PROCEEDINGS
IS&T/SPIE
Electronic Imaging
Science and Technology

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

Reiner Eschbach
Gabriel G. Marcu
Alessandro Rizzi
Editors

24–26 January 2012
Burlingame, United States

Sponsored and Published by
IS&T—The Society for Imaging Science and Technology
SPIE

Volume 8292

Proceedings of SPIE, 0277-786X, v. 8292

Please use the following format to cite material from this book:
Author(s), "Title of Paper," in *Color Imaging XVII: Displaying, Processing, Hardcopy, and Applications*, edited by Reiner Eschbach, Gabriel G. Marcu, Alessandro Rizzi, Proceedings of SPIE-IS&T Electronic Imaging, SPIE Vol. 8292, Article CID Number (2012).

ISSN 0277-786X
ISBN 9780819489395

Copublished by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org
and
IS&T—The Society for Imaging Science and Technology
7003 Kilworth Lane, Springfield, Virginia, 22151 USA
Telephone +1 703 642 9090 (Eastern Time) · Fax +1 703 642 9094
imaging.org

Printed in the United States of America.

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

ix *Conference Committee*

xi *Abstracts from "The Dark Side of Color" session*
A. Rizzi, Univ. degli Studi di Milano (Italy); G. Beretta, Hewlett-Packard Labs. (United States); E. A. Fedorovskaya, Eastman Kodak Co. (United States); M. A. Kriss, MAK Consultants (United States); N. M. Moroney, Hewlett-Packard Labs. (United States); C. E. Parraman, Univ. of the West of England (United Kingdom); E. Peli, Schepens Eye Research Institute (United States); C. E. Rodriguez-Pardo, Gaurav Sharma, Univ. of Rochester (United States)

SESSION 1 VISION AND HDR I

8292 03 **Color assimilation and contrast near absolute threshold (Invited Paper)** [8292-02]
J. McCann, McCann Imaging (United States)

8292 04 **Multi-illuminant color constancy for HDR images through exposure segmentation** [8292-03]
H. Zhang, Oregon State Univ. (United States) and Broadcom Corp. (United States); H. Liu, Oregon State Univ. (United States); S. Quan, Broadcom Corp. (United States)

SESSION 2 VISION AND HDR II

8292 05 **Tone mapping for HDR images with dimidiate luminance and spatial distributions of bright and dark regions** [8292-04]
M. Kitaura, F. Okura, M. Kanbara, N. Yokoya, Nara Institute of Science and Technology (Japan)

8292 06 **Color universal design: analysis of color category dependency on color vision type (3)** [8292-05]
N. Kojima, Kogakuin Univ. (Japan); Y. G. Ichihara, Kogakuin Univ. (Japan) and NPO Color Universal Design Organization (Japan); T. Ikeda, M. G. Kamachi, Kogakuin Univ. (Japan); K. Ito, The Univ. of Tokyo (Japan) and NPO Color Universal Design Organization (Japan)

8292 07 **Colour perception with changes in levels of illumination** [8292-06]
K. F. Baah, Dept. of Health (United Kingdom) and Univ. of the Arts, London (United Kingdom); P. Green, M. Pointer, Univ. of the Arts, London (United Kingdom)

SESSION 3 COLOR MANAGEMENT

8292 08 **Reducing the number of calibration patterns for the two-by-two dot centering model** [8292-07]
V. Babaei, R. Rossier, R. D. Hersch, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

8292 09 **Spatial gamut mapping for preserving the details of an image** [8292-08]
I.-Y. Song, H.-G. Ha, W.-J. Kyung, Y.-H. Ha, Kyungpook National Univ. (Korea, Republic of)

8292 0B **Optimizing color fidelity in wide gamut display devices when processing images compressed by block-based discrete cosine transforms (DCT)** [8292-10]
F. Lebowsky, STMicroelectronics (France)

8292 0C **Optimal gamut volume design for three primary and multiprimary display systems** [8292-11]
C. E. Rodríguez-Pardo, G. Sharma, Univ. of Rochester (United States); X.-F. Feng, J. Speigle, I. Sezan, Sharp Labs. of America, Inc. (United States)

SESSION 4 THE DARK SIDE OF THE COLOR

8292 0D **The dark side of CIELAB** [8292-12]
G. Sharma, C. E. Rodríguez-Pardo, Univ. of Rochester (United States)

8292 0E **Complexities of complex contrast** [8292-13]
A. M. Haun, E. Peli, Schepens Eye Research Institute (United States)

8292 0F **It's not the pixel count, you fool** [8292-14]
M. A. Kriss, MAK Consultants (United States)

8292 0H **Dark texture in artworks** [8292-16]
C. Parraman, Univ. of the West of England (United Kingdom)

8292 0I **Harmonious colors: from alchemy to science** [8292-17]
G. B. Beretta, N. M. Moroney, Hewlett-Packard Labs. (United States)

SESSION 5 IMAGE PROCESSING I

8292 0J **Detection of backlight images using chrominance** [8292-18]
H. J. Park, S. W. Han, Samsung Electronics Co., Ltd. (Korea, Republic of)

8292 0K **A new method for skin color enhancement** [8292-20]
H. Zeng, Hewlett-Packard Co. (United States); R. Luo, Univ. of Leeds (United Kingdom)

SESSION 6 IMAGE PROCESSING II

8292 0M **Comparative performance analysis of mobile displays** [8292-22]
R. Safaee-Rad, Qualcomm Canada, Inc. (Canada); M. Aleksic, Qualcomm Inc. (United States)

8292 0N **Termites: a Retinex implementation based on a colony of agents** [8292-23]
G. Simone, Gjøvik Univ. College (Norway); G. Audino, Gjøvik Univ. College (Norway) and Univ. degli Studi di Milano (Italy); I. Farup, Gjøvik Univ. College (Norway); A. Rizzi, Univ. degli Studi di Milano (Italy)

8292 0O **A color quantization algorithm based on minimization of modified L_p norm error in a CIELAB space** [8292-24]
H. Xue, Purdue Univ. (United States); P. Bauer, D. Depalov, B. Bradburn, Hewlett-Packard Co. (United States); J. P. Allebach, C. A. Bouman, Purdue Univ. (United States)

SESSION 7 APPLICATIONS

8292 0P **Human skin imaging using three-phase spectral matching imager** [8292-25]
A. Kimachi, Osaka Electro-Communication Univ. (Japan); S. Ando, The Univ. of Tokyo (Japan); M. Doi, S. Nishi, Osaka Electro-Communication Univ. (Japan)

8292 0Q **Appearance analysis of human skin with cosmetic foundation** [8292-27]
R. Ohtsuki, S. Tominaga, R. Hikima, Kanebo Cosmetics Inc. (Japan) and Chiba Univ. (Japan)

8292 0R **Color analysis and image rendering of woodblock prints with oil-based ink** [8292-28]
T. Horiuchi, T. Tanimoto, S. Tominaga, Chiba Univ. (Japan)

SESSION 8 PRINTING AND HALFTONING I

8292 0S **Pre-RIP color management for soft proofing** [8292-30]
I. Tastl, K.-W. Koh, Hewlett-Packard Labs. (United States)

8292 0T **Parametrically controlled, stochastically seeded clustered halftones** [8292-31]
E. A. Bernal, S. Wang, R. P. Loce, Xerox Corp. (United States)

8292 0U **Assessing color reproduction tolerances in commercial print workflow** [8292-32]
G. B. Beretta, E. Hoarau, S. Kothari, I.-J. Lin, J. Zeng, Hewlett-Packard Labs. (United States)

8292 0V **Investigating the paper dependency of laser printed colors for uncoated papers** [8292-33]
S. Gorji Kandi, Institute for Color Science & Technology (Iran, Islamic Republic of)

SESSION 9 PRINTING AND HALFTONING II

8292 0W **Color-dependent banding characterization and simulation on natural document images** [8292-34]
S. Hu, Purdue Univ. (United States); H. Nachlieli, D. Shaked, Hewlett-Packard Labs. Israel Ltd. (Israel); S. Shiffman, Hewlett-Packard Indigo Ltd. (Israel); J. P. Allebach, Purdue Univ. (United States)

8292 0X **Modeling large-area influence in digital halftoning for electrophotographic printers** [8292-35]
Y. Ju, D. Saxena, Purdue Univ. (United States); T. Kashti, D. Kella, Hewlett-Packard Indigo Ltd. (Israel); D. Shaked, M. Fischer, Hewlett-Packard Labs. Israel Ltd. (Israel); R. Ulichney, Hewlett-Packard Labs. (United States); J. P. Allebach, Purdue Univ. (United States)

8292 0Y **The lattice-based screen set: a square N-color all-orders Moiré-free screen set** [8292-36]
Y.-Y. Chen, Purdue Univ. (United States); M. Fischer, Hewlett-Packard Labs. Israel Ltd. (Israel); T. Kashti, Hewlett-Packard Indigo Ltd. (Israel); D. Shaked, Hewlett-Packard Labs. Israel Ltd. (Israel); J. P. Allebach, Purdue Univ. (United States)

8292 0Z **Colour print workflow and methods for multilayering of colour and decorative inks using UV inkjet for fine art printing** [8292-38]
C. Parraman, Univ. of the West of England (United Kingdom)

8292 10 **Halftone blending between smooth and detail screens to improve print quality with electrophotographic printers** [8292-39]
S. J. Park, Purdue Univ. (United States); M. Shaw, G. Kerby, T. Nelson, D.-Y. Tzeng, V. Loewen, K. Bengtson, Hewlett-Packard Co. (United States); J. P. Allebach, Purdue Univ. (United States)

8292 11 **Ink-saving strategy based on document content characterization and halftone textures** [8292-37]
M. V. Ortiz Segovia, Purdue Univ. (United States) and Océ Print Logic Technologies (France); N. Bonnier, Océ Print Logic Technologies (France); J. P. Allebach, Purdue Univ. (United States)

SESSION 10 SPECTRAL AND DISPLAY

8292 12 **Spectral transmittance model for stacks of transparencies printed with halftone colors** [8292-40]
J. Machizaud, M. Hébert, Lab. Hubert Curien, CNRS, Univ. Jean-Monnet Saint-Etienne (France)

8292 13 **Optimal estimation of spectral reflectance based on metamerism** [8292-41]
T.-R. Chou, W.-J. Lin, National Taiwan Normal Univ. (Taiwan)

8292 14 **Hue-shift model for DLP projector with the white peaking function** [8292-42]
I.-S. Park, H.-G. Ha, D.-C. Kim, Y.-H. Ha, Kyungpook National Univ. (Korea, Republic of)

8292 15 **Content-dependent block noise reduction for mobile displays** [8292-43]
G.-H. Kim, Y.-G. Lee, H.-E. Kim, C.-W. Kim, Inha Univ. (Korea, Republic of)

INTERACTIVE PAPER SESSION

8292 16 **Characterization of color scanners based on SVR** [8292-44]
B. Li, Y. Zhang, Jiangnan Univ. (China)

8292 17 **Deducing ink thickness variations of fluorescent print by a spectral prediction model** [8292-46]
Q. Wang, Y. Zhang, Jiangnan Univ. (China); D. Tian, Univ. of Shanghai for Science and Technology (China)

8292 18 **Bio-inspired color sketch for eco-friendly printing** [8292-48]
I. V. Safonov, E. V. Tolstaya, M. N. Rychagov, Samsung Research Ctr. (Russian Federation); H. Lee, S. H. Kim, D. Choi, Samsung Electronics Co., Ltd. (Korea, Republic of)

8292 19 **Reflectance model for recto-verso color halftone images** [8292-49]
D. Tian, Univ. of Shanghai for Science and Technology (China); Q. Wang, Y. Zhang, Jiangnan Univ. (China)

8292 1A **The study on physical dot gain of second-order FM halftone based on ink spreading in all ink superposition conditions** [8292-50]
S. Xi, Y. Zhang, Jiangnan Univ. (China)

8292 1B **Tensor decomposition for color printer model lookup table** [8292-51]
M. Maltz, Xerox Corp. (United States); V. Monga, The Pennsylvania State Univ. (United States); Z. Fan, Xerox Corp. (United States)

8292 1C **Colony image acquisition and genetic segmentation algorithm and colony analyses** [8292-52]
W. X. Wang, Henan Polytechnic Univ. (China)

8292 1D **Edge detection by using edge density and eleven algorithm comparisons in three types of color images** [8292-53]
W. X. Wang, Henan Polytechnic Univ. (China); J. Y. Xu, Huawei Technologies Co. Ltd. (China)

8292 1E **Spectral prediction model for variable dot-size ink jet presswoke (Invited Paper)** [8292-54]
W. Xing, Y. Zhang, Southern Yangtze Univ. (China)

Author Index

Conference Committee

Symposium Chairs

Majid Rabbani, Eastman Kodak Company (United States)
Gaurav Sharma, University of Rochester (United States)

Conference Chairs

Reiner Eschbach, Xerox Corporation (United States)
Gabriel G. Marcu, Apple Inc. (United States)
Alessandro Rizzi, Università degli Studi di Milano (Italy)

Program Committee

Jan P. Allebach, Purdue University (United States)
Scott J. Daly, Dolby Laboratories, Inc. (United States)
Phil J. Green, London College of Communication (United Kingdom)
Roger D. Hersch, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
Choon-Woo Kim, Inha University (Korea, Republic of)
Michael A. Kriss, MAK Consultants (United States)
Fritz Lebowsky, STMicroelectronics (France)
Nathan Moroney, Hewlett-Packard Laboratories (United States)
Carinna E. Parraman, University of the West of England (United Kingdom)
Shoji Tominaga, Chiba University (Japan)
Stephen Westland, University of Leeds (United Kingdom)

Session Chairs

1 Vision and HDR I
Reiner Eschbach, Xerox Corporation (United States)

2 Vision and HDR II
Alessandro Rizzi, Università degli Studi di Milano (Italy)

3 Color Management
Gabriel G. Marcu, Apple Inc. (United States)

4 The Dark Side of the Color
Reiner Eschbach, Xerox Corporation (United States)

5 Image Processing I
Alessandro Rizzi, Università degli Studi di Milano (Italy)

6 Image Processing II
Fritz Lebowsky, STMicroelectronics (France)

7 Applications
Jan P. Allebach, Purdue University (United States)

8 Printing and Halftoning I
Carinna E. Parraman, University of the West of England (United Kingdom)

9 Printing and Halftoning II
Shoji Tominaga, Chiba University (Japan)

10 Spectral and Display
Reiner Eschbach, Xerox Corporation (United States)

The dark side of color IV

Alessandro Rizzi [a], Giordano Beretta [b], Elena A. Fedorovskaya [c], Michael A. Kriss [d], Nathan M. Moroney [b], Carinna E. Parraman [e], Eliezer Peli [f], Carlos E. Rodriguez-Pardo [g], Gaurav Sharma [g]

[a] DICO – Università degli Studi di Milano, Italy
[b] Hewlett-Packard Labs, USA
[c] Eastman Kodak Co., USA
[d] MAK Consultants, USA
[e] Univ. of the West of England (United Kingdom)
[f] Schepens Eye Research Institute, USA
[g] Univ. of Rochester, USA

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.