THE ICC COLOUR PROFILE

Klaus Kompatscher describes the background and standards of the International Color Consortium's colour profiles

NOWADAYS ICC COLOUR PROFILES ARE OMNIPRESENT IN IMAGE PROCESSING AND IT IS UNTHINKABLE TO DO WITHOUT THEM. A PROFILE DESCRIBES THE COLOURS A DEVICE CAN REPRODUCE AND MAKES IT POSSIBLE TO DEFINE EACH ONE UNIVOCALLY AND INDEPENDENTLY FROM THE DEVICE, MAKING IT POSSIBLE TO PREDICT THE OUTCOME OF COLOUR WORK.

Even before the foundation of the ICC (International Color Consortium) in 1993, many companies used colour profiles to clearly define colour information within their own product families, but these were proprietary systems that could not be used inter-company. Thanks mainly to Apple and a number of individual European competitors, top companies in the image-processing sector got together to develop a shared standard through the foundation of the ICC.

The ICC standard (currently v4), among other things, regulates the structure and content of an ICC colour profile. In detail, ICC profiles are organised into seven classes:

- Input
- Monitor
- Output
- Device link
- Colour space conversion
- Abstract
- Named colour.

This classification makes it possible to adjust an ICC profile to the foreseen use. For example, an input ICC colour profile only requires conversion of the colorimetric space of the device (RGB scanner or digital camera) in the PCS (Profile Connection Space). For a monitor or output class profile, the inverse conversion is also important. For each of these transformations there is a specific table in an ICC colour profile.

THE COLORIMETRIC SPACE

The ICC standard envisions the possibility of using XYZ or Lab as a profile connection space (PCS). Both are colorimetric spaces independent of the device and are used to define, univocally and whatever the device, colour data that instead does depend on the device (RGB or CMYK); in other words, colour information not transferable 1:1 to another device.

The XYZ colorimetric space has theoretical RGB base colours and is therefore used for monitor class profiles. On the other hand, Lab is an equidistant colorimetric space and is used for all the other classes. This fact makes it possible to numerically define differences in colour with a value (?E) that is expressed the same way worldwide. Measured values and tolerances establish whether or not a colour has been correctly printed. The variations to which an observer is exposed have no importance.

An exception among colour profiles is the device link profile, in which no PCS is used because it only permits conversion from the original device to a given destination device. The advantage of a device link profile is that the structure of black can be kept or, if necessary, modified in a targeted way. On the other hand, in a CMYK to Lab to CMYK conversion (original profile to destination profile) the original separation is lost. The disadvantage is that a device link profile can be used solely for a given conversion (device to device) with a rendering intent. The rest of this text will be devoted mainly to the output profile and the colorimetric workspace.

RENDERING INTENTS

Therefore a profile contains tables converting from Lab to the device's colorimetric space and vice versa, in a distinct way for every rendering intent. What usually happens is that the original colorimetric space is larger, meaning it can show more colours than the destination space. This means that at least one calculation method is required to convert colours 'out of gamut' into the destination colorimetric space. The ICC standard describes four of these calculation methods (rendering intents, RI), the first two of which are most commonly used:

- Perceptual (photographic)
- Relative colorimetric
- Saturated
- Absolute colorimetric.

Except for the Absolute colour method, the first step in conversion is to relate the original white to the destination white and consequently adapt all the other colours: a tonality of colour is, in fact, always interpreted by the human eye in relation to the white point. With the relative colour method the 'in gamut' colours are reproduced in a way that is colorimetrically correct, while the 'out of gamut' colours are converted into the closest possible colour tonality. This might give 'out of gamut' colours the same colour tonality.

With the perceptual method this cannot happen because in this case, the colours within the destination colorimetric space are closer together, creating space for the 'out of gamut' colours. This procedure retains the image effect but can lead to an excessive loss of contrast, depending on how many colours are 'out of gamut'. In this case even the black point is involved in the rendering intent; that is, here too with the relative colour calculation method, details may be lost due to 'clipping'.

With 'black point compensation' Adobe developed an unofficial standard that avoids this problem. Quite simply, a kind of perceptual method is used for the black in the destination chromatic space. In practice this is the fifth RI that, although widely used, has not yet been included in the ICC standard.

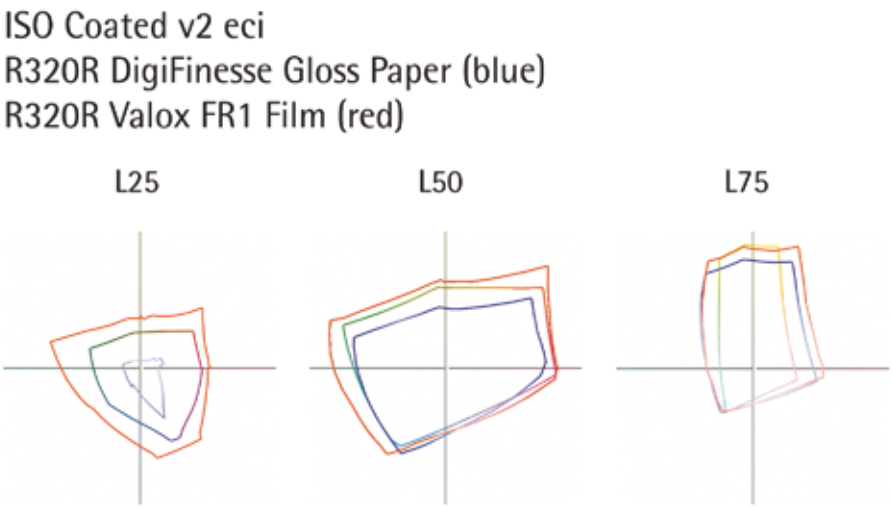
For these reasons it is clear that the smaller the degree of difference between the original profile and the destination profile, the fewer problems there will be in converting an image file. For the same reason, it makes no sense to create documents in the Lab colorimetric space; this would, in fact, have some advantages but could also create a quality problem because of its size.

ICC PROFILE PRECISION

The quality of an ICC profile can be defined basically by size, meaning that the number of bases (8 or 16 lut) is determinant to ICC profile precision. Many bases make sense, although to create a profile many colour fields (more than 1200) are measured.

This characterisation data is extremely important to ICC profile precision. Examining

The output of an image is affected by the Rendering Intent (RI)



A comparison of the gamuts of three different colour profiles

all the aspects of measurement technology is beyond the scope of this article, however in the inkjet printing process and in its innumerable supports, the requisites of the measuring instrument and the user should not be undervalued.

The right balance between print quality and economy is set by separation. The choice of software for profile creation is significant only in the case of perceptual RI. For perceptual RI the ICC has left open many possible interpretations, and so in this case software creators may distinguish themselves from competitors with different algorithms.

How are 'out of gamut' colours rendered and what effect is there on 'in gamut' colours and contrast? For the RC RI the 'in gamut' colours have to be reproduced in a way that is colorimetrically correct. Any profiling software should be able to do this and the user can also objectively check this.

What remains at this point is the subjective assessment of an ICC profile, which in the last analysis is the determinant one. The presuppositions are specific standardised environments and lighting preset by the ISO 3664 standard. Naturally, in this case the result is also influenced by monitor quality and its profile or by the test print and its profile.

A COLORIMETRIC WORKSPACE

ISO coated (Europe) and SWOP coated (USA) colorimetric spaces are used by different printers from different manufacturers (Fogra characterisation data). They are also used in inkjet printing because of a lack of alternatives and due to the state of the colorimetric spaces in the printing and pre-printing sector.

The advantage of a colorimetric workspace lies in its use: this common platform means the exchange and processing of image documents is simplified and the risk of using an erroneous profile is reduced to a minimum. Exchanging chromatic data between graphic artists and printing companies is facilitated. The graphic artist sees the colours that can be printed on the screen. Once all the chromatic data is in the colorimetric workspace, converting the printer's colorimetric space is no longer a problem because these spaces are similar in size.

The bandwidth of the colorimetric spaces on an inkjet system is very big because of the variety of printing materials. While the colour profile for paper in the example used is more or less covered by ISO coated, in the colour