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The Influence of the Surrounding Space on the Lighting Conditions in a Photographic Scene

Veronika Štampfl and Jure Ahtik

University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Textiles, Graphic Arts and Design, Chair of Information and Graphic Arts Technology, Ljubljana, Slovenia

Introduction

Lighting conditions are one of the most important factors for good photographic exposure. In enclosed spaces, like a photography studio, we can control the light in several ways. We can adjust the type of light source, the shape of the light source, its intensity, and in some cases the colour temperature of the emitted light. The distance of the light source from the observed photographic scene affects the amount of light that reaches the desired target, and therefore the actual lighting conditions on the photographic scene. However, the environment surrounding the photographic scene is often overlooked.

Problem Description

The emitted light interacts not only with the objects within the photographic scene, but also with any obstacle in the path upon which a light ray falls. Light rays can be reflected, partially reflected, absorbed, or scattered from any surface in the immediate vicinity of the scene, depending on the material properties of the objects they encounter. In the case of reflection, the observed scene is additionally illuminated by the reflected light, since the reflecting surface in the near environment acts as another light source. Light-absorbing surfaces, on the other hand, do not affect the scene in the same way, since the light is absorbed and not multiplied by the reflection. Reflections from the surrounding environment can therefore affect the intended lighting conditions of the observed scene in ways that we did not anticipate.

Methods

This study compares the lighting situations in scenes:

- different colour backgrounds (white, grey, black, orange, blue),
- reflective materials as backgrounds (silver and gold),
- positioning often used objects in the background, such as extra lights,
- darkroom with minimal environmental influence.

The general illumination conditions at the observed photographic scene are described using spectrophotometric methods, while image analysis is used to numerically describe the differences in uniform illumination of ColorChecker DC test chart. For the image analysis we developed a Python programme, whose actions are represented with the following pseudocode:

```
import images
read RGB values of all patches on all images
import measured RGB values of all patches
convert all RGB values to CIE XYZ
convert CIE XYZ to CIE Lab
calculate colour differences dE00
  for test images and imported colour values
calculate colour differences dE00
  for test images and darkroom image
convert CIE XYZ to CIE Luv
convert CIE Luv to CIE LCHuv
get average differences
  for each component in CIE LCHuv
plot results
```

Results

The results show that the lighting conditions in the scene change drastically when the background is changed. In darker environments such as darkroom, grey and black backdrops, and grey and black lights, the colour differences are the smallest, indicating the best colour rendering conditions, seen in *Figure 1*. This is due to the combination of: (1) low surface reflectance of the materials, (2) their CIE xy values have no obvious chromaticity, and (3) the brightness aues are relatively low. We expected the white background and white lights to give similar results, but they show a higher colour difference, although their reflectance rates are in the same range as the darker backgrounds and show no obvious material chromaticity. However, their *CIE Y* values are the highest of the entire test group. This indicates that the brightness of the background material is a sufficient parameter to affect the colour differences that appear in the photographic scene. This finding prompted us to analyse the brightness and colour properties separately in the further course of the study.

We would expect the blue and orange backdrops, along with the gold reflector, to produce the greatest colour differences, as a colour shift is clearly observed in spectrophotometric analysis of the scenes. The same is observed in the sample for silver reflector, while it has no colour shift in previous analysis. This suggests that the ability of the material to reflect light can strongly influence the colour differences produced in a photographic scene and can be less predictable.

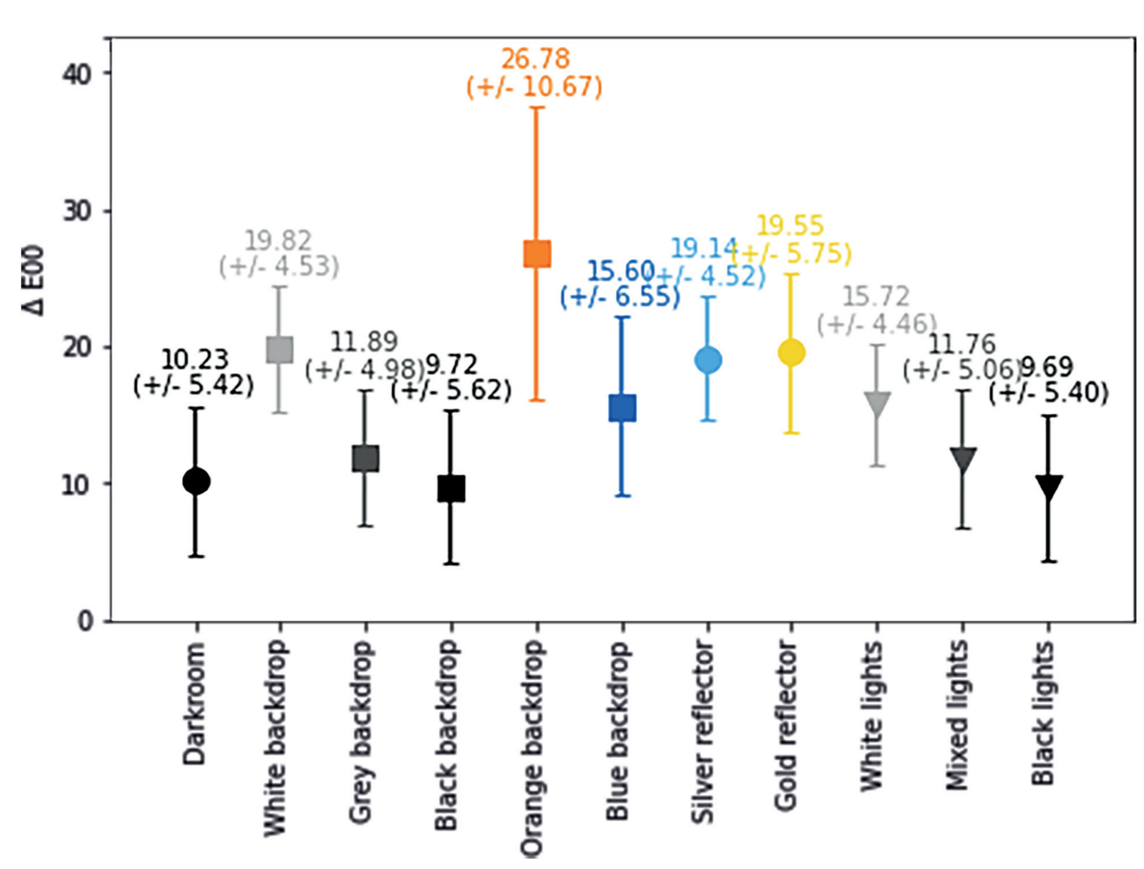

Figure 1 *Mean colour difference ΔE_{00} of the sample between measured colour values of the ColorChecker DC and tested setups.*

Figure 2 shows results with similar trends for each CIE LCH_{uv} component. In general, the brightness difference *Δ CIE L* is most affected out of the three parameters and becomes proportionally larger with background brightness. The difference between chromaticity and hue for grayscale background situations (backgrounds and lights) never exceeds the normalized value of 0.2, indicating that the light reflected from the background does not contain any additional chromaticity not generated by the light source. For coloured samples (orange and blue backdrop, silver and gold reflector), not only the *Δ CIE C* chromaticity values are the highest, but also the *Δ CIE* H_{uv}, indicating a shift in hue. The *Δ CIE* H_{uv} for blue backdrop deviating from this thesis only due to illumination conditions, since the emission spectra of light source overlaps with the absorption spectra of the material.

Results for the darkroom, black backdrop, black light show low ΔE_{00} values and are closely followed by grey backdrop and mixed lights. These five setups also produce the lowest chromaticity and hue differences, while darkroom, black backdrop, and black lights have low *Δ CIE L* values. Therefore, we evaluate the darkroom, black backdrop and black lights setups as the most successful in having no effect on the colour properties of the scene and suggest that such setups should also be used in research analysing the colour properties of scene elements.

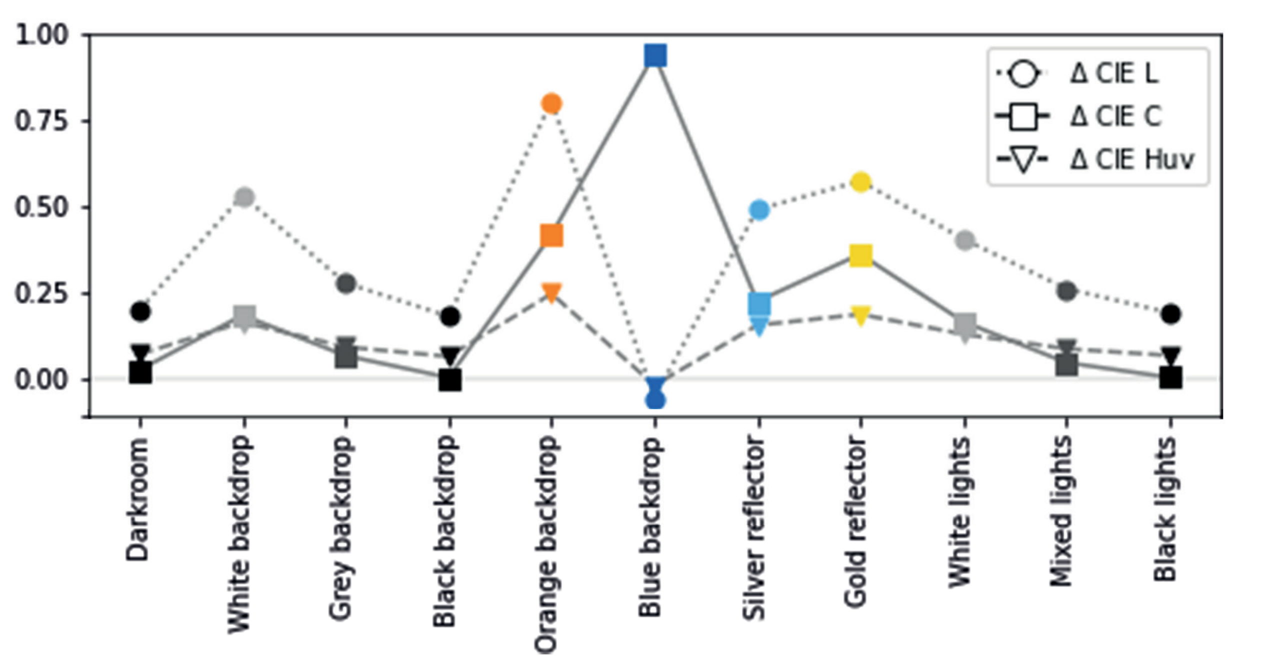

Figure 2 *Normalized differences for each component in CIE LCH_{uv} colour space between measured colour values of the test chart and tested setups.*

Discussion / Conclusion

Research has shown that surfaces in the environment should have the lowest possible reflectance, no obvious coloration, and low brightness values so that the photographic scene is affected as little as possible by the environment. Each of these three parameters has been shown to have a significant effect on the observed colour properties of the scene.

We have observed a large influence of the properties of the light source on the colour conditions of the scene in cases where the emission spectrum of the light source overlaps with the reflection spectrum of the material under study, resulting in the majority of the light being absorbed and therefore the background having less influence on the illumination differences of the scene.

REFERENCES

Ahtik, J. (2017) Comparison of ICC and DNG colour profile workflows based on colorimetric accuracy. Journal of Print and Media Technology Research, 6(3), pp. 115-121.

Bitlis, B., Jansson, P. A., & Allebach, J. P. (2007) Parametric point spread function modeling and reduction of stray light effects in digital still cameras. In Computational Imaging V, 6498, pp. 253-260.

Colour Developers. (2022) Colour Science. Colour. Available from: https://www.colour-science.org/ [Accessed 17th August 2022].

Davis, W., & Ohno, Y. (2009) Approaches to color rendering measurement. Journal of Modern Optics, 56(13), pp. 1412-1419.

Gunde, M. K., Ahtik, J., Golob, G., & Krašovec, U. O. (2009). Color rendering properties of light continuously modulated by an electrochromic switchable device. Color Research & Application: Endorsed by Inter-Society Color Council, The Colour Group (Great Britain), Canadian Society for Color, Color Science Association of Japan, Dutch Society for the Study of Color, The Swedish Colour Centre Foundation, Colour Society of Australia, Centre Français de la Couleur, 34(4), pp. 321-329.

Hough, C. (2013) Studio Photography and Lighting: Art and Techniques. Crowood.

Lindbloom, B. (2022) RGB/XYZ Matrices. Available from: http://www.brucelindbloom.com/index.html ?Eqn_RGB_XYZ_Matrix.html [Accessed 17th August 2022].

McCamy, C. S. (1992) Correlated color temperature as an explicit function of chromaticity coordinates. Color Research & Application, 17(2), pp. 142-144.

Mokrzycki, W, Tatol, M. (2011) Color difference Delta E - A survey. Machine Graphics and Vision, 20, pp. 383–411.

Morris, R. A. (2005) Colour management. Häuser, CL, Steiner, A, Holstein, J, and Scoble M J. Digital imaging of biological type specimens. A manual for best practice. Stuttgart: European Network for Biodiversity Information, pp. 31-36.

Raskar, R., Agrawal, A., Wilson, C. A., & Veeraraghavan, A. (2008) Glare aware photography: 4D ray sampling for reducing glare effects of camera lenses. ACM SIGGRAPH 2008 papers, pp. 1-10.

Štampfl, V., Možina, K., & Ahtik, J. (2021). Different Textile Materials as Light Shaping Attachments in Studio Photography and Their Influence on Colour Reproduction. Tekstilec, 64(1).

X-Rite. (2022) Color Management Workflow with DNG Camera Profiles. Available from: https://www.xrite.com/service-support/color_management_workflow_with_dng_camera_profiles [Accessed 29th August 2022].

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