

An Effective Method for Analyzing the Human's Region of Interest

Cheng-Min TSAI,¹ Shing-Sheng GUAN,² M Ronnier LUO,³ Stephen WESTLAND³

¹ Department of Creative Product Design and Management, Far East University, Taiwan

² Graduate School of Design, National Yunlin University of Sci. and Tech., Taiwan

³ School of Design, University of Leeds, United Kingdom.

ABSTRACT

The aim of this study is to develop an effective method to analyze Regions of interest (ROI). A psychophysical experiment was conducted in this study. The observer's eye movement data were accumulated. The fixation map was established in terms of CIELAB L^* values. The delta L^* values between two maps were used to express the difference of visual fields, counting methods. Thirty observers participated in visual experiment (19 females and 11 males whose average age was 23). The experimental images were categorized into three groups, portraits, landscapes with architectural images, indoor multiple objects images. The results showed that the fixation map can be effectively used to analyze the distribution of eye movements between images. The delta L^* value calculated between two fixation maps is easy to understand and is more effective by computing the difference only based on ROIs than that based on entire image. The results also showed that eye-tracking data is robust for evaluating image quality study.

1. INTRODUCTION

More recent studies were to identify the Region(s) of Interest (ROI) in an image, which is defined as the area of an image that attracts more visual attention than the others (Fedorovskaya *et al.*, 1996; Privitera & Stark, 2000; Privitera *et al.*, 2005). Privitera and Stark indicated that the ROIs are defined as the loci of the human's eye fixations and they can be analyzed by their spatial distribution over the visual stimulus and their temporal ordering (Privitera & Stark, 2000). They developed an image quality model based on the focus of visual attention of an image rather than the entire image (Santella & DeCarlo, 2004). Privitera *et al.* conducted a series of experiments to predict the scan-paths of eye movements using an eye-tracking system (Privitera *et al.*, 2005). They then used geometrical spatial kernels and linear filter models to locate the ROIs in an image. Nguyen *et al.* grouped ROIs, based on the analysis of scan-paths and sequences of fixation for viewing grayscale images, and subsequently performed compression on the areas based on ROIs of an image (Nguyen *et al.*, 2006). The algorithm only addresses grayscale images and therefore may not work well for colour images.

Henderson and Hollingworth indicated that eye movements are critical for the efficient and timely acquisition of visual information during complex visual-cognitive tasks (Henderson & Hollingworth, 1998). The eye tracking technique has widely applied in various research areas, such as human factor and interface design, advertising and marketing, psychology and neuroscience, attention span and visual text. In the image assessment research field, fixation map analysis provides an opportunity to objectively define the principal areas of ROI for viewing images (Wooding, 2002). This study was designed to be different from the previous studies by employing eye-tracking technique. The aim of this study is to develop an effective method to analyze ROI.

2. EXPERIMENT

2.1 Sample Preparation

The experimental images were selected from ISO standards and some were collected from the Kodak Lossless True Color Image Suite (Kodak, 2007). All of these images were first categorized into three groups, portraits, landscapes with architectural images, indoor multiple objects images. The experimental images were then selected from each category for the current experiment as shown in Fig. 1. The size of an image was 1280 by 768 (pixels). The images were randomly displayed during each observation session where the background was a mid-grey colour having L^* about 60.

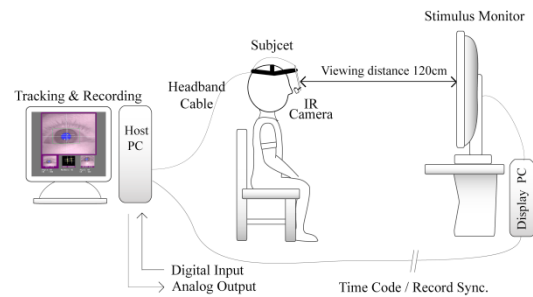


Figure 1 *The images used in Experiment.* Figure 2: *The eye tracking apparatus set for experimental condition.*

2.2 Psychophysical Experiment

An EyeLink II was used using an infra-red head-mounted, video-based, pupil and corneal reflection eye tracking apparatus. It had a high resolution (noise-limited at $<0.01^\circ$) and a fast data rate (more than 250 samples per second). It was easy to operate and required less than a minute to conduct the calibration process before commencing the experiment. Fig. 2 shows the experimental condition. Observers sat in front of the LCD-TV and wore a headset containing a camera to record their eye movements and fixation locations. The time fixated on each pixel and the eye position of the image was stored on the Host PC. The observers judged image quality on the stimulus monitor controlled by the Display PC. The eye-movement data were processed instantly in terms of fixations and saccades, the count of the fixation point, in a form ready to be used for the data analysis. A 30-inch LCD-TV was adopted to display images. The study was conducted in a laboratory with an ambient illuminance at about 230 lux, and a correlated colour temperature (CCT) close to 6,500K.

2.3 Observers

Thirty observers participated in Experiment I (19 females and 11 males whose average age was 23). All were staff members and postgraduate students from the School of Design, at the National Yunlin University of Science and Technology. All had normal color vision, according to the Ishihara color vision test.

2.4 Data Analysis

All results were reported in terms of CIELAB color differences (CIE, 2004). Fig. 3 shows the workflow to obtain the final outcome to describe ROI (filtered mask and fixation map) from the original image and eye movement data. Each pixel of an image was started as sRGB data

(note the earlier monitor was characterized to be a sRGB monitor). It was then transformed to XYZ, and then CIELAB L^* , a^* and b^* values. Only, the L^* data were used to construct the filtered mask and then fixation map with the visual data from the eye-tracking system. The eye movement data were first analyzed in a square for each fixation point corresponding to a particular visual field size in unit of angle. Many fixation points were then collected from each observer's eye positions, which were used to produce a fixation map for each image.

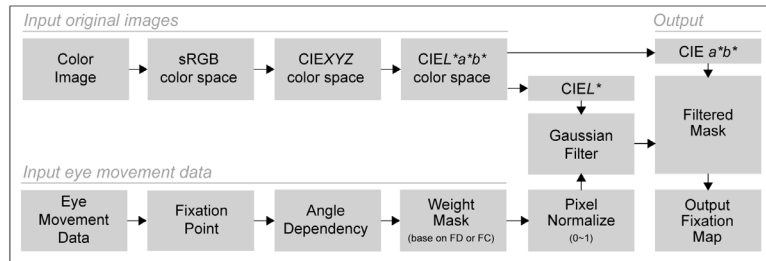


Figure 3: The workflow to calculate Fixation Map.

2.5 Construction of the Fixation Map

The weight (w) of fixation map was constructed by each pixel's fixation area relative to their maximum value of the image considered. Finally, the L^* value of pixel ($_{ij}$) was calculated using Eq. (1) by multiplying the L^* value of original image by the weight for the pixel in question.

$$L^*_{ij} = L'_{ij} \times w_{ij} \tag{1}$$

where L'_{ij} is the L^* value for pixel ($_{ij}$) and w_{ij} is defined by Eq. (2)

$$w_{ij} = \frac{I_{ij}}{Imax_{ij}} \tag{2}$$

where I_{ij} is the frequency of fixation area for pixel ($_{ij}$), and $Imax$ is the peak value of the frequency of the pixel in question.

3. RESULTS AND DISCUSSION

The lightness-difference value calculated between two fixation maps is easy to understand and is more effective by computing the difference only based on ROIs which received more attention. The present results showed that observers tend to ignore the blue sky, grass and foliage in the landscape images; they almost always pay attention to the main objects of the image, such as a building, a fountain. As mentioned earlier, Privitera, and Henderson and Hollingworth, paved a new wave of ROI research (Privitera *et al.*, 2005; Henderson & Hollingworth, 1998). The present study continued their studies by focusing more detailed examination of ROI. It can be concluded that the eye movement measurements provide a valuable research means in imaging science in terms of ROI. The method of fixation map established here corresponding to ROIs of an image is effective.

4. CONCLUSIONS

The results showed that the fixation map which made from fixation area base on L^* value can be effectively used to analyze the distribution of eye movements between images. The delta L^* value calculated between two fixation maps is easy to understand and is more effective by computing the difference only based on ROIs than that based on entire image. The results and trend from two experiments were quite consistent, which implies that eye-tracking data is robust for evaluating image quality study.

ACKNOWLEDGEMENTS

The authors would like to thank NSC scholarship from Taiwan (R.O.C.) for the main author of this paper to study at the Colour, Imaging and Design Centre, at the University of Leeds. The authors would also like to thank many observers too part in the experiments.

REFERENCES

- CIE, Colorimetry. Vienna: CIE 15:2004.
- Duchowski, A.T., 2003. *Eye Tracking Methodology: Theory and Practice*, London: Springer-Verlag.
- Fedorovskaya, E.A., H. Ridder and F.J. Blommaert, 1996. Chroma variants and perceived quality of color images of natural scenes, *Color Research and Application* 22(2) 96-110.
- Henderson, J.M., and A. Hollingworth, 1998. Eye movements during scene viewing: An overview. In G. Underwood (Ed.), *Eye guidance in Reading and Scene Perception* 269-294. Oxford: Elsevier.
- Kodak, 2007. Kodak *Lossless True Color Image Suite*, Retrieved from <http://r0k.us/graphics/kodak/>, August 2007.
- Nguyen, A., V. Chandran and S. Sridharan, 2006. Gaze tracking for region of interest coding in JPEG 2000, *Signal Processing: Image Communication* 21(5) 356-377.
- Privitera, C.M., and L.W. Stark, 2000. Algorithms for defining visual regions-of-interest: Comparison with eye fixations, *IEEE Transactions on Pattern Analysis and Machine Intelligence* 22(9) 970-982.
- Privitera, C.M., T. Fujita, D. Chernyak and L.W. Stark, 2005. On the discriminability of hROIs, human visually selected regions of interest, *Biological Cybernetics* 93(2) 141-152.
- Wooding, D.S., 2002. Fixation maps: Quantifying eye-movement traces, *Proceeding of Eye Tracking Research & Applications Symposium (ETRA 2002)* 31-33.

*Address: Cheng-Min Tsai, Department of Creative Product Design and Management,
Far East University, No.49, Zhonghua Rd., Xinshi Dist., Tainan 74448, Taiwan (R.O.C.)
E-mails: ansel.tsai@gmail.com*