Effect of Background Colour on Monitor Characterisation

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ABSTRACT

A common solution for transferring images from one device to another without loss of colour fidelity is to characterise each device in terms of CIE tristimulus values. For example, it would be possible with appropriate characterisation procedures to convert the LCD RGB values to CIE XYZ values and vice versa. Characterisation of devices into a standard colour space that is independent of the device reduces the number of transformations which may be required for adequate performance. The first stage in characterisation is to linearise the data termed "gamma correction" for certain devices and then transform the linearised values in CIE XYZ tristimulus values. In order to determine the non-linearity of the characterisation and the matrix for linear conversion between RGB and XYZ it is normal to make colour measurements of certain colour patches displayed on the system. However, it is known that the colour measurements of the patches may vary with the colour and luminance of the background against which they are displayed. Lack of spatial independence is one of the factors that can cause this phenomenon. This raises the question of what the nature of the background should be for an optimal characterisation of a display system. It is likely that what is optimal will depend upon the intended application of the characterised display (for example, is it being used to display simple images in a psychophysical experiment or more complex images in some other setting). This research considers characterisation with four background conditions (white, grey, black and a new Mondrian-like coloured background) and explores the effect of these background effects on the characterisation model's parameters and on the usefulness of the characterisation in various imaging scenarios.

1. INTRODUCTION

Modern display technology (LCD and LED) has become increasingly popular because of their low power consumption and versatility with respect to placement. To control such displays precisely, it is essential to understand the relationship between digital input values and output colours. Hence colorimetric characterization of a colour display device is a major issue for the accurate colour rendering of a scene. The GOG model (Berns and Katoh, 2002) has been a popular choice for monitor characterization, particularly using the older CRT display technology. Some authors have advised using the GOG model for characterization of LCD displays in part because the nonlinearity of the displays may be not well suited to a gamma function but also because of lack of channel independence (Day et al., 2004). However, many LCDs effectively exhibit a gamma-like response because of manufacturers' desire for them to behave more like a CRT display (and hence facilitate market uptake of the new technology). The work in this paper is part of a wider project to explore characterisation methods for LCD display technology and to assess the effectiveness of the GOG model despite theoretical concerns about its applicability. One particular issue that relates to both CRT and LCD technology is background colour against which samples used to estimate parameters for the nonlinear response of the display are measured. It is known that the colour of a patch displayed on a screen changes depending whether the background of the display is grey, white or black. A grey background is often recommended and this is particularly appropriate if the calibration model is being used to display stimuli in a psychophysical experiment where colours are displayed against a grey background. Even for general use, where the background is not grey, then arguably grey is still a reasonable choice whereas white and black would represent more extreme positions. However, what if the characterization model is being used to display movies? Is a grey background still appropriate and what impact would motion in the background have on the measurements? It is this particular question that the work in this paper addresses.

2. EXPERIMENTS

A Minolta CS1000 spectroradiometer was used to make measurements of stimuli displayed on an LED HP DreamColor LP2480zx monitor housed in a darkened room. Measurements were made using the spectroradiometer mounted on a tripod at a measuring distance of 1 m. Stimuli were generated on the display using a MATLAB GUI so that specific colours (generated with known RGB values) in different backgrounds could be displayed. The colours were 6 × 6 cm displayed on a background that otherwise filled the display screen. Measurements were made using the spectroradiometer of the centre of the colour stimulus. The spectroradiometer setting was such that the instrument automatically integrated light from the display until a sufficiently accurate reading was taken.

Fourteen colours were measured (see Table 1 for the RGB specifications) and these were chosen to include black, white, different greys, the additive primary colours (red, green and blue) and a few colours where all three primaries were moderately active. Measurements were taken for each colour displayed against three backgrounds: (a) grey, (b) Mondrian and (c) Mondrian with movement. The spectroradiometer measured CIE XYZ values (1964 standard observer) which were downloaded to a computer and subsequently analysed.

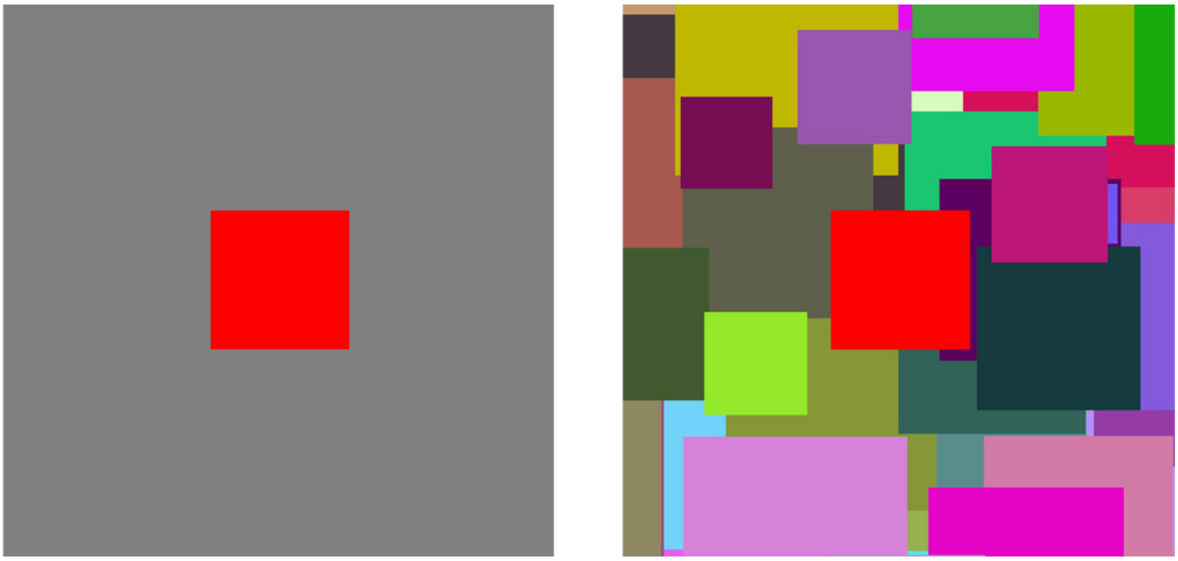

Figure 1: Typical colour stimulus displayed against a neutral grey and Mondrian background

Figure 1 shows an illustration of a typical colour stimulus displayed against a neutral grey and Mondrian background. The grey background RGB values were [128 128 128]. The Mondrian was generated using a specially developed algorithm and each patch of the

Mondrian pattern had a random colour. In the moving-Mondrian condition the Mondrian background moved across the display (diagonally) at a rate of about 0.01 m/s.

3. RESULTS AND DISCUSSION

Table 1 shows the CIE XYZ values that were measured for each of the colour stimuli in each of the three conditions (background). These values are absolute colorimetric measurements so that the luminance of the white, for example, when displayed on the grey background was 174.67 cd/m^2.

Table 1: CIE XYZ measurements of the stimuli in each of the three conditions

			Grey background			Mondrian background			Movie background		
R	G	B	X	Y	Z	X	Y	Z	X	Y	Z
0	0	0	0.65	0.63	0.86	0.65	0.64	0.92	0.77	0.75	1.02
255	255	255	171.23	174.67	184.60	171.10	174.60	184.60	169.29	172.96	183.81
50	50	50	4.98	5.07	5.51	5.07	5.19	5.53	4.91	4.98	5.51
128	128	128	39.41	40.93	42.60	39.48	41.03	42.70	38.61	40.09	41.86
200	200	200	106.00	109.83	116.23	106.00	109.87	116.30	104.67	108.45	115.15
255	0	0	96.47	44.86	1.91	96.35	44.81	1.99	95.07	44.25	2.14
0	255	0	43.35	116.73	9.34	43.43	116.77	9.47	43.07	115.84	9.46
0	0	255	33.08	14.76	175.60	33.04	14.74	175.47	32.98	14.77	174.73
128	180	50	44.28	69.20	9.98	44.29	69.22	10.08	43.55	68.26	9.87
128	50	180	39.13	20.42	87.28	39.17	20.48	87.22	38.51	20.09	86.46
50	128	180	29.00	35.89	88.67	29.09	35.95	88.63	28.60	35.24	87.78
180	128	50	57.45	49.40	7.99	57.42	49.38	8.12	56.55	48.55	7.88
50	180	128	31.75	63.32	44.50	31.81	63.37	44.62	31.28	62.47	43.73
180	50	128	55.01	28.03	41.13	55.05	28.09	41.25	54.27	27.61	40.59

The data in Table 1 were converted to CIELAB L*a*b* values (using the white from the grey-background condition as the white point) so that the white for the grey-background condition (only) had values of L* = 100 and a* = b* = 0.

CIELAB ΔE values were computed between the colours with the Mondrian and movie backgrounds and the corresponding colours with the grey background. Table 3 shows the colour differences that resulted.

4. CONCLUSIONS

The colour difference between the Mondrian-background condition and the grey-background condition was, on average, 0.25 CIELAB units. However, the mean colour difference for the movie-background condition was 0.70 and this is statistically different from the Mondrian-background condition ($p<0.05$). This suggests that using a static grey background for the characterisation samples might not be the best strategy for a display-characterisation model that will be used for display of moving images.

Table 2: Colour differences between Mondrian- and movie-condition backgrounds and the grey-condition backgrounds.

			Grey v Mondrian	Grey v Movie
R	G	B	ΔE	ΔE
0	0	0	0.59	0.74
255	255	255	0.06	0.59
50	50	50	0.57	0.50
128	128	128	0.06	0.53
200	200	200	0.05	0.46
255	0	0	0.71	2.46
0	255	0	0.35	0.88
0	0	255	0.03	0.53
128	180	50	0.21	0.53
128	50	180	0.21	0.41
50	128	180	0.16	0.72
180	128	50	0.37	0.61
50	180	128	0.10	0.43
180	50	128	0.08	0.36
Average			0.25	0.70

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