Matrox Imaging

Webinar

A Practical Approach to Color Consistency

Frequently Asked Questions (FAQ)

Q: How much time does each method take for a 1Kx1K image?
A: On a modern PC processor with say four cores, about 2ms for Histogram Specification and about 500µs for Direct Mapping as well as the new novel approach.

Q: Is there a distance measure for the XYZ color space?
A: The distances are mainly defined in the Lab color space because this space is uniformly distributed. In XYZ, a conventional way of visualizing color distance is with the MacAdam ellipses, which also reveal the non-uniform Just-Noticeable-Difference (JND) capability of human color vision. This is why most modern color distance measures are done in Lab or other color spaces which are perceptually uniform. The CIE has also defined over time more complex distances in Lab to achieve greater accuracy. There are specialized distances defined in other color spaces, and for example in XYZ, there is the Bakery Contrast Unit to grade the color of baked food.

Q: Must I convert to sRGB if using a D65 light?
A: If you use a White D65 light, and you white-balance and remove the gamma of the camera, the resulting RGB space is definitely closer to sRGB. But the camera primaries and response will not necessarily fit the sRGB ones.

Q: Do you have to white balance a camera before calibration?
A: White balancing is not mandatory to process colors. An algorithm can be parametrized to work in the native RGB space. If you display the image, you will typically want a white-balanced image for a better visual experience. For simple color analysis where the environment such as the illuminant varies a lot, the white balancing operation will perform an inaccurate, but good enough, relative calibration – actually more of an approximated chromatic adaptation. The Chromatic Adaptation Transform (CAT) is generally reserved for a 3x3 color conversion in XYZ. White Balancing only applies a 3x1, so it's more a gain adjustment than a true Chromatic Adaptation. If performing a relative calibration between two very different illumination and camera setups, white balancing the systems beforehand will make the calibration step a bit easier by getting the RGB spaces closer. But if the systems are similar, white balancing only the reference system is enough.

Q: How many colors are required for a good calibration?
A: Usually the more the better! For Histogram Specification and the like, this means acquiring images of enough differing product to cover the set of expected colors. For Direct Mapping, the chart can be customized, or narrowed, to calibrate the system only around the expected colors. The more the better holds true if the color samples are representative of future inspections. But, for instance, trying to calibrate for baked cookies that are yellowish – some darker and some lighter – by training with a chart that contains blue, cyan, magenta, etc., would not be a good idea. In this case, the irrelevant colors weaken the calibration for the gamut of interest. In all cases, what's important is to cover the expected gamut enough to avoid excessive color extrapolation.

Q: What's the accuracy after calibration?
A: This varies with the calibration technique and the situation. If target system is very different from the reference system for example, then the accuracy will be lower. But in the standard situation of two fairly similar systems, we have seen an error of 2 to 3 in RGB.

Q: Can any of the Matrox products utilize ICC profiles as a method of calibration and conversion to Lab?
A: That's a good point, indeed, if the color management information is known, then it is possible to use it to transform RGB into Lab. Unfortunately it is not used by Matrox for now.

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Frequently Asked Questions (FAQ) - (cont.)

Q: Is there any different approach for line scan cameras?
A: Not really, it can be done the same. However, line-scan cameras often come with a large field of view and thus vignetting. The same color can thus appear with a different RGB value according to its position in the image. This is of course an issue for all the discussed techniques. Ideally the vignetting should be minimized or first corrected using some flat-field correction technique.

Q: What method is better for measuring whiteness or how white the product is?
A: First you need to make sure that the whites are visible by the system, that is, they fit inside the gammut of the system with no saturation. Then it is possible to measure the distance of the color of a product under inspection to the one of a reference product or a reference white such as D65 or D50, in Lab, in terms of Delta E. Note that the CIE also defines a whiteness metric (W,T) in the XYZ for comparing samples under a known illuminant.

Q: All the methods shown seem to be just doing a software-based correction to the image. Do you have any recommendations for how to get camera hardware (gains, offsets, etc.) in alignment before applying these methods.
A: The calibration will be better for sure if the output RGB spaces are closer. Removing the gamma to reduce non-linearity, adjusting the black level and, white-balancing – if the camera itself supports it – or at least using the same gain factors for similar systems, are all good practices.

Q: Do these methods need to be re-applied at each exposure level you are using for your camera? Any recommendations on a more generic function that would work across multiple exposures?
A: Yes since different exposure levels correspond to different RGB spaces. For a finite number of exposure levels, you should ideally do one calibration per exposure level. If using a camera's auto exposure mode, you would select a calibration done at an exposure value closest to the current one.

Q: Do you have any white paper references or anything to explain how the "new novel approach" works?
A: Unfortunately, we cannot share further details on our new novel approach at this time.

Q: Could you elaborate on how do you estimate the quality of the conversion?
A: Once the calibration is performed, we acquire the images of the same scene under the conditions of the reference and the target system. After conversion, the error can be evaluated either in terms of differences in the reference RGB space, or measured in terms of perceptual Delta E distances in the Lab, the later requiring of course more steps.