*Proffesional paper*

# COMPARISON OF INDUSTRIAL AND NON AUTOMATED COLOR CALIBRATION CREATED COLOR PROFILES

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## 1. ABSTRACT

*To use color management systems the condition is to useappropriate color profiles to the device. There are two ways to get to these appropriate color profiles. We can use industrial color profiles or we can create our own color profiles by color calibration. The great advantage of the industrial profiles is the easy access, however arising from manufacturing and other uncertainties these reliability is in question. Creating our own color profiles is lengthy and requiring expertise and even this is no guarantee of perfect color profile, because during the calibration we can make different types of measurement errors. These errors can be significant mainly in the case of manual (non automated) calibration. In this paper, the question we would like to provide answer is that industrial or non automated calibration should we use to an inkjet printer?*

***Keywords:*** *ICC color management, inkjet printing, color measurement*

## 2. INTRODUCTION TO ICC COLOR MANAGEMENT

In 1993, eight companies specified to color management and they founded the International Color Consortium (ICC). Their aim was to develop an opened, platform-independent color management system that provides color accurate function of several image transferring and image display devices [1]. ICC color management system includes the following items:
a. Device-independent color model, which ensures that the device-independent color spaces (gamut) can be converted into each other. For example, color accuracy is not obtained if RGB color coordinates of a scanner displayed directly on an LCD monitor. However, if we convert the input RGB values into an intermediate color space (for example CIE Lab), while the colorimetric characteristics of the devices are known, then the correct output RGB values can be set from this intermediate color space (Fig. 3.).
b. The color profile is a digital data file that describes the color management abilities of a device. The profiling shall consist in measuring (calibrating) the radiometric, photometric and colorimetric properties of the input and output devices.
c. The Color Management Module (CMM) is a calculating and converter part of the color management system. In general, it is a part of the operating system, but there are individual CMMs used by image-editing programs - like Adobe (ACE) that is the CMM of the Photoshop. The CMM is able to using several color profiles. It establishes equivalences so called gamuts (color spaces) of two devices and mathematical connection between two device-dependent color spaces. During operation it uses the color profiles and the so called rendering intents (RI). RIs - described by mathematical model – defining the color transfer, between the devices,optimized for what kind of visual effect. If the color stimulus which is need to be converted not contained of the gamut of the target device, then the RI determines the compliance of the transforming so as to the current color coordinates transform to the gamut of the other device [2]. There are four types of RI in color management (Fig.2.):

- The perceptual RI is striving to a faithful reproduction of the perceived color while conversion.
- The most important property, converting saturation RI, is the color saturation.
- The absolute colorimetric RI is optimizing to the colorimetric same displaying
- The relative colorimetric RI is compounding to the previous method, nevertheless takes account to the source parameters while converting the white color stimuli.

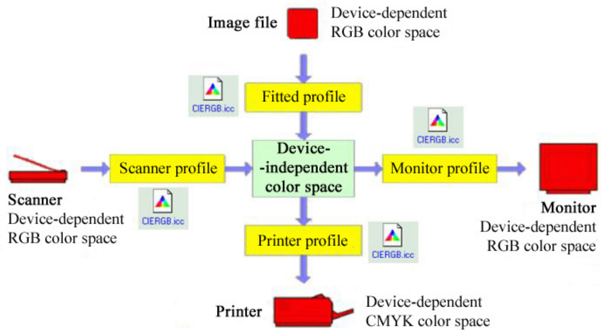


*Fig.1. The operation of the color management system*

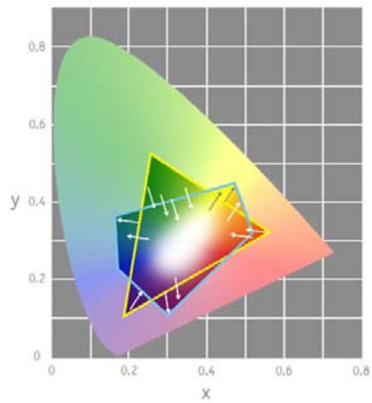


*Fig.2. Explanation of RI in the case of a printer with five primary colors and an RGB monitor*

## 3. USING COLOR PROFILES IN PRINTING

A decisive step of a designing, architectural, CAD or DTP (printing preparation) work process is to color the product according to the corresponding design. During designing usually this operation is carried out by a computer while the output is generally a color printer or printing machine. The key questionsare that the stimuli could see on the monitor how to appear on the output side or even can we display them on the monitor within a specific color tolerance. If we don't use color management, the result is totally random and we can experience significant colorfidelity and quality problems. Thereforeit is obvious to use color management, because all the operating systems and design-softwareincluding color management modules. Using color management has two conditions: application skills and having ICC color profile files. The first condition can be met by appropriate courses or knowing the literature however creating ICC color profiles is technically more complex and a costly process. Using the most simple color management – where we want to print a color-stimuli-perfect copy of a monitor displayed picture – we need at least two ICC color profile files: one monitor input and one printer output files. Creating ICC profile of a monitor is simple: an automatic calibrating software and a spectrophotometer or for the cheaper version a colorimeter with a color filter array are required. Fixing the optical aperture of the instrument to the monitor and starting the automatic software the ICC color profile file (containing the color display properties of the monitor) is ready in minutes. Printer calibration (profiling) is more complex, more time-consuming and more costly [3]. For measuring only expensive reflectance spectrophotometer is able to use. Primary color patches of printed test figures with certain number of patterns should be measured one by one. The results are analyzed by software and the ICC color profile is creating from these data. Hundreds of color patterns has to measure to create color profiles with appropriate quality (accuracy) and this is a time- and patience-consuming process even if investing in a costly X-Y coordinate moving table. It should be known that the manufacturer provides ICC profile files to the output devices (such as monitors or printers). These devices can be accessed on supplied CDs or on the manufacturer's website. A good question therefore, that why are expensive and time-consuming calibrations required, if these files are as easy to get? To decide a color profile of a printer and several manual calibrated ICC profiles were compared.

## 4. CREATING ICC PROFILE OF AN INKJET PRINTER

The investigated printer was an upper mid-range Canon Pixma iX5000 4 headed (CMYK) inkjet printer. The profile, created to this printer, was available on the website of the manufacturer.Because the color profile carries the properties of the paper therefore No. MP101 Canon paper and ink (included in the specification of the ICC color profile) were used. 343, 729 and 1728 colorpatterns were printed on these papers without color management. Our aimwas to compare the color profile of the manufacturer against small, medium and large numbers of calibrating patterns. The color spots were measured by an X-Rite Eye-One Pro reflectance spectrophotometer (Fig.3.) Measuring small series takes 1,5 hour, the medium takes 3 hours and the large one takes 8 hours. Measuring with coordinate-board would take tenth of this. To create these three ICC profiles MonacoPROFILTER was used.

*Fig.3. Calibration pattern and device using for calibration*

## 5. CREATING THE COLOR STIMULI OF THE INKJET TEST

*Table 1. The CIE Lab values of the 25 control color stimuli*

| No. | color stimulus (notation) | coordinates of color stimulus | | |
|---|---|---|---|---|
| | | L* | a* | b* |
| 1. | Normal red (np) | 43 | 57 | 39 |
| 2. | Light red (vp) | 74 | 30 | 12 |
| 3. | Dark red (sp) | 36 | 51 | 24 |
| 4. | Normal blue (nk) | 53 | -21 | -34 |
| 5. | Light blue (vk) | 76 | -18 | -19 |
| 6. | Dark blue (sk) | 36 | -10 | -33 |
| 7. | Normal green (nz) | 62 | -49 | 31 |
| 8. | Light green (vz) | 82 | -27 | 20 |
| 9. | Dark green (sz) | 40 | -34 | 20 |
| 10. | Pink (p) | 64 | 37 | -9 |
| 11. | Turquoise (t) | 70 | -39 | -8 |
| 12. | Light blue 2 (vk2) | 85 | -22 | -4 |
| 13. | Greenish blue (zk) | 56 | -46 | -9 |
| 14. | Normal yellow (ns) | 82 | 16 | 79 |
| 15. | Greenish yellow (zs) | 82 | -3 | 47 |
| 16. | Orangish yellow (nrs) | 78 | 24 | 51 |
| 17. | Normal brown (nb) | 46 | 15 | 14 |
| 18. | Beige (b) | 84 | 7 | 12 |
| 19. | Dark brown (sb) | 31 | 8 | 9 |
| 20. | Light grey (vsz) | 79 | 0 | 2 |
| 21. | Dark grey (ssz) | 47 | 0 | 0 |
| 22. | Normal purple (nl) | 60 | 20 | -20 |
| 23. | Light purple (vl) | 79 | 12 | -14 |
| 24. | Dark purple (sl) | 39 | 22 | -22 |
| 25. | Orange (n) | 70 | 37 | 60 |

To compare the color profile files testpatterns were printed bya printer set for 3 calibrated and 1 manufacturing profiles. These testpatterns containing 25 reference color stimuli (fig 4), which are compiled from specific color stimuli of NCS colorpatterns [4, 5]. Colorsamples are printed by Adobe Photoshop using the available 4 (3+1) color profiles and all the several RI, defining with CIE Labcoordinates of color stimuli - belonging to NCS color samples - in the Table 1. Thus, a total of 16x25 colorsample were measured.In order to objectivity, the control-measuring - also in CIE Lab color space [6] – were carried out using an other colorimeter (AvantesSpectrocam).


*Figure 4: Reference test patterns*

## 6. RESULTS AND EVALUATION

Theoretically, because of using color management, color-stimuli coordinates - measured with 25 colorsamples printed by four different profiles - should agree with values in the Table 1. Of course it is not the case, due to the inaccuracies of the profile of manufacturer and the numbers of the profiles. To adjudicate the quality of the profiles CIE $\Delta E^*_{a,b}$ color stimulus difference [7] were calculated, between each of measured color samples and the - theoretically- correct color stimuli from the Table 1. Using this method the color fidelity of the printed color sample can be shown. The high color fidelity belongs to a small color differences, and the small color fidelity conversely.Table 2.shows, considering for example the relative colorimetric RI, increasing the number of samples (343→729→1728) the $\Delta E^*_{a,b}$ color stimulus difference is reducing, deviating (not specified trend) or increasing.

*Table 2: Trend of color stimuli in the case of absolute colorimetric RI*

| Trend | Abbreviation of color stimulus | Nr. of pieces |
|---|---|---|
| reducing $\Delta E^*_{a,b}$ | nk, vp, ns, nlvk, zs, sb, b, sz, vsz, p, ssz, sl, nrs, | 16 |
| deviating$\Delta E^*_{a,b}$ | sk, nz, vz, t, vk2, zk, nb, vl | 7 |
| increasing$\Delta E^*_{a,b}$ | np, sp, n | 2 |

Result, similar to the above, appeared in the case of the other three RIs as well. Thus our logical expectation is justified: increasing the number of the calibration patches is resulting ICC profiles with better color fidelity. Then let us see how the ICC profile of the factory was related to the three color profiles we created. This was examined that we were looked for that in how many cases were better or worse the color differences calculated with the profile of the manufacturer as color differences made withour calibration carried out withthe maximum number of elements (1728). In the case of the 4 RIs this number on average was 16, thus the profile of the manufacturer performed better result than the profile executed by hand and calibrated carrying out with the maximum number of elements.

At the beginning of the measurements, it was expected that the calibration carried out with large number of elements resulting better color fidelity than the calibrating by the manufacturer, because we had that experiences about monitors [8]. However following the results of our measurements we can trust in an ICC profile of a reputed manufacturer in the case of the printers. Probably, the color fidelity measured by the profile of the manufacturer is due to the original paper, the ink and this profile is presumably created using thousands of samples. This large number of elements is compensating the commercial quality changes of paper and the ink well. It can be possible, that using aftermarket-commodity causes much more worse results. Better color fidelity can be achieved with own calibration, if possibly the number of the elements by the calibration is even larger (more than 1728). Mechanized XY coordinate-table is need to this, otherwise we should calibrate for several days.

## 7. LITERATURE


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