Analysis of the Eye Movements and its Applications to Image Evaluation

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Introduction

As is well known, image quality is dependent on sharpness, tone scale reproduction, graininess and color reproduction characteristics of the observed image.

Over the last 50 years many quality criteria have been proposed and used for image evaluation[1]. However, image quality is also dependent on the scene content, particularly in subjective evaluations. It is reported that eye movements provide useful information in the analysis of subjective evaluations. Hence, in this paper the relationship between gazing areas and image quality is analyzed in terms of eye movements.

We measured the eye movements of six observers during the viewing of seven kinds of images on a CRT. The gazing areas are the most important regions of the image for the observers, therefore its information can be applied to the development of improved data compression and transmission algorithms and systems.

The purpose of this paper is to discuss and clarify the relationships between gazing areas and both subjective and objective image quality evaluations.

Gazing Area on CRT Images

Eye movement of six observers (students of our laboratory, three males and three females) were measured during the viewing of the images. Seven digitized images (512×480 at 8 bits) were used as test scene. Six observers viewed these images displayed on a CRT for a minute. Figures 1 and 2 show typical images used in our experiments.

Gazing points were obtained from raw eye movements data by gazing point definition[2]. The images were divided into 10×10 sub-regions and the number of gazing points were counted for each sub-region. The distributions of gazing points were obtained by normalizing the maximum number of gazing points as 1.0 in the 10×10 sub-regions. Regions with value larger than 0.5 were defined as gazing areas of the image. Figs. 3 and 4 show sample distributions of gazing points corresponding to the image Figures 1 and 2. The individual distributions by six observers were very similar in each scene. Then the differences between average gazing area and individual gazing area were evaluated as individual differences. The result is shown in Table 1. They are less than 4 sub-regions, that is, less than 4.0% of total area in each image.

These results mean that most images tend to have a particular gazing area.

Figure 1. Fruits (original is color)

Figure 2. Woman (original is color)

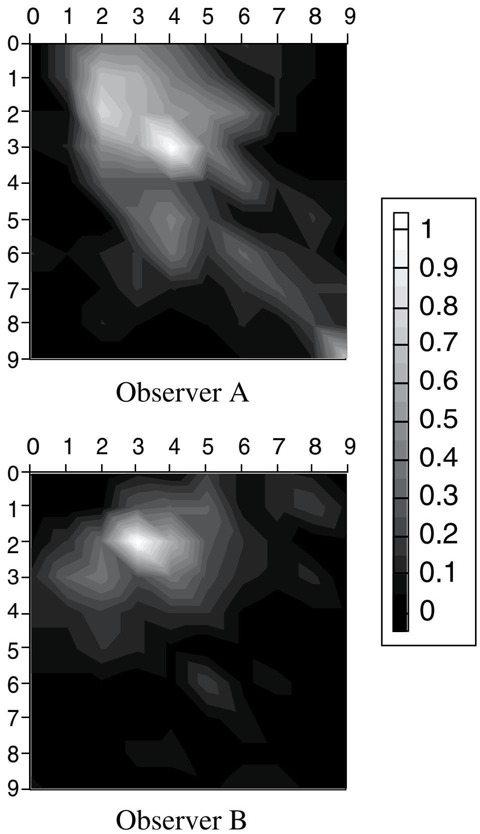

Figure 3. Sample distributions of gazing points (fruits)

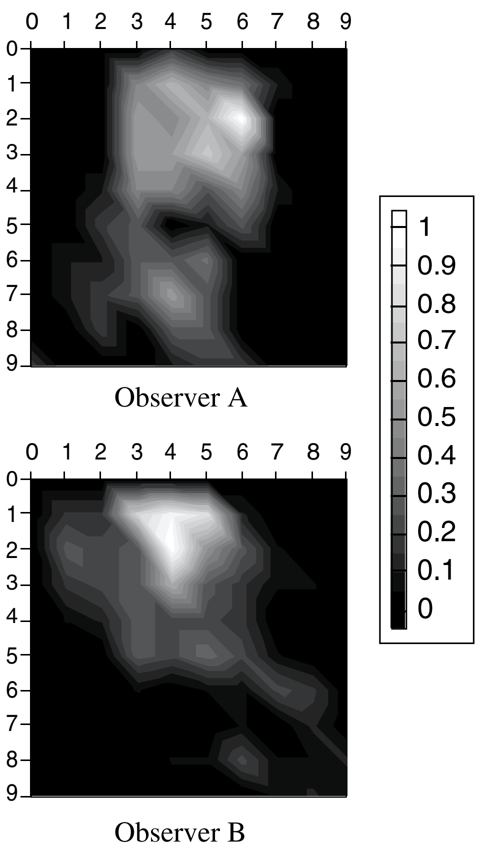

Figure 4. Sample distributions of gazing points (woman)

Table 1. Individual differences for gazing area

image	individual differences
fruits	3.67
woman	0.33
chart	2.5
orchids	3.67
girl	3.5
Fuji	2.17
portrait	3.83

Subjective Evaluation of Modified Images

It is postulated that the gazing area can be used to implement data compression and transmission because gazing areas are the most important regions of the image. Hence, the images degraded partially by blurring or adding noise were evaluated subjectively. Three types of degradation, inside of gazing area, outside of gazing area and in entire scene, were tested.

Same observers in above experiment were asked to rank how much the impression of image quality changed and to place each image into one of five categories (good, ... poor). In this experiment, images were displayed for 5 seconds.

As shown in Figure 5, the images modified outside of the gazing area, that is, the images in which the gazing area remained without modification, were ranked higher except for two images, fruits and chart. This experimental result shows that the gazing areas are the most important regions for evaluation of image quality, consequently suggests that its information is useful for data compression and transmission. The result associated with fruits and chart scenes, however, are opposite to others. In fruits and chart scenes there are several regions to gaze at since their scenes are much more complex with detail than the other, then gazing points were spread for a few seconds.

These experimental result show that the method can be applied to image compression. Then we partially compressed images using JPEG (Joint Photographic Experts Group) in stead of the operations mentioned above and performed subjective evaluation experiments in the same method. After compression the file size was 1.1% ~ 2.3% compared with original file size. The result is shown in Figure 6. Except for the chart and orchids scenes, the images compressed outside of the gazing area were ranked higher. Gazing area is applicable to practical compression. Orchids scene has a lot of uniform regions outside of the gazing area. We consider that typical block artifact by local compression was appeared especially in such regions and yielded the above result.

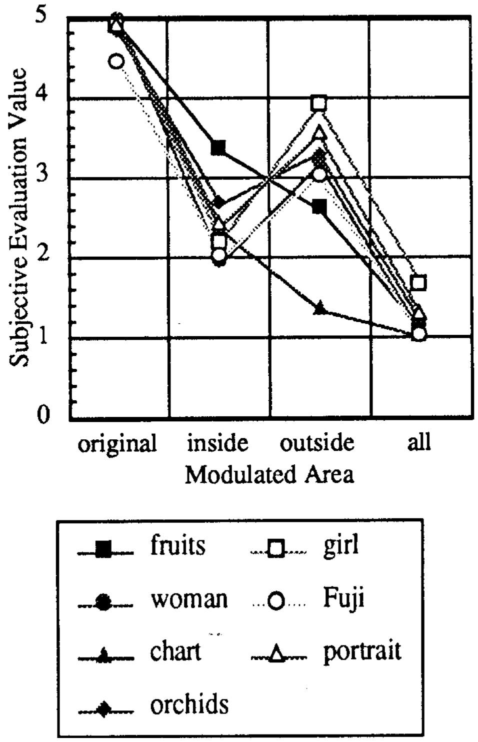

Figure 5. Result of subjective evaluation

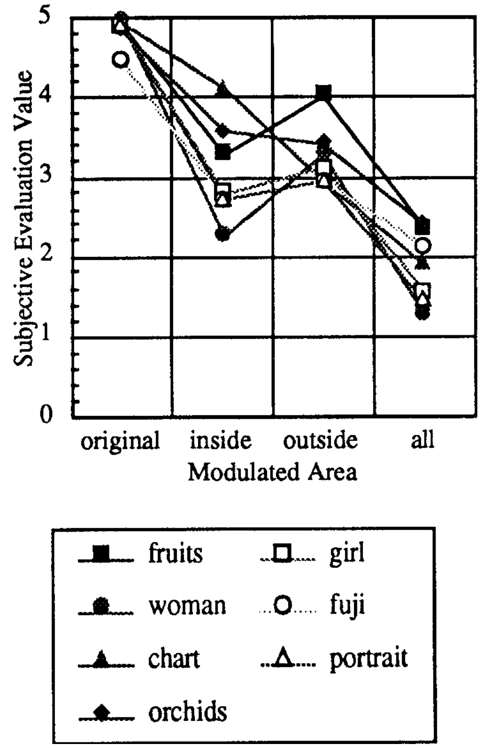

Figure 6. Result of subjective evaluation

Conclusion

It was shown that images have a particular gazing area. It was also found that the image quality impression is influenced by the quality of the gazing area, particularly in images such as a human face. From the experimental results, it can be concluded that this type of gazing area information can be applied to data compression and transmission.

References

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