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Gamut Extension Algorithms on the basis of Experimental Data

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The principal aim of this study is to demonstrate the extended applicability of the experimental tool (GUI) used in the colour imaging manipulation experiment of gamut compression [1][2] by applying it to the study of gamut extension.

Two experiments were conducted, *Experiments GE1* and *GE2*. *Experiment GE1* were designed to acquire observer data on the extension of gamuts in terms of colour pleasantness. The experimental tool used in the previous studies [1][2] was modified for *Experiment GE1*. Observers were asked to alter the colours of image pixels based on their location in colour space. The tool consists of two principal parts: *Colour Region Selector* (CRS) for selecting a particular region of colour space and *Colour Appearance Adjuster* (CAA). Many plots were generated to examine the relationship between the initial and reproduction images in the same manner like the data analysis used for investigating gamut compression in the previous studies [1][2]. Figures of lightness and chroma between the initial and reproduction (extended) images, hue variations plotted between the hue angles and hue differences (ΔH^*), and data on the L^*-C^* planes were analysed. A GEA, GEA-1 (*Eq. 1* and *2*), was developed to model the observer experimental data from *Experiment GE1* and its coefficients for lightness and chroma extension were derived using the least square technique.

STEP 1: A Linear Lightness Mapping

A linear lightness mapping is defined in the following equation.

$L_r = 1.02L_o \quad 4.44$ *(Eq. 1)*

where subscripts o and r denote the original and reproduction.

STEP 2- A Linear Chroma Mapping

$C_r = \theta C_o$
where θ =1.33 *(Eq. 2)*

Coefficient 'θ' was obtained using least square fitting technique of statistics analysis software.

Other models (GEA2-6) were devised for (1) to test GEA-1 and (2) to encompass possible perception of pleasantness in higher extension rates. *Experiment GE1* data shows that observers did

not fully adjusted chroma onto CRT gamut boundary. Particularly, developing the group-2 models (*Table 1*) tried to cover the different observer behaviour in the lower chroma levels in the Smile test image. This behaviour was analysed as the skin tone colours considered as memory colour. This was also evaluated in Experiment GE2. The *Group-1* model was devised from the averaged data of three test images, i.e. "IT8" , "Ski" and "Orchid" , having the chroma extension pattern from the origin (neutral point). The *Group-2* models were developed using all four averaged data sets. This model is divided into two parts with a point of 23 (of chroma): this value was obtained qualitatively. It assigns C^*_r to be the same as C^*_0 for C^*_0 less than 23, otherwise $C^*_r = \theta\, C^*_0$, where is the slope obtained from various plots. Each group of models is divided into two or three in terms of the degree of gamut extension determined by the slope of C^*_r/C^*_0 which are given in *Table 1.*

Table 1 Five Different Variations of Chroma Extension

Group	GEA	(Extension) Starting Point	Image data used to fit each model	Sub-Group[1]	θ	R^2
1	2	(0, 0)	IT8, Ski, Orchid	2+3	1.57	0.87
	3	(0, 0)	IT8, Ski, Orchid	3	1.93	0.85
2	4	(23, 23)	IT8, Ski, Orchid, Smile	1+2+3	1.48	0.54
	5	(23, 23)	IT8, Ski, Orchid, Smile	2+3	2.05	0.29
	6	(23, 23)	IT8, Ski, Orchid, Smile	3	3.53	0.14

1: Divide group into three sub-groups (1, 2, 3) in terms of the extent of gamut extension , i.e. $a=C^*/C^*_0$ *(C_r: chroma of reproduction, C_0: chroma original)*

Five variations, i.e. GEA2-6, took the structure of GEA1 and increased the amount of chroma extension so as to verify (1) the amount of extension that the observers have applied was indeed sufficient and (2) they were too cautious with their modifications in the Experiment GE1. In *Experiment GE2*, the GEA-1 and its five variations (GEA-2, 3·6) were evaluated using a pair comparison method together with the average observer images obtained in *Experiment GE1*. GEA-1, GEA-2 and the average images by the observers generally out-performed the others.

References

[1] Kang B. H., Cho M. S., Morovic J. and Luo M. R. (1999) Gamut compression analysis based on observer experimental data, *Proceedings of 7th Color Imaging Conference*:295-300.

[2] Kang B. H., Cho M. S., Morovic J. and Luo M. R. (2000) Gamut compression algorithm development on the basis of observer experimental data, *Proceedings of 8th Color Imaging Conference*:268-271.