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The dark side of color VI

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ABSTRACT

This year, at Electronic Imaging 2014, as part of the "Color Imaging XIX: Displaying, Processing, Hardcopy, and Applications" and “Human Vision and Electronic Imaging XVIII” conferences, we hold the sixth annual special session entitled, "The Dark Side of Color". This session aims at introducing innovative thinking, opening discussion from experts working in a wide range of disciplines related with color, fostering ideas and stimulating ongoing issues and revealing common misunderstanding in color science and technology. It is comprised of a limited number of invited short presentations that are presented as summaries in this paper together with an overall description of the session point of view.

Keywords: Dark side of color, Color, Color models, Color teaching, Colorimetry, Vision, Color related phenomena

1. WHAT THIS SESSION IS ABOUT

Color is a very complex phenomenon that cannot sufficiently be explained using only simple physical principles. Instead, a more holistic approach incorporating the human vision system of eye and brain is needed to understand how the base physical stimuli are transformed into the visual colors we see.

Color related topics are often taught and communicated without presenting their inner complexity, their limits and the simplifications that generally are taken at some point. Dealing with color is usually reduced to the automatic and repetitive use of pre-defined "recipes" and this can lead to the risk of loosing the overall framework and consequently a correct understanding of the technique to use.

Classic colorimetric methods, specifically designed to deal with color in aperture mode (isolated, out of visual context), have become dominant in digital color science and technology. Their use has been extended to deal with a great variety of situations in which color is considered within a visual context, thus outside of its initial scope. As such, the aperture approach has been very successful in describing a vast number of color effects. However, in some cases, an extension of the aperture view seems problematic, since the context plays a major role. Color science is facing this transitional evolution in order to deal with color in context and appearance, but without substantial changes in their original foundation.

There is a need for widening the scientific debate and discuss about paradigms. This can be achieved by, for example, new questions, different attention for details; information in the margins that so far are often discounted or overlooked. These aspects are what we consider to be the "dark side of color".

The invited speakers of this session have been asked to stimulate ideas and discussions on the needs and the characteristics of possible alternative approaches and/or point of view. This session aims at suggesting paradigm shifts, lateral thinking and bottom up experimentation by re-addressing the current state of the evolving situation in color in sciences, arts and technologies.

Following these principles, every speaker has chosen a topic of his/her preference and presents open issues and problems in a short 15-minutes presentation. The presentation abstracts are reported in the following paper to give the reader a glance on the discussed topics.

We would like to stress that basically no answers are expected to arise from the presentations of this session, but more likely questions and perspective shifts.

2. THE SPEAKERS

Here are the abstracts of the speakers that will participate at this Dark Side of Color session.

2.1 "ColorChecker at the beach: dangers of sunburn and glare" John J. McCann, McCann Imaging (United States)

In High-Dynamic-Range (HDR) imaging, optical veiling glare sets the limits of accurate scene information recorded by a camera. But, what happens at the beach? Here we have a Low-Dynamic-Range (LDR)scene with maximal glare. Can we calibrate a camera at the beach and not be burnt? We know that we need sunscreen and sunglasses, but what about our camera? The effect of veiling glare is scene-dependent, so when we compare RAW camera digits with spotmeter measurements we find significant differences. As well, these differences vary, depending on where we aim the camera. When we calibrate our camera at the beach we get data that is valid for only that part of that scene. Camera veiling glare is an issue in LDR scenes in uniform illumination with a shaded lens.

2.2 "The bright future of metameric blacks" Philipp Urban, Fraunhofer-Institut für Graphische Datenverarbeitung (Germany)

Reconstructing spectral reflectances from low-dimensional camera responses is an ill-posed problem addressed by many researchers so far. Independently from the reconstruction approach, estimated reflectances may always deviate from the ground truth by device metameric black spectra. What seems to be a drawback on the spectral acquisition side may be utilized to conceal device limitations in spectral printing in order to create copies matching with originals under selected illuminants. Such a strategy enables the use of perceptually meaningful distance metrics for mapping non-reproducible reflectances into the spectral gamut of the printer satisfying colorimetric criteria across a hierarchical set of considered illuminants. In the talk, I briefly explain this approach and show some examples of spectral prints.
The concept might be extended to reproduce optical material properties (defined by the Bidirectional Reflectance Distribution Function - BRDF) by novel multi-material 2,5D and 3D printers. Here, prints can be perceptually optimized with respect to a set of measuring geometries by picking in-gamut BRDFs deviating from given BRDFs only by metameric blacks. In this context, metameric blacks refer to the difference of BRDFs that match for the considered measuring geometries. The strict requirement of a perfect match might be relaxed by perceptual distance criteria. There are various open questions related to this BRDF gamut mapping strategy, such as "How to select meaningful measurement geometries for a BRDF considering the shape of a 3D-object?" or "What is the perceptual error for not-considered geometries?" Furthermore, it is unclear so far, how to predict perceptual differences between materials for geometries where the radiance factor exceeds one (here the materials have lightness values larger than the lightness of the perfect reflecting diffuser).

2.3 "Can Color Management and Anaglyph 3D Images be Friends Once More?" Andrew J. Woods, Curtin University, Perth (Australia)

The anaglyph 3D method is a very widely used technique for presenting stereoscopic 3D images – particularly for printed 3D images, but also for emissive displays such as LCDs. Left and right images are encoded in two complimentary color channels (often red left, cyan right) and the observer wears a pair of 3D glasses containing appropriate color filters at the left and right eyes. One of the important characteristics when presenting stereoscopic 3D images is that the left and right image channels must be maintained separate. If any mixing or leakage occurs between the image channels, this will be interpreted as crosstalk or ghosting, and can significantly degrade 3D image quality if leakage levels are high.

Now let's consider color management – a process used to maintain color consistency or color accuracy between different display devices or display techniques. Color management involves the characterisation of the color properties of a display and the use of a color management engine to vary the color channel values using a mathematical formula to achieve a consistent appearance of color between displays. The use of color management is now a common feature in many computer operating systems, image processing software, and printers. The use of color management can result in very good color consistency between displays, however the process of varying the color channels also results in the mixing of color channels which is bad for the presentation of high-quality anaglyph 3D images.

On this basis, color management can adversely affect the quality of anaglyph 3D images, because color management mixes the color channels, and anaglyph 3D requires the color channels to be maintained separate. In essence, color management adds crosstalk to anaglyph 3D images.

The printing of anaglyph 3D images is particular badly affected by the effects of color management.

This paper raises a number of open ended questions about how color management and anaglyph 3D images can be friends once more.

Firstly, color management is now so tightly integrated with the computer operating system and printer drivers that it is near impossible to override color management, and to allow control the individual color channels directly. We need a way of bypassing color management in these scenarios.

Secondly, color management does have advantages and it would be beneficial if a color management algorithm could be implemented which does not introduce crosstalk into anaglyph 3D images. The author believes that this is possible to develop a colour management algorithm which does not cause crosstalk in anaglyph 3D images, but it remains an outstanding task to prove this possibility.

Can color management and anaglyph 3D images be friends once again?

2.4 "Feeling edgy about color blindness" Reiner Eschbach, Stephen Morgana, Xerox Corp. (United States); Anna Quaranta, Cristian Bonanomi, Alessandro Rizzi, Università degli Studi di Milano (Italy)

The classic explanation of color blindness is based on the lack or on a malfunctioning of channel sensors. This has led in some cases to simplified models of color-blind people visual perception: e.g. miss of "green" cones, lack of green visual component.

There is no doubt that the base of color blindness is a problem for some kind of cones, but recent findings suggest that color sensation could be based on low level mechanisms different from the elemental Von Helmoltz tri-chromacy[1]. Moreover, other less recent findings suggest an important role of edges and gradients in the formation of color sensation[2].

The hypothesis here is that color blindness could be not just the absence or a diminished signal from the defective channel. The idea is that color-blind people compensate in some way using edges, considering that edges are the base of normal vision too.

Here we present a discussion based on a very preliminary tests about the role of edges in normal and color-blind vision.

3. THE PREVIOUS DARK SIDE SESSIONS

Here is a list of the speakers and topics that have participated at the previous Dark Side of Color sessions.

3.1 The dark side of color I (2009)

"Well asked questions" Reiner Eschbach

"Pictorial information as transcribed by the artist or designer" Stephen Hoskins

"Consider the Size: And Other Display Features" Garrett M. Johnson

"Adaptation! … What Adaptation?" John McCann

"The Opposite of Green is Purple?" Nathan Moroney
"Now...what color was that again?" Sabine Süsstrunk
"Stepford – the city for Colour Engineering" Stephen Westland

3.2 The dark side of color II (2010)

"Color naming: color scientists do it between Munsell Sheets of Color" Giordano Beretta and Nathan Moroney
"Size matters: The problem of color-difference estimation for small visual targets" Robert C. Carter and Louis D. Silverstein
"Controlled versus uncontrolled viewing conditions in color evaluation" Reiner Eschbach
"Mind over Matter" Jennifer Gille
"Globalization of color" Paul Hubel
"The appearance of illusions and the delusion of reality" John McCann

3.3 The dark side of color III (2011)

"The Color Side of Dark" Raja Bala
"What a bad signal from this strange device!" Alessandro Rizzi
"HDR Imaging and Color Constancy: Two Sides of the Same Coin?" John McCann
"Is the future of digital printing paperless?" Giordano Beretta, Eric Hoarau, Jun Zeng
"Can less be more?" Jan Allebach
"Can displays go wild?" Gabriel Marcu

3.4 The dark side of color IV (2012)

"The dark side of CIELAB" by Gaurav Sharma and Carlos Eduardo Rodriguez-Pardo
"Complexitites of complex contrast" by Eliezer Peli
"It's not the pixel count, you fool" by Michael A. Kriss
"Color imaging and aesthetics: is there the cheshire cat ?" by Elena A. Fedorovskaya
"Dark texture in artworks" by Carinna E. Parraman
"Harmonious colors: from alchemy to science" by Giordano B. Beretta, Nathan M. Moroney

3.5 The dark side of color V (2013)

"Can trichromats really know what dichromats see?" Michael H. Brill, Datacolor (United States)
"Color scales for visualization: traveling though color space" Bernice E. Rogowitz, Visual Perspectives Consulting (United States)
"Color spaces" Jan J. Koenderink, Technische Univ. Delft (Netherlands)
"You can't rely on color, yet we all do" Floris L. van Nes, Technische Univ. Eindhoven (Netherlands)
"How 'high-level' is human color perception? Michael E. Rudd, Univ. of Washington (United States)
"Complex spatiochromatic interactions in a real world art laboratory" Scott Daly, Dolby Labs., Inc. (United States)

4. REFERENCES

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