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The dark side of color III

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ABSTRACT

This year, at Electronic Imaging 2011, will be held for the third time, as part of the "Color Imaging XVI: Displaying, Hardcopy, Processing, and Applications" conference, the special session entitled, "Dark Side of Color". This session aims at introducing innovative thinking, and discussion from experts working in a wide range of disciplines related with color, to foster ideas and stimulate about open issues and common misunderstanding in color science and technology. It is composed by 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, Color related phenomena

1. WHAT THIS SESSION IS ABOUT

What is the dark side of color ?

Color is a very complex phenomenon that cannot be explained with only physics principles. The human vision system is what transforms the physical stimuli into the colors we see.

Color related topics are sometime taught and communicated without presenting their inner complexity, their limits and the simplifications that sometime are at their base. A-critically following pre-defined "recipes" can lead to the risk of loosing the overall framework and consequently a complete understanding of the chosen technique.

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 inside a visual context, thus outside its initial scope. 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 section 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 choosen 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 sections 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 second edition of the session of the Dark Side of Color. They are listed in alphabetical order.

2.1 "The Color Side of Dark" Raja Bala

Earlier studies examining preferred printed reproduction of "gray" patches indicated a bias towards the quadrant in the chrominance plane where both a* and b* are negative (i.e. towards blue). Furthermore, visual tolerance for gray appeared to be asymmetric about a*=b*=0, decreasing rapidly for colors in quadrants where a* or b* is significantly positive. In follow-on experiments examining preference across different image content and viewing conditions, it was surmised that gray perception is likely affected by a combination of adaptation, image content, and personal preference. In this presentation we extend this analysis to look at preferred black in prints. We observe that in many cases, the preferred black point has a significant chrominance component, and furthermore, as was observed with gray, preferred black has a significant bias towards the chrominance quadrant where both a* and b* are negative. This observation raises interesting implications in dynamic range compression and gamut mapping in the dark regions of color space.

2.2 "What a bad signal from this strange device!" Alessandro Rizzi

We are acquainted to a description of the eye as a good camera with clearly determined optical and spectral properties. Reality is not exactly like that. This presentation aims at reviewing the many peculiar characteristics that sometime are not considered in the process of modeling our human vision system. One can be tempted of simplifying or of considering our vision system as a black box that we can describe from a top-down point of view, following the habit of using more engineering than biological descriptions. This talk want to suggest that within the unusual property of our eye it can be hidden the key of interpretation of the inner mechanisms of our vision.

2.3 "HDR Imaging and Color Constancy: Two Sides of the Same Coin?" John McCann

At first, we think that High Dynamic Range (HDR) imaging is a technique for improved recordings of scene radiances. Many of us think that human color constancy is a variation of a camera's automatic white balance algorithm. However, on closer inspection, glare limits the range of light we can detect in cameras and retinas. All scene regions below middle gray are influenced, more or less, by the glare from the bright scene segments. Instead of accurate radiance reproduction, HDR imaging works well because it preserves the details in the scene's spatial contrast. Similarly, human color constancy, also on closer inspection, depends on spatial comparisons that synthesize appearances from all the scene segments. Can spatial image processing play similar principle roles in both HDR imaging and color constancy?

2.4 "Is the future of digital printing paperless?" Giordano Beretta, Eric Hoarau, Jun Zeng

Before ICC profiles, a device-independent document would encode all color in a device independent CIE space like CIELAB. When the document was to be printed, the press person would measure a target and create a color transformation from the CIE coordinates to device coordinates. For office and consumer color printers, the color transformation for a standard paper would be hardwired in the printer driver or the printer firmware. This procedure had two disadvantages: the color transformations required deep expertise to produce and were hard to manage (the latter making them hard to share), and the image data was transformed twice (from input device to colorimetric and then to output device coordinates) introducing discretization errors twice. The first problem was solved with the ICC profile standard, and the last problem was solved by storing the original device dependent coordinates in the document - together with an input ICC profile - so the color management system could first collapse the two profiles and then perform a single color transformation. Unfortunately, there is a wide variety in the quality of ICC profiles. Even worse, the real nightmare is that quite frequently the incorrect ICC profiles are embedded in documents or the color management systems apply the wrong profiles. For consumer and office printers, the solution is to forgo ICC profiles and reduce everything to the single sRGB color space, so only the printer profile is required. However, the sRGB quality is insufficient for print solution providers. How can a modern print workflow solve the ICC profile nightmare?

2.5 "Can less be more?" Jan Allebach

Methods for color halftone imaging have been used in the printing industry for over 100 years. In 1987, Ulichney associated color with another dimension of halftoning when he used the color blue to characterize aperiodic, dispersed-dot halftones for which the spatial Fourier transform has energy predominantly in the short wavelength band. Eleven years later in 1998, Lau continued this theme by using the color green to characterize aperiodic, clustered-dot halftones, for which the spatial Fourier transform has energy predominantly in the mid-wavelength band. There is yet a third dimension of halftoning that can be associated with a color – also the color green, and that is associated with the environmental impact of halftoning.

Halftoning is just one aspect of printing; and a truly meaningful assessment of its environmental impact would require a cradle-to-grave analysis of the cost of manufacture and recycling or disposal of all the hardware associated with the marking, finishing, and distribution processes, as well as all consumables, and a comparable analysis of the environmental impact of alternative means of personal and broadcast communication that could substitute for printing. Our goal in this presentation is much more modest. We propose to consider only the amount of colorant that is required to achieve a fixed level of visual quality in a printed halftone image. Here we assume that the colorant set, the medium onto which the colorant is to be printed, and the marking technology are all fixed. In this case, the primary components of the overall printing process that can be altered are the color management scheme and the halftoning algorithm.

Even within this restricted scope, the problem is far from trivial. In fact, color management and digital halftoning are each, in their own right, sufficiently complex that the practice in the research community has generally been to keep one component fixed while varying the other one. To reduce colorant usage while maintaining a fixed visual appearance, a basic tenet has been that the colorant should be spread more thinly over the media. This argues in favor of using higher spatial frequency periodic or aperiodic halftone textures. However, it is precisely these types of halftones that are most challenging for marking processes to render in a stable, reproducible manner. In our previous research, we have shown that probabilistically based microscopic models that depend on a micro-scale characterization of surface reflectance can substantially improve image quality in the presence of such limitations. Such a characterization of surface reflectance requires a properly calibrated high-resolution imaging device.

If a micro-scale reflectance model could be augmented with a micro-scale model for colorant usage, we believe that the halftoning process could be simultaneously optimized with respect to both halftone image quality and colorant usage. However, we will argue that the capability to obtain micro-scale measurements of colorant usage is presently not well developed. In this paper, we will examine the present capability to make halftoning truly green from the standpoint of minimizing colorant usage while maintaining a fixed level of print quality. We will also discuss what can be achieved given current limitations of measurement devices, and what could be achieved if better micro-scale measurement processes were developed.

2.6 "Can displays go wild?" Gabriel Marcu

This presentation points out several aspects about color displays that are specific to the recent development of display technologies. The traditional color models fail for those devices. The author try to rise awareness on the danger of using color management for those devices based on conventional color models. Elements such as cross talking, RGB primary and white point migration, gamma and gray tracking, dynamic contrast are discussed. Each aspect is illustrated with examples so the viewer can understand the true effect of ignoring them in the color model.