative study on the difference between hardcopy (printed material) and soft copy (displayed image) is next subjects.

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