Colour Image Adjustment and Digital Printing

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Abstract

Even subtle (and subjective) colour image adjustments may result in visually significant colour changes. This kind of adjustments were compared with the (more or less) incontrollable colour alteration of modern digital reproduction process. Hundreds of differently adjusted photographic pictures were printed on different papers with (Xeikon) digital colour press and (HP) ink jet printer.

The prints were evaluated visually. The results showed that despite the careful colour management and calibration of all the devices and processes, the appearance of the prints could not be accurately predicted. In many cases the reproduction process caused at least as large changes on the visual appearance (of the original) as delicate image adjustment. In addition to the printer characteristics, the properties of the printing paper proved to be an important explanatory factor for these results.

Introduction

The colour adjustment of digital images may be necessary in order to correct some clear deficiencies of the original picture, such as poor contrast or colour balance. However, often even high quality pictures are adjusted. When this happens, the changes are usually small (but visually significant) and reflect someone's subjective preferences.

Making subtle colour balance, lightness, contrast or saturation changes is not very sensible if these changes cannot be reproduced by means of the output process. The goal of this paper is to proportion this kind of delicate colour adjustments to the qualitative performance of modern colour management and digital printing.

Colour Image Adjustment

The high quality photographic test images were carefully chosen in such a way that the visually critical colours were safely within the output gamut of all processes. Thus (at least theoretically), colorimetric rendering was possible. All the digital originals were Adobe (1998) RGB or sRGB images.

The grey balance, lightness, contrast and saturation of the test images were adjusted. The adjustment parameters were varied and a variety of "one- and two-dimensional" (1×5, 5×5, 1×7, 7×7) combination pictures was calculated. An example is shown in *Fig. 1*. The goal of the adjustments was to produce relatively small but clear visual difference between adjacent pictures. In practice this meant that, for most images, the magnitude of colour differences between the visually critical image colours was about 3 ΔE* (CIELAB).

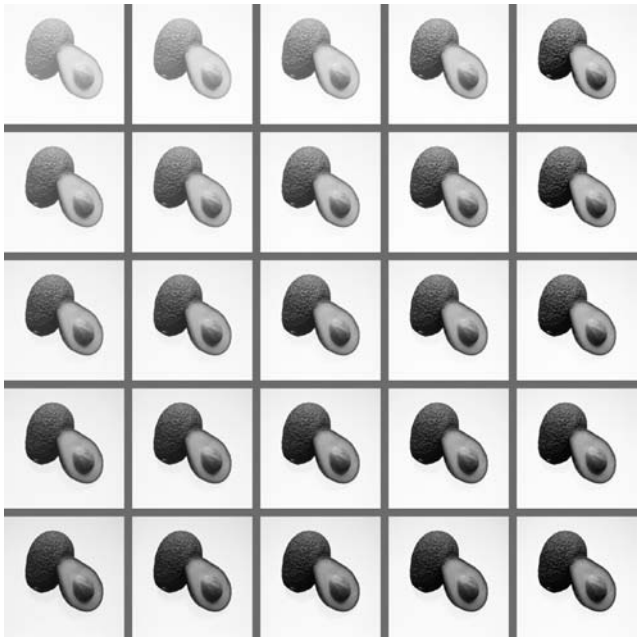

Figure 1. Contrast/Lightness adjustment test image. (contrast increases from left to right; this is a black-and-white version of the original colour image)

Digital Printing

About 900 differently adjusted pictures were printed on different papers with Xeikon DCP 500 D digital colour press and HP DesignJet 2500CP ink jet printer. The experiments were made primarily with the ink jet printer but extensive tests were also made with the Xeikon press. At first spatial and temporal colour variation was measured. The spatial variation within the printed sheet was occasionally evident but consistent effect on the visual appearance of any test image could not be shown. The variation was spatially dense and random but usually moderate as illustrated in *Fig. 2.* (Only the lightness component of the CIELAB values is shown.) It should be noted, however that spatial variation may also have an effect when colour management profiles are made. The size of the measured print sample was 18x26 cm^2, which is roughly the same as the size of a typical printed (IT8) test image used for making output (ICC) profiles.

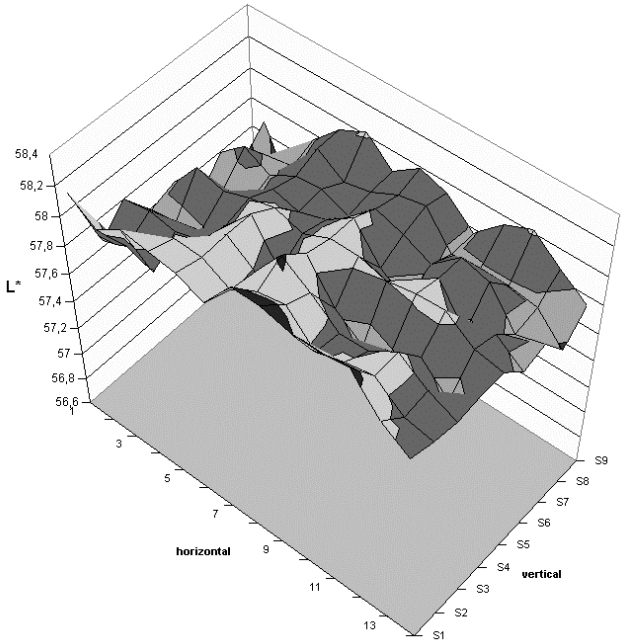

Figure 2. An example of spatial lightness variation (HP ink jet; hi-gloss photo paper; CIELAB medium grey)

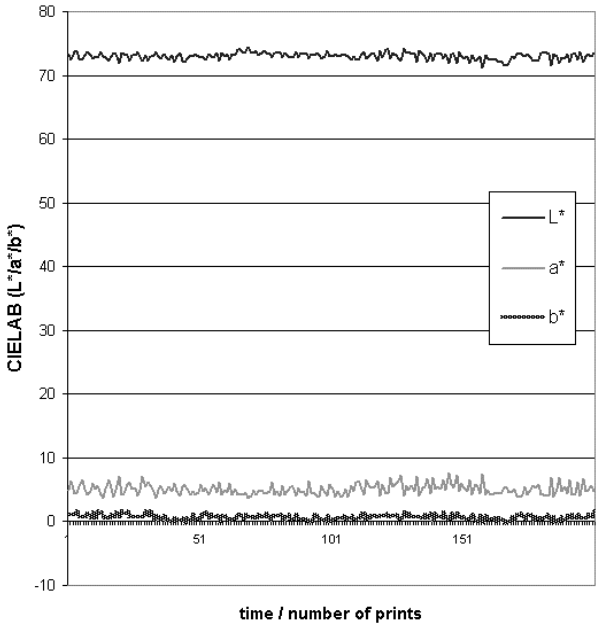

Figure 3. An example of temporal colour variation (CMY light grey; UPM digicote; 200 copies)

The temporal colour variation of the digital printing press was occasionally quite substantial as shown in *Fig 3.* When compared with spatial variation the maximum ΔE* was higher (> 4) and the visual effects noticeable.

ICC profiles were made for all papers used for digital printing. The papers are listed in Table 1.

Table 1. CIELAB (D_{50}) values of the printing papers

Ink jet papers	**L***	**a***	**b***
HP hi-gloss photo	91.90	0.47	-7.24
HP heavy coated	95.94	0.96	-5.26
Digital press papers			
Galerie fine silk	95.05	1.47	-5.46
Galerie one silk	94.02	1.03	-5.56
Silverblade digital gloss	93.72	1.37	-5.21
UPM digicote	92.11	0.80	-1.98

Visual Tests

All the prints were evaluated visually in standard viewing conditions (CIE D_{50} illumination). Direct comparison of the prints, printed on the same paper, showed that temporal colour variation could cause grey balance changes of the magnitude similar to subtle image adjustment.

Simultaneous visual evaluation of the prints, printed on different papers, showed also interesting results. Due to the gamut and dynamic range differences e.g. contrast was often perceived quite differently. However, the contrast adjustment parameters could still have the same optimum values. Grey balance, however, was clearly affected by paper properties. For example, when Galerie fine silk and UPM digicote prints were compared the large colour difference between these papers (ΔE* = 4.6) predicted well the perceived visual difference of the prints. For many images this did mean that in order to attain optimum results quite different adjustment parameters should be used. In general the digicote prints gave warmer and more yellowish an impression. This was clearly the case when direct simultaneous comparison and relative colorimetric rendering was used. This difference diminished when binocular viewing was used. However, in normal reading situations the properties (and especially the colour) of the printing paper proved to have an essential effect on visual image appearance.

Conclusion

Despite the careful colour management and calibration of all the devices and processes, it proved to be difficult to predict the appearance of the prints. In many cases the reproduction process caused substantial incontrollable changes on the visual appearance of the original image. This unpredictability depends partially on image properties but may well affect the result more than delicate image adjustment measures.

The improvement of this situation requires more profound understanding of the colour management and digital printing processes as well as the effects of paper properties and practical viewing conditions.

Biography

Pekka Laihanen received his Ph.D. in Graphic Arts and Image Science from the Helsinki University of Technology (HUT) at Espoo in 1995. His work has primarily focused on different aspects of color image quality.