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# *Color Imaging XVII: Displaying, Processing, Hardcopy, and Applications*

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# The dark side of color IV

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## ABSTRACT

This year, at Electronic Imaging 2012, will be held for the fourth time, as part of the "Color Imaging XVII: Displaying, Processing, Hardcopy, and Applications" conference, the special session entitled, "The 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, Vision, 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 taken at some point. Sometimes dealing with color is reduced to a-critically following pre-defined "recipes" and this can lead to the risk of loosing the overall framework and consequently a correct 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 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 "**The dark side of CIELAB**" [8292-12] by Gaurav Sharma and Carlos Eduardo Rodriguez-Pardo

Standardized in 1976 as a uniform color space, CIELAB is extensively utilized in color science and engineering applications. CIELAB provides both a color difference formula and correlates for common perceptual descriptors of color. Deficiencies in both areas are well-known, and based on these known limitations, numerous fixes have been developed yielding alternative color difference formulae that are derived as modifications of the color difference in CIELAB. In addition, several new color appearance spaces have also been proposed as modifications of the basic CIELAB framework.
In this paper, we point out other, lesser-known and poorly-appreciated, limitations of CIELAB that occur particularly in the dark regions of color space. We demonstrate via examples, how these limitations not only cause performance compromises but lead to fundamental breakdowns in system optimization and design problems, making CIELAB completely unusable in these problems. We consider the reasons why these fundamental limitations were overlooked in the original development of CIELAB and analyze the mathematical representations contributing to the undesired behavior. We argue that fundamental new research is required to overcome this dark side of CIELAB; the development of uniform color spaces and new color appearance spaces must be revisited afresh using new experimental data and keeping in mind newer devices and applications.

### 2.2 "**Complexitites of complex contrast**" [8292-13] by Eliezer Peli

For the visual system, luminance contrast is a fundamental property of images, and is one of the main inputs of any simulation of visual processing. Many models intended to evaluate visual properties such as image discriminability compute perceived contrast by using contrast sensitivity functions derived from studies of human spatial vision. Such use is of questionable validity even for such applications (i.e. full-reference image quality metrics), but it is usually inappropriate for no-reference image quality measures. In this paper, we outline why the contrast sensitivity functions commonly used are not appropriate in such applications, and why weighting suprathreshold contrasts by any sensitivity function can be misleading. We propose that rather than weighting image contrasts (or contrast differences) by some assumed sensitivity function, it would be more useful for most purposes requiring estimates of perceived contrast or quality to develop an estimate of efficiency: how much of an image is making it past the relevant thresholds.

### 2.3 "**It's not the pixel count, you fool**" [8292-14] by Michael A. Kriss

The first thing a "marketing guy" asks the digital camera engineer is "how many pixels does it have, for we need as many mega pixels as possible since the other guys are killing us with their "umpteen" mega pixel pocket sized digital cameras. And so it goes until the pixels get smaller and smaller in order to inflate the pixel count in the never-ending pixel-wars. These small pixels just are not very good. The truth of the matter is that the most important feature of digital cameras in the last five years is the automatic motion control to stabilize the image on the sensor along with some very sophisticated image processing. All the rest has been hype and some "cool" design. What is the future for digital imaging and what will drive growth of camera sales (not counting the cell phone cameras which totally dominate the market in terms of camera sales) and more importantly after sales profits? Well sit in on the Dark Side of Color and find out what is being done to increase the after sales profits and don't be surprised if has been done long ago in some basement lab of a photographic company and of course, before its time.

## 2.4 "**Color imaging and aesthetics: is there the Cheshire cat?**" by Elena A. Fedorovskaya

There is an increasing desire within the imaging community to expand the understanding of images beyond image quality to include higher-level attributes such as aesthetics. Potentially, computational methods can be developed that evaluate and select images with the highest aesthetic quality. This concept remains controversial, however, as the nature of the aesthetic phenomenon, and the understanding thereof, remains complex and elusive. Some scholars state that an experience of art, culture, or nature has an aesthetic quality for an observer when a new knowledge or insights can occur. What attributes of objects induce such experience? In the case of images, how does aesthetics relate to the role of color, individual preferences, or semantic content? Are aesthetic images like a Cheshire Cat—you only know them when you see them?

## 2.5 "**Dark texture in artworks**" [8292-16] by Carinna E. Parraman

This presentation highlights issues relating to the digital capture printing of 2D and 3D artefacts and accurate colour reproduction of 3D objects.
There are a range of opportunities and technologies for the scanning and printing of two-dimensional and three-dimensional artefacts. A successful approach of Polynomial Texture Mapping (PTM) technique, to create a Reflectance Transformation Image (RTI) is being used for the conservation and heritage of artworks as these methods are non invasive or non destructive of fragile artefacts.
In order to reproduce an object, as a facsimile or replica, the types of files need to be either as a polygonal mesh that describes the contours of the surface, or as a series of 2D layers, which when stacked together form a 3D object. Recent experience has highlighted problems in obtaining good scanning data for object reproduction through additive layer manufacturing (ALM) technologies. In fact a large file does not necessarily lead to a file that contains relevant or quality information.
Digital printing technologies have begun to consider colour for 3D printing and 2D texture printing, but this has not been sufficiently considered. Most ALM manufacturers use materials that include, thermoplastics, metal, flexible and non flexible photopolymers and powder, which are body coloured (metallic, neutral resin, white powder), in some technology colour is sprayed to the outside of the object as part of the additive layer process, for example, ZCorp printers employ coloured heads that inkjet a coloured layer to the surface (ZPrinter® 650 contains 5 print heads, including black). With the introduction of 2D ultra violet curing printers, it is possible to begin to add texture to flat surfaces. It is also possible to combine colour and texture to create a surface relief, but the height is limited to approximately 1-2mm due to the restrictions of the head height. The file information to do this is based on a vector format.
The questions therefore are how can artworks be reproduced with the benefit of printed texture. Can this texture be incorporated that could be used for example as a method for improving visually impared or to reproduce fine detail such as cracks, brush strokes or impasto to the surface of paintings to provide meaningful information to the conservator or assists the artist in new ways for creativity?

## 2.6 "**Harmonious colors: from alchemy to science**" [8292-17] by Giordano B. Beretta, Nathan M. Moroney

There is a very long tradition in designing color palettes for various applications. Although color palettes have been influenced by the available colorants, starting with the advent of aniline dyes there have been few physical limits on the choice of individual colors. This abundance of choices exacerbates the problem of limiting the number of colors in a palette.
The traditional solution is that of "color forecasting." Color consultants assess the sentiment or affective state of a target customer class and compare it with new colorants offered by the industry. They assemble a limited color palette, name the colors according to the sentiment, and publish their result.
The color forecasting business is very labor intensive and difficult, thus for years computer engineers have tried to come up with algorithms to design harmonious color palettes, alas with little commercial success. Contrary to the auditory sense, there is no known physiological mechanism sustaining harmony and the term "harmonious" just has the informal meaning of "going well together."

We argue that the intellectual flaw resides in the belief that a masterful individual can devise a “perfect methodology” that the engineer can then reduce to practice in a computer program. We suggest that the correct approach is to consider color forecasting as an act of distillation, where a palette is digested from the sentiment of a very large number of people. We describe how this approach can be reduced to an algorithm by replacing the subjective process with a data analytic process.