A Note on Changing Display Colors on Computers Running Windows

Detlef Ruschin
(detlef.ruschin@hhi.fraunhofer.de)

DISCLAIMER

The following text is based on an internet search and represents the summery of the understanding I gained from studying several sources not referenced here. I do not claim that everything I reported is accurate. The intended effect is that the reader is able to undertake his own enquiry, starting with keywords or key ideas presented here. Please contact me if you feel that corrections are required.

Color Management in Windows

Microsoft Windows since version 7 includes a color management module that can use icc profiles as well wcs profiles generated according to Microsoft's own "Windows Color System". Third party software is needed to generate complete color profiles using a computer running windows, and commercial and free programs are available for that purpose.

Normally a display is first calibrated before sample colors are produced and measured to make a color profile. This calibration includes the setting of black level, contrast, white point and gamma within the used monitor. However, Windows can also change the three gamma values of the red, green and blue color channels in the graphics card and write a respective entry into the video card gamma table (vcgt) tag of a color profile. The intended usage of this capability is to correct deviations of the display gamma from the value of 2.2 prescribed in the sRGB standard, if the display itself cannot be calibrated. This feature can be also used to set ad hoc any other gamma value, though, if that is desired for some reason.

Adjusting Monitor Gamma in Windows

Gamma adjustment with the respective Windows tool is performed purely visually. The procedure requires it to match the lightness of a pattern of alternating thin black and white stripes, which are averaged in the eye to 50 % of the display's maximum luminance, with a homogeneous grey field.
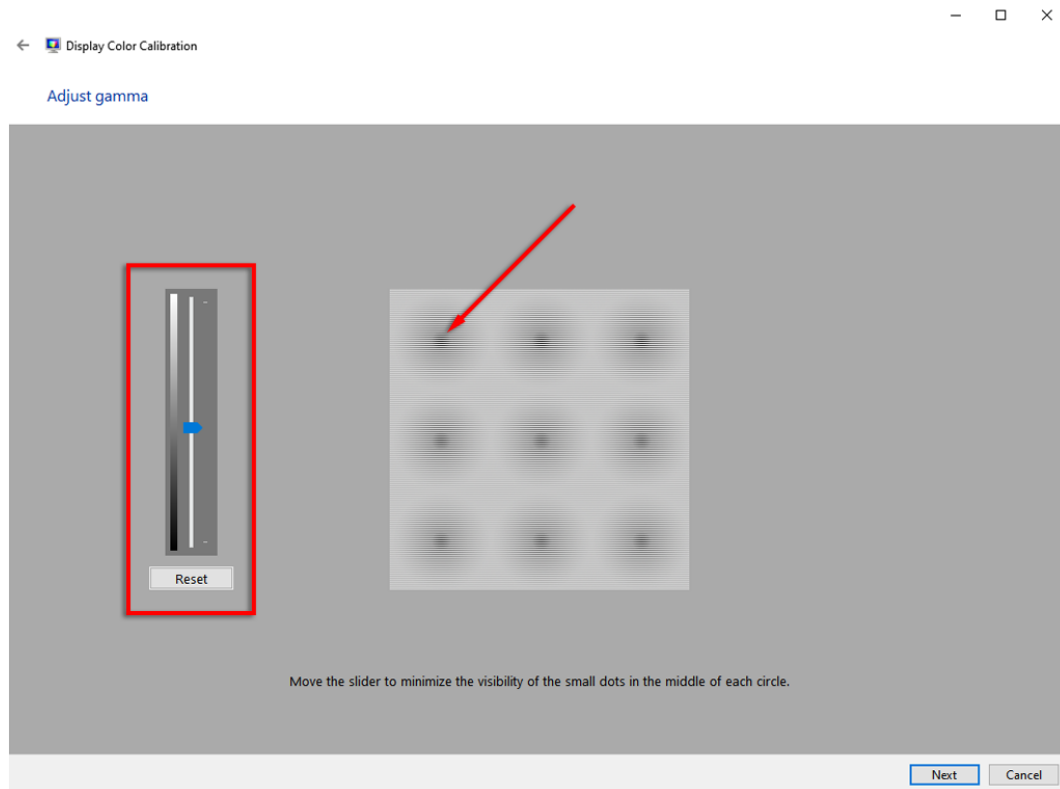
The luminance of black and white stripes is independent of gamma, but the lightness of the grey field changes with the gamma setting and has the intended 50 % maximum luminance when the overall output gamma has the correct value of 2.2. This procedure is illustrated in the screenshot below. When the gamma slider is used, the dot in the center of the circles becomes darker or lighter. The correct value is found when the homogeneous dot becomes indistinguishable from its striped surround (which may require squinting to blur the stripes).

Windows takes care that the additional gamma values for correcting or changing the gamma of the used display are loaded into the lookup table of the graphics card at startup and restored whenever it gets lost, for instance after hibernation of the system. Actually, Windows allows it to adjust the r, b, and g gamma parameters, but the built-in calibration tool sets them all to the same value. Third party software allows it to adjust the individual color channels, but mostly uses the same visual procedure as described above, see e.g., the free software Calibrize (https://www.calibrize.com). Another free tool, Quickgamma (https://www.quickgamma.de), provides color ramps flanked by the mentioned stripe pattern. By identifying that part of the ramp, which matches the averaged stripes the user can read the current gamma value on a corresponding ruler. The task is fairly difficult, but allows it, at least in principle, to diagnose the display before applying a gamma correction. While with the already mentioned tools the found gamma value needs to be saved by the user to take effect, the two other freeware tools Gamma Panel (https://gamma-panel.de.uptodown.com/windows) and Gamminator (https://sourceforge.net/projects/gamminator) autosave any change in real-time so that the system-wide effect can be immediately observed. Gamma-Panel has no been updated since 2007 and its homepage is gone, but it still works and can be found on several freeware sites including the one linked above.

Display Calibration with 3D Lookup Tables

In some professional areas it is felt that the calibration and profiling procedures indicated above are too limited in their options for mapping the colors specified in a file to the colors in the gamut of the

used display. The restrictions are that only a limited number of mapping principles ("rendering intents") can be employed and that the mappings for the colors residing between the few ones that were measured during the profiling procedure are only interpolated. The alternative approach pursued in the film and tv industry is to use 3d lookup-tables (LUTs), in which each individual color (of for example 256*256*256 = 16.75 million in systems with 8 bit resolution per color channel) is explicitly mapped. Professional TV monitors can store such 3d LUTs, but if only ordinary computer monitors are used with modern graphics cards, the LUT functionality can be implemented in the graphics processors on these cards, i.e. it can run as a program on the GPU. Obviously a gamma change is just a simple form of color remapping and can thus be included in any 3d software LUT, so that such a solution would leave the three adjustable hardware LUTs unused.

Recent graphics processing units can convert an image in less than a millisecond, which means that color corrected videos can run in real-time. A commercial Russian supplier of a respective software is Fast Video (https://www.fastcompression.com/solutions/gpu-3dlut.htm), but there are probably others, and there is also at least one freeware solution (https://github.com/ledoge/dwm_lut) available.

This paper is available under the following URLs

http://color.li.tu-berlin.de/RUSCHIN22.PDF

or

http://farbe.li.tu-Berlin.de/RUSCHIN22.PDF

I thank *Detlef Ruschin* who writes this paper for Gamma applications, for example according to the ergonomic standard ISO CEN DIN 9241-306:2018. For the ISO-test charts see

http://standards.iso.org/iso/9241/306/ed-2/index.html

Klaus Richter