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Abstracts

Colour appearance data for mobile phone display

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The mobile phone has developed into a portable display device which requires image quality. This study is to investigate the characteristics of mobile phones and to develop a characterisation model to convert the display-dependent values to device-independent values. PLCC (piecewise linear interpolation assuming constant chromaticity) and polynomial model were used for characterisation modelling. Subsequently, a psychophysical experiment was conducted to collect colour appearance data under two surrounds and three backgrounds. Colour appearance data from the psychophysical experiment showed that lightness of the colour patches appear lighter when displayed against a black background other than against grey or white backgrounds. Lightness of colours appears slightly lighter under the dark surround than that under the dim surround. However there was little colour variety for colourfulness and hue. The colour appearance effect are verified by comparing the visual data between each session. Then the colour appearance data is used to test the CIECAM02. CIECAM02 predicted lightness of the colour patches quite well under different surrounds and backgrounds. However, CIECAM02 predicted light colours lighter than the experimental results and dark colours darker when the colours are displayed against a grey and a white background. The CIECAM02 colour appearance model predicted the colours much more colourful than the visual results when the samples were displayed against a black background. Under every condition, the CIECAM02 colour appearance model predicted the reddish blue colours more bluish and greenish colours more bluish.

Image Quality Difference on a Mobile Display

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A series of psychophysical experiments using paired comparison method (or external reference) was performed to construct an image quality difference model of a mobile LCD. Test images rendered by manipulating visual resolution, colour bit depth, luminance, correlated colour temperature, lightness, chroma and hue were prepared and observers were asked to choose one of the images in a pair as which one is more natural, clearer, sharper and so on.

All image quality attributes show that there is a difference in 95% confidence level expect for the colour temperature attribute. Bit depth differences are twice less noticeable than resolution difference and the threshold values were image dependent. Most observers could not distinguish 6-bit images from 8-bit images in colour change. However, the colour differences between 160 ppi, 180 ppi and 200 ppi were discernable in the images that contained many

details. All attributes increased image quality until reaching 200 ppi in resolution. Comparing luminance, all attributes increase image quality until reaching 80%. Most attributes stopped increasing image quality at 6-bit (or 5-bit) in bit depth. The results show that there are hardly visual differences between 6-bit, 7-bit and 8-bit. Comparing different colour temperatures, it is confirmed that the preferred colour temperature is 6500K and sharpness and colourfulness are independent of the change in colour temperature. This finding is different from the above results, which could be due to the degree of adaptation. In the current experiment, observers did compare two subsequent images leading to incomplete adaptation. The result in lightness, chroma and hue manipulations showed better quality in the original images.

An image quality difference modeling was performed to predict image quality difference scale as functions of the observer's visual responses. The correlation coefficient between image quality scale and image quality difference metric was 0.99. The weight factors of each attribute indicate that the most important attribute is naturalness and sharpness and clearness are also crucial to image quality difference.

Image quality metrics of a mobile LCD

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Image quality research can be divided into two approaches: external and internal reference. The former assumes that reductions in image quality correspond to perceptible visual differences from its origin. The latter can be similarly written that reductions in image quality correspond to perceptible visual differences from its memory prototype. This study focuses on the internal reference to develop image quality metrics of a mobile LCD.

A psychophysical experiment using category judgment method was carried out in a dark room to develop image quality metrics of a 2-inch QVGA mobile LCD. Five natural test images were rendered in terms of 8 physical parameters, lightness with linear and non-linear alterations, chroma, hue, luminance, correlated colour temperature (CCT), bit depth, and resolution (220 images in total). Ten observers rated each of the rendered images, using 9-category (1 to 9), for 7 visual attributes, those used were naturalness, clearness, sharpness, contrast, colourfulness, quality, and preference. All image quality attributes showed that there is a difference in 95% confidence level except for the hue angle. Sky and fruit dominated images showed their highest quality for the hue angle level of -15° , and 15° . For colour renderings using the lightness, luminance and chroma attributes, lighter and more colourful images showed higher quality and were more preferred by observers. However, the difference between the highest level and second highest level was not significant. Observers did not recognise a difference between different CCTs, since they fully adapted to each white point. A non-linear effect was found when increasing bit depth from 4 to 8 bits. Image quality scales were reduced for lower resolutions. It was found that naturalness, clearness, and sharpness are the main attributes for image quality.

Quality of the LED Based Daylight Simulators

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The colour appearance of a physical sample varies according to the composition of the light reflected from it, which enters the observer's eyes. This is governed by two factors: the reflectance characteristics of the sample and the composition of the light falling on it. However, the natural daylight, which is used prevalently and widely, varies significantly in composition, from the reddish light of sunrise to the bluish light of cloudless northern sky.

Furthermore, natural daylight is not available either at night or in many interior rooms. These limitations have motivated a long search for ways to simulate natural daylight, usually by choosing lamps and developing filters to modify their spectral power distributions, such as tungsten lamps, xenon lamps and fluorescent lamps. However, these traditional lamps may be replaced by LEDs, which are longer life span, higher luminous efficacy and more energy saving etc. With these in mind, different coloured LEDs were employed to simulate D65 by different physical criteria in this study, such as colour rendering index (CRI), reflectance difference (RD) and metamerism index (MI). The results show that when the light of different coloured LEDs were mixed together, high ranked colour with high CRI and low MI can be achieved theoretically. Although the agreement between the practical light and the predicted light was not good enough due to the low illuminance, the limitation of the LED samples on the wavelength coverage and the uniformity of the device, the idea of using coloured LEDs as a D65 simulator is still promising.

Input Device Characterisation: A Comparison between Iteration and Regression Methods Using either XYZ or L*a*b*

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Scanner and digital camera characterisations are mostly done with regression method, transforming RGB of those devices to XYZ tristimulus values (XYZ approach). Another approach is transforming RGB to L*a*b* (L*a*b* approach). The non-linear relationship between XYZ and L*a*b* means that the L*a*b* approach requires higher order polynomials which are more vulnerable to local maxima and minima. Therefore some researchers suggest it would be preferable to avoid the L*a*b* approach of characterisation.

A drawback of the XYZ approach is that the optimum is the minimum of the sum of the squares of difference between measured and predicted XYZ tristimulus values. However, this optimisation criterion has no direct relationship to the visual perception of colour. In order to solve this problem researchers suggested different methods of which iteration method is an important one.

In this study, an “Epson Perfection 2400 Photo” scanner has been characterised by regression in different approaches and it could be shown that, using the same polynomial order, the L*a*b* approach will lead to more accurate results than XYZ approach. The former approach has the benefit of having an optimisation criterion, the sum of the squares of difference between measured and predicted L*a*b*, which has a direct relationship to the visual perception of colour.

Furthermore, the results of the iteration methods with different optimisation criteria, such as the sum of colour difference, the sum of the squares of colour difference, etc, have been compared with the results of the regression methods (XYZ and L*a*b* approaches) and it has been concluded that regarding characterisation accuracy there is no advantages of using the iteration method.

Finally, advantages and disadvantages of each method are summarised.

Testing the softproofing paradigm

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The purpose of this work was to assess the suitability of softproofs as a surrogate for the final print in judging colour-reproduction quality. A complex viewing apparatus was specially designed for this study to ensure that no cognitive cues were visible to observers and that the surround conditions for viewing softcopies and hardcopies were in very close agreement.

Observers were first prompted to assess whether two colorimetrically identical stimuli were generated by the same or different media. They could reliably observe the media difference because of the intrinsic inaccuracies of the devices involved, but they could not identify the exact type of medium used to generate the stimuli. Although obtaining an exact colorimetric match is thus probably impossible for complex images, we conclude that the type of medium used to generate stimuli does not influence their appearance. Furthermore, two experiments targeting judgements related to colour quality were carried out. Each experiment was conducted using two workflows: one involving hardcopy stimuli, and the second involving softcopy simulations of those hardcopies. The conclusion that can be drawn is that judgments made on the basis of softproofs are transferable to prints. Providing that the viewing conditions are very carefully equated and that a significant number of test images is used, softproofs are suitable as surrogates for the final print in judging the quality of colour reproduction.