

Color management in multimedia applications

I. Tortajada Montañana*, **B. Defez García**, **T. Magal Royo**, **F. Brusola Simón**, y **G. Peris-Fajarnés**

UNIVERSIDAD POLITÉCNICA DE VALENCIA, Departamento de Expresión Gráfica en la Ingeniería, Camino de Vera s/n, 46022 Valencia, España

Nowadays, multimedia applications have become a social and cultural phenomenon, not only for being used as educational tools, but at all imaginable levels. Therefore, it is essential to employ them correctly in all technologies around us in the design of these applications. As it is well known, the quality of the color in an image is subjective, since color is a visual feeling of human beings. Nevertheless, it can be adjusted to objective criteria, provided that perceptual aspects are taken into account. In this work, it is explained how color management should be, and the complexity that this management generates in multimedia applications. The appearance of the color in this image would vary with regard to the color space used to reproduce it. Consequently, it is very important the control of the color in the reproduced image with respect to the original one (color reproduction problem). In addition, in multimedia applications (either in design or in their posterior use) participate different devices that use different color reproduction mechanisms. The problem generated is known as crossed color reproduction. An analysis of these problems is also discussed in this communication.

Key words: color management, crossed color reproduction, color space

1. Introduction

In a multimedia document, usually appear different elements: texts, sounds, pictures, graphics (the last two are static objects many times, and occasionally dynamic ones). Bearing in mind just images, each type of them have some associated attributes (printing pattern, grey level, resolution, color...), that have to be treated differently.

If an image should be part of a multimedia application, it has to follow, at least, the trajectory showed in figure 1. It can be digitalized by a scanner or a digital camera (recycled image), or straightforwardly created from an appropriated software (synthetic image). Afterwards it is possible to be processed by the same or a different software (depending on the purpose) and then it will be incorporated to the multimedia application by means of author tools software. Already inside of the application, there are many different actions to perform with the image: (a) to visualize it in a LCD or CRT screen; (b) to print it in a particular kind of printer or printing press, (c) to store it, being part of an images library; (d) to use it in a website, (e)...

Accepting this implies accepting that, very probable, when an image should be captured, worked, visualized and printed, compatibility problems would appear. From now on, we will study, within all attributes in an image, the color treatment, denominated by Sharma [1] in 1997 "COLOR IMAGING".

The last definition given by the International Commission of Illumination (CIE) [2] in 2001 says that color is "a characteristic of the visual perception, which could be described by the attributes of shade, luminance and chromacy. Based in this definition, it can be supposed that the total quality of an image regarding its color has to be, partially, subjective. Nevertheless, in the 90s, some color imaging researchers [3-6] quantified in 4 the areas that define the total quality of an image with respect to its color:

1. Reproduction of intensity and color levels
2. Interference patterns (More effect, watermarks...)

* Contact author e-mail: itortaja@degi.upv.es, Teléfono: +34 962849300

3. Resolution of fine details
4. Characteristics of the image surface (brightness, texture...)

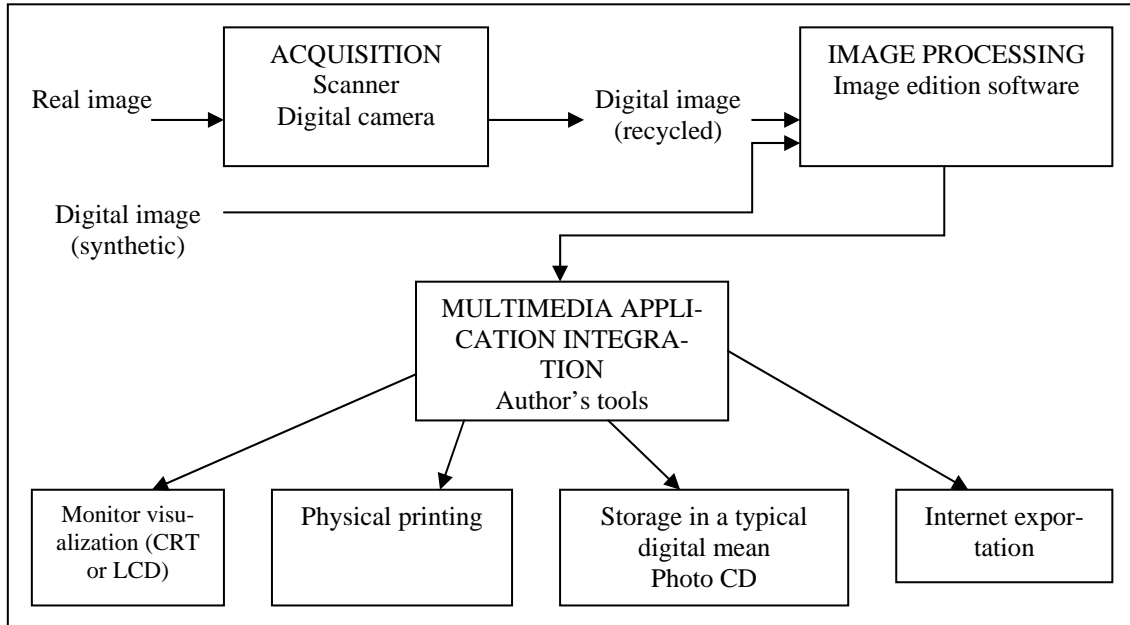


Fig 1. Trajectory that could follow a determinate image in a normal multimedia application

The 4 areas are quite related one to each other, thus it would be interesting to study the influence of every one of them in the others. However, experimentally, it is known that the structural aspects of color reproduction (involving the last 3 areas) have a lot of influence in the first one [7]. Therefore, this paper will focus in the analysis of the reproduction and equalized the images color.

2. Image reproduction color control

Color Management Systems have as one of their main objectives to appropriately perform images color reproduction control.

Basically, there are two ways of color reproduction: additive (RGB space) and subtractive (CMYK space). However, multimedia devices for color control have to be compulsorily adjusted to one of these ways. In fact, scanners, photo and video cameras (either analogue or digital) and screen (either LCD or CRT) reproduce color additively, whereas any kind of printer or printing press would codify it subtractively.

It could be thought that, if to generate and use a multimedia application one has to employ devices that only work with one of the two types of color reproduction, the problem could be simplified, but not even in these cases the color reproduction quality is guaranteed.

The main problems that could raise belong to one of these three categories:

1. Nowadays, there is no device that could be designed in a way that its reproduction primaries (RGB or CMYK) are ideally perfect.
2. Moreover, none of them shares the same three reproduction primaries, not even within devices of the same family, since every manufacturer employs different technological means, which offer quite different results. For instance, scanners and LCD screen red primaries, or CRT screen and printer paper white, could be different with respect to both, spectrum and color.

3. If a multimedia system with several connected devices is available, the logic thing is to establish a connexion between one or more pairs of input-output devices, creating a space known as “device dependant color representation space”, with huge problems of both, compatibility and computational cost.

A part of these problems would be solved if an intermediate color representation space could be described, so that it could link all input and output devices, creating a space known as device independent color representation space.

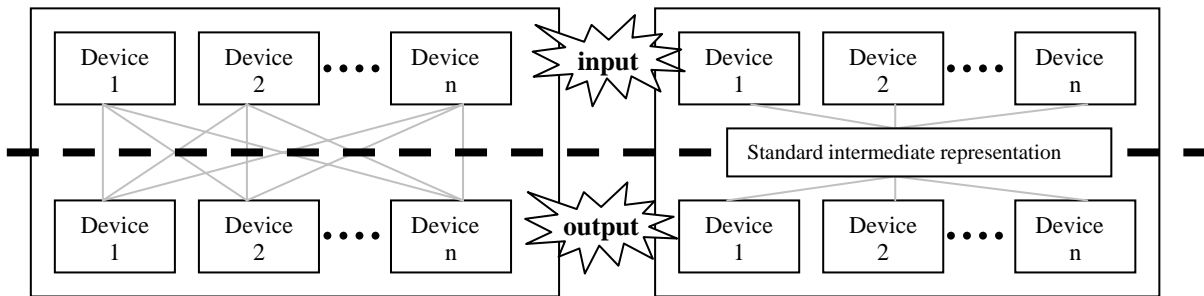


Fig. 2. Image color control devices characterization. Left: device dependant color representation space. Right: device independent color representation space.

That color representation space should have some special properties. The most remarkable are: to be uniformed, to have a separated channel for luminance, to adopted a model of chromatic adaptation, to be device independent (as already said), to have a wide range of reproducible colors, to have a perfectly described relationship with the rest of the color representation spaces, to provide good compressions, to allow suitable color differences measurements...

It is clear that, among all color spaces, there is none able to be perfectly adjusted to all properties listed before. In 1992, Xu and Holub⁸ performed a test, on which the adaptation capability of most color representation spaces was evaluated regarding the mentioned properties. As a conclusion, the best spaces were CIElab and CIEluv, but they depend on the intermediate space CIEXYZ. Therefore, this last space was fixed as the common color language, although a little chromatic adaptation is necessary.

3. Color crossed reproduction

The central ideal of this work is to study the problematic of images color reproduction, however, it is known that in multimedia systems, color reproduction devise can only belong to the two categories already mentioned: additive and subtractive. Therefore, color reproduction should be analysed bearing in mind the relationships that could be established between them both. This study philosophy is known as color crossed reproduction study.

The main problems of color crossed reproduction are:

1. To modify the color space in a device dependant color reproduction space.
2. To transform color between color representation spaces which are both devices dependant.
3. To find the white point equivalency problem during color representation
4. To find the gamut mapping problem if colors could be reproduced only by one of the devices.
5. The theoretical fundamentals of color reproduction differ due to the differences between image control mechanisms.
6. Visualization conditions for color reproduction comparison can differ. On one hand, there is an influence of the luminosity source geometry and the spectrophotometrical characteristics of the same. On the other hand, the observation geometry and characteristics of the observer.

7. Visual comparison between the image reference and the sample is normally subjective (since, as already commented, color is defined as a visual perception, and therefore it depends on the observer). This is known as the appearance color problem
8. To end with, the ageing to the system devise for color treatment could cause temporally vary the operability of the same.

Here has been only raised the most important problems. To analyse and solve every one of them exceeds the limits of this work, being each problem, separately, cause of an independent work.

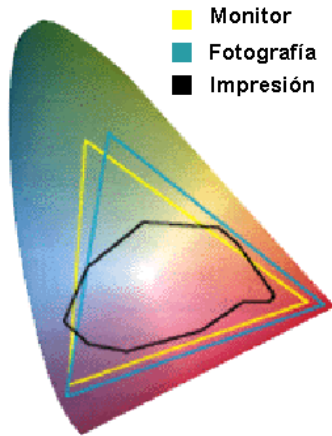


Fig. 3 Representation of the maximal reproducible color range in the CIE31 diagram for the usual three devices in multimedia: CRT screen, photo camera and printer. It can be noticed that, devices that reproduce color additively own a wider range. In screens, the reproducible colors are greener, while in the camera, although the amount of colours is approximately the same, shades are redder. As a consequence, printers have a narrower range (irregular shape), predominating reddish and bluish shades, being green ones more difficult to reproduce.

4. Standarization attempt

As all multimedia systems are defined as opened systems, evidently all these problems affect directly to color management in these systems, fundamentally deriving in possible unforeseen events such as incompatibility among the different devices that are part of the multimedia system. All this make necessary some kind of coordination technique o standardization among device manufactures.

In 1993, the Institute on Graphic Arts Research (FOGRA), together with 8 important companies of the multimedia industry created an organization called International Color Consortium” (ICC). These days, the consortium has 72 members among founder partners, honour partners and firms, grouping the most important multinationals of all related multimedia subsectors: manufacturers and commercials of scanners, cameras, photographic films, platforms (hardware), informatic applications, visualization screens, printers, printing press...

As the most important fact, in this organization, trying to avoid compatibility problems among devices for color creation and transfer, and solving the problem of device dependant color representation spaces, propose the creation of a file format, know nowadays as “ICC profile”, that basically has 4 elements (figure 4):

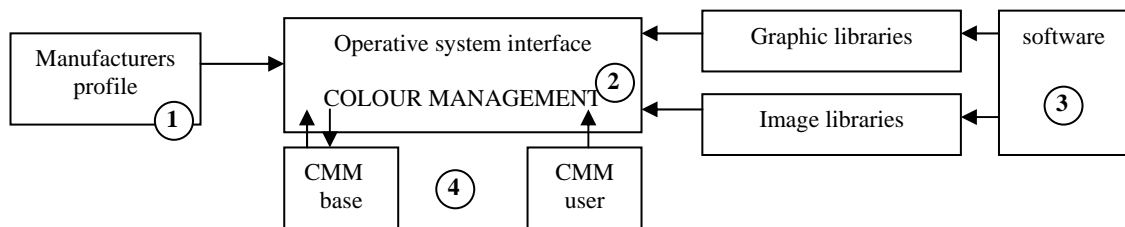


Fig.4. General elements that compose a ICC profile.

1. An element that show data and profiles of color characteristics of the multimedia devices of the same manufacturers
2. A Color Management Module (CMM), which links all profiles and produce the color transformations among the devices.
3. A software to manage color transformation as required by end users
4. An operative system that allow access to profiles and CMM, providing a basic color management module when end users have installed an specific module with this purpose.

5. Color management future

Both, the International Color Consortium (ICC) and the International Standards Organization (ISO), are making a great effort to standardize the images color reproduction processes. Among the different raised working lines, the strongest one consists on dividing the multimedia color management in two different fronts. On one hand, codifying color in a space called sRGB, which would be used in non-professional environments. On the other hand, by means of the ICC profile exclusively for expert users in high quality color reproduction and control [7]. Anyway, there are also critics against these initiatives [9-10].

It is very important to be conscious of the fact that the devise that are part of a crossed color reproduction chain have to do their, and only their role in color management. It would be a mistake for control software to record color in printer color spaces.

It is needed to improve end user interfaces, as much as to work in common configurations to make color management control more consistent, understandable and efficient.

En cuanto a la representación de los espacios de color, se deben buscar nuevos espacios que puedan solucionar los problemas actuales de la reproducción cruzada del color, pero no deben de olvidarse dos cosas: (1) a medio plazo, el espacio de color CMYK todavía va a seguir siendo un espacio de color necesario en las artes gráficas, y (2) el espacio de representación CIEXYZ es el elegido Para utilizarlo como lenguaje común de color.

As per color spaces representation, new spaces able to solved the current problems of color crossed reproduction should be searched, but without forgetting 2 things: (1) in the middle time, the CMYK color space would be remain necessary in Graphic Arts, and (2) the CIEXYZ color representation space is the chosen one as common color language.

Finally, just to comment that a lot of progress have be done in the last years in images color reproduction control, but to achieve total compatibility among devices in a multimedia, there is still a long way to travel.

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