To Predictability and Beyond: 20 years of Color Printing at CIC

Ján Morovič; Hewlett–Packard Company; Barcelona, Catalonia, Spain

Abstract

Color printing has been a key topic at CIC since its kick-off in 1993 and is still well represented today. This invited talk will provide an overview of the variety of print-related work presented at this conference over the last 19 years and will give some thought to future direction. The material shown in print here is only a brief summary of the talk and the interested reader is advised to look for a copy of the slides after the conference at the following address: http://www.slideshare.net/jmorovic/

Color printing at the CIC

Of the 1240 papers that will have been presented at the CIC by the end of this year's conference, 313 are print–related (Figure 1), which represents between a third and a fifth of papers presented in any one year.
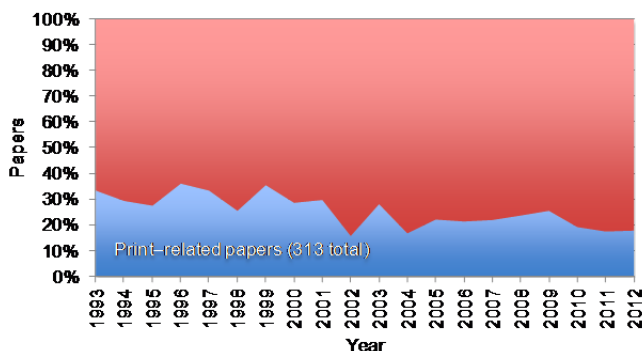

Figure 1. Print–related papers as a proportion of all CIC papers.

Beyond looking just at how much of the CIC's attention has been aimed at printing, let us also take a closer look at what aspects of it were presented and discussed during the first 20 CICs (Figure 2).
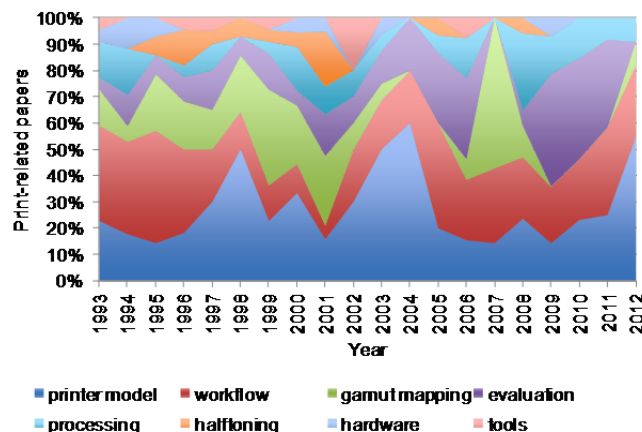

Figure 2. Topics addressed by print–related papers.

About a quarter of all print-related papers were concerned with predicting color or spectral properties of print colorant overprints and/or their halftoned patterns, which is at the basis of using printers in color reproduction, of keeping printers calibrated and of making choices when designing printing systems. In essence all the effort in this area aims to provide predictability of printed color without the need to print and measure. Since the interactions among colorants and with a substrate (which can range from traditional paper-like ones to plastics, textiles and even ceramics) are so complex and dependent on the specifics of the materials involved, were are still not in a position where an arbitrary printing systems could be easily and accurately characterized.

Another quarter of papers was concerned with what I call 'workflows,' which encompasses such topics as color management, color reproduction, spectral reproduction and the enabling of specialists applications (e.g., print verification, encryption of data in print, etc.). This topic was the most dominant one during the early years of CIC, but has maintained good representation throughout the last 19 years. As other parts of the color and imaging ecosystem change, so too do its interactions with print and so does the challenge of re-targeting and re-purposing content meant for one medium for another.

The next most popular aspect of dealing with print has been that of adjusting original/source color content to fit the range of colors that print is capable of generating – i.e., color gamut mapping. This topic has been particularly strong during the first 10 years of CIC, but has had peaks more recently too. One of the reasons for its popularity and recent resurgence is that no universally successful solution exists for this problem and that whenever progress is made elsewhere (e.g., image difference prediction, print quality evaluation), attempts are made to roll it back here.

The last of the larger areas of focus is that of evaluating print – either by itself and as a function of its constituent materials or in the context of it being the reproduction of other color content. This is a topic that has seen particular growth in recent years and I believe has strong potential to keep our attention in the coming years. The better our understanding of what a given print's properties are, the better a chance we have to adjust them to an optimal state.

The remaining 20 per cent of papers have addressed various color processing algorithms relevant to print (e.g., more efficient, accurate or faster interpolation algorithms), have presented solutions to color halftoning, have introduced new printing hardware and materials or have been about tools that could be used to better understand print attributes or the workflows that have lead to them.

During the talk I will pick out my favorite print-related papers from the last 19 CICs and try to give a flavor of how things have

changed since CIC 1 (e.g., how we have gone from considering RGB→CMYK or Lab→CMYK workflows in one go to the modular approach of today or how the speed of color transformations needed to drive printers has gone from a peak in single digit megapixels per second on a dedicated ASIC to multiple gigapixels per second on off-the-shelf GPUs).

What to expect at CIC 30

Shooting for CIC 40 would be completely useless, and even CIC 30 is so far out that any attempt at prediction is pretty futile. Nonetheless, let me say a couple of words about where I see printing some years down the line, after I share the following two quotes with you: "You can't connect the dots looking forward; you can only connect them looking backwards." –Steve Jobs and "The only way you can predict the future is to build it." –Alan Kay

With that in mind, I believe that we will see developments in two areas: First, 'color as color' – what I mean by this are developments in traditional areas that can directly be identified as coming from color science/engineering: larger gamuts, more resolution, better spatial detail, better re–rendering, controlled color on new materials and under new conditions, professional performance for consumers at consumer prices. The question that often comes up in this context is whether better looking prints are needed. Isn't what we have good enough? I'd like to argue that it isn't! Customers may not ask for any of the above, but they will appreciate and demand it once they see it (à la Ford's faster horses v. cars).

Second, and more interestingly, I also believe in a resurgence of the need for color in a hidden way. I.e., the use of color science and technology to drive aspects of print other than color. E.g., its use to enable the use of cheaper hardware/materials/resources, faster setup and performance, easier use, applications to new contexts (e.g., 3D printing) and making printing more predictable and more consistent. In this sense, good color technology can be like good typography – invisible.

Author Biography

Ján Morovič received his Ph.D. in color science from the Colour & Imaging Institute of the University of Derby (UK) in 1998. After working there as a lecturer in digital color reproduction, he became senior color scientist and later master technologist at Hewlett-Packard in Barcelona, where he has been since 2003. He is currently the director of the CIE's Division 8 on Image Technology and Wiley and Sons have published his 'Color Gamut Mapping' book.