Three Years of Practical Experience in Using ISO Standards for Testing Digital Cameras

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Introduction

In 1997 we started to build our test booth for testing digital still cameras. The decision to start this kind of testing digital cameras was made because just looking at pictures on the screen or analysing printed pictures ended in different results depending on the test person and the surrounding conditions. We designed the testing equipment by using ISO Standards, except some parameters which are discussed on the following pages.

Until today we had the possibility to measure more than 150 different cameras and could also test up to 40 cameras of the same type. So there is a good base to make some conclusions about this way of camera testing.

The evaluated parameters in the test cycle are:

- ISO 14524 OECF measurement
- ISO 12232 Determination of ISO Speed
- ISO 15739 Noise measurements
- ISO 12233 visual Resolution / SFR measurements
- Color Reproduction
- Shading

Target Illumination

The homogenous illumination of the target area is achieved by an ulbricht integration sphere with a diameter of 1 meter. Two 250 W halogen bulbs with appropriate filtering for daylight and tungsten conditions are used for illumination. The light source is arranged in an 90 degree angle to the viewing direction of the camera towards the target. The outside of the ulbricht sphere is coated with a coal/plexisol mixture inside we used a bariumsulfate/plexisol mixture. The maximum daylight illuminance is about 500 cd/m^2, the maximum tungsten illuminance is more than 1500 cd/m^2. Both values are measured with the OECF chart 1:1000 in place. Without any chart maximum tungsten illuminance is about 1650 cd/m^2. The spectral distribution of the light source fits the requirements of ISO 7589.

The reflective targets like the Kodak SFR targets and the resolution targets are illuminated by halogen lamps with daylight filtering.

OECF

The OECF is measured using the camera method with a chart of 1:1000 contrast. Noise and speed are measured using the same chart. (ISO Standard: 1:80 reflective).

The OECF is measured by taking ten exposures of the target and evaluating them with a photoshop-plugin to get mean value and standard deviation of at least 64x64 Pixels of the 12 patches. These values are evaluated for each of the three channels red, green and blue. Y and R-Y and B-Y is calculated for ISO speed determination. The test target is exposed in a way that clipping is reached in the lightest patch which is needed for measuring saturation speed.

The dynamic range is given by the maximum log luminance minus log luminance where the S/Nx is below a certain value. Right now we are using S/Nx = 2 to determine the dynamic range of a camera.

Until now we had only a few cameras which were able to reproduce the whole dynamic range of 1:1000 according to 10 f-stops. Most of the consumer cameras are below that range at about 4-7 f-stops.

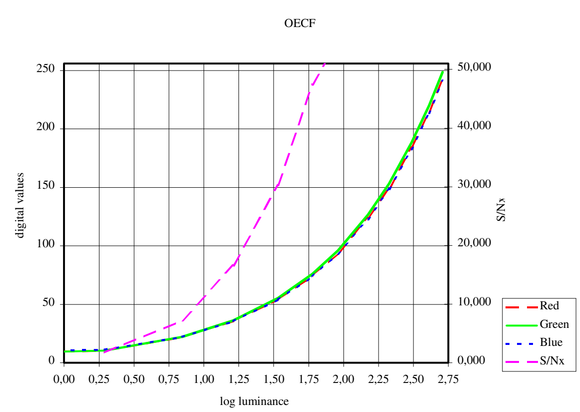

Figure 1. OECF daylight of Leica S1 with high dynamic range

The OECF curve is plotted in a chart with digital values against log luminance. The shape of the curve will be exactly linear if gamma is 2.2, but most of the cameras are calibrated to a gamma below 2.2, so the curve is hanging a little bit.

It is easy to see whether the camera has a well balanced tone reproduction or shows clipped highlights or noisy shadows. The quality of the white balancing algorithm can also be determined. If the three tone curves of red, green and blue are lying exactly one over the other the white balance is working perfectly. The white balance algorithms seem to be very different and some manufacturers seem to know better than others how to get a neutral picture.

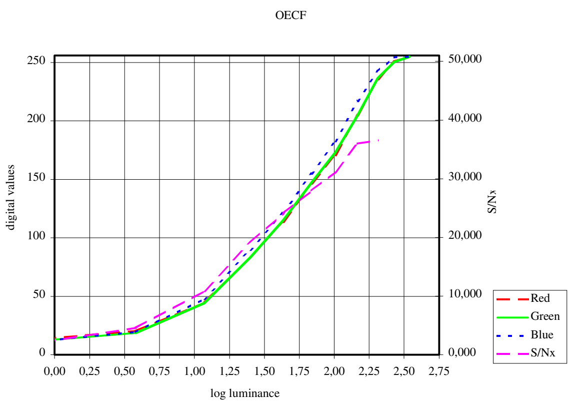

Figure 2. Fuji Finepix 4900 daylight

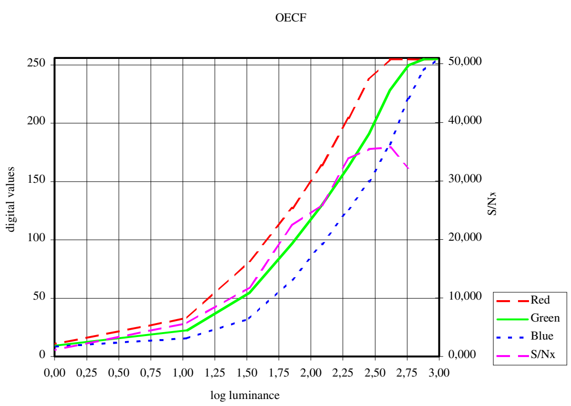

Figure 3. Fuji Finepix 4900 tungsten

There are cameras which have a sensible white balancing. Very slight differences in the angle pointing at the OECF target are resulting in a different white balancing. The target is neutral grey and so the camera should be able to produce neutral pictures with an ISO-standard illumination.

Our Photoshop-Plugin writes the meanvalue of R-G and B-G into a text file.

A remarkable value which can be determined from the OECF is the range of used digital values. There are some cameras which are hardly using 245 digital values so they are throwing away about 5 percent of the possible contrast range only because of a non perfect tonal range correction.

The ISO Speed is computed from the shutter speed and the used aperture given by the camera.

Noise

Three noise patches in the middle of the ISO-Noise chart are evaluated using a photoshop plugin. Because the chart is made on a film recorder it is important to choose the appopriate shooting distance. Another possibility is to defocus the lens a little bit.

We decided to frame our target between two glass plates to keep dust and mechanical stress as low as possible. The three noise patches are exactly in the middle of the target and the optical axis of the camera lens is pointing exactly to this place on the target. The target acts like a mirror and the reflection of the lens or the whole camera is to be seen in the image. This could be avoided by placing the noise patches out of the center of the target.

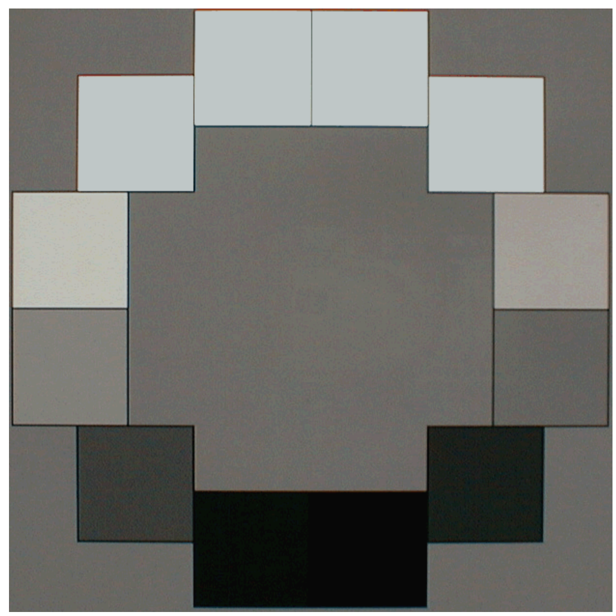

Figure 4. Reflection of the camera in the target (shown with the old target for better visibility of the reflection)

The results of these noise measurements are comparable only with values done with the same illumination of the three patches.

Resolution Measurements

For resolution measurements we started to use the standard transmission ISO SFR-Target.

The visual evaluation of the parabolic resolution structures and the parallel line structures on the target gave good results. But we always had to use one picture as a kind of reference for comparing.

We tried to produce a computational evaluation of the parallel line structures in the image by measuring the contrast difference between the black and the white lines. The first minimum of this should be the maximum resolution.

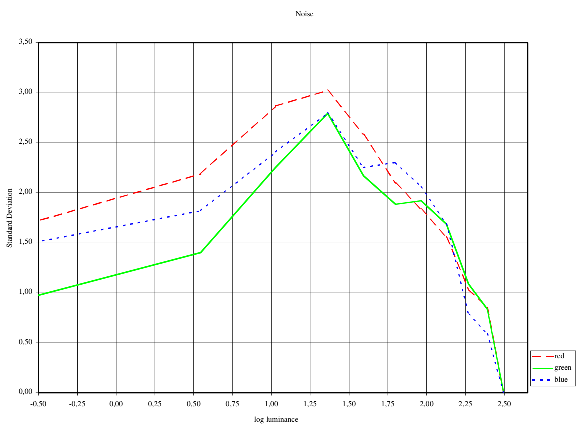

Figure 5. absolute digital noise values (the starting point of the noise reduction is visible)

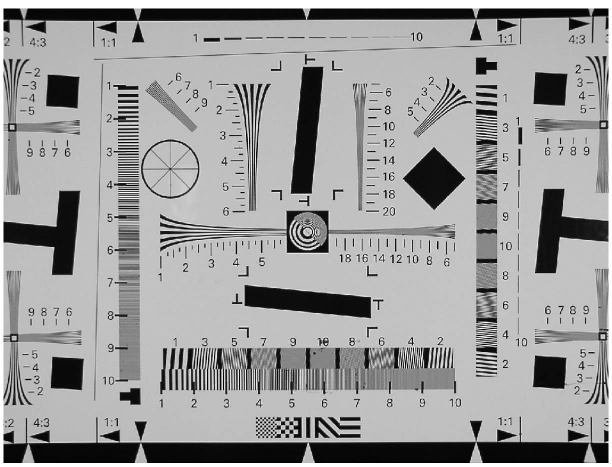

Figure 6. image of reflective target with Olympus E-100RS

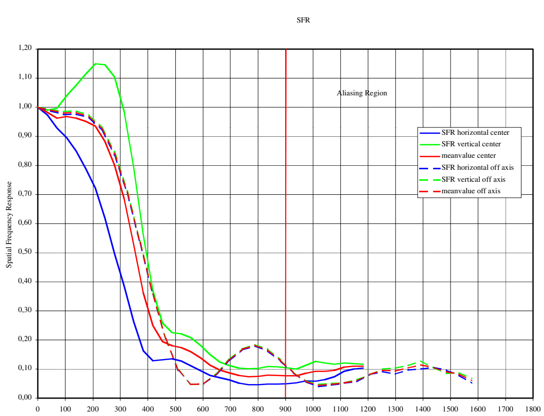

Figure 7. SFR of Canon Powershot Pro 90 IS

Due to the fact that the resolution of this structure is changing from line to line there is no possibility to achieve a result where you can be shure that there are not already some aliasing effects which are misleading.

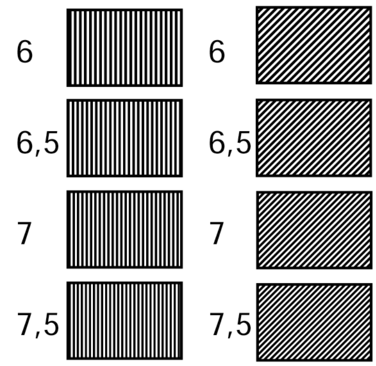

Figure 8. Linear structures for visual resolution evaluation

Some of the cameras with fixed lens had to be placed very close to the resolution testchart to use the maximum picture height. The focusing mode had to be changed to macro range because there was no possibility to get the resolution in standard focusing range.

We decided to print the resolution target 0.8m heigh and to take the pictures in reflection daylight mode. So we could use a focusing distance of 1.5 m to 2.5 m which is more realistic.

The SFR-based evalutation of the transmission target works with scanners or with camerabacks which have the possibility to switch off the unsharpmasking. Otherwise we did get results with a contrast higher than 1.0 and depending on the camera manufacturer the results had a certain offset. So you could not compare the results of two cameras of different manufacturers which have theoretically and visually the same resolution. The image processing inside the camera is changing the picture in a way that the SFR-algorithm gives the correct edge analysis, but this is not related to the details of a scene reproduced by the camera.

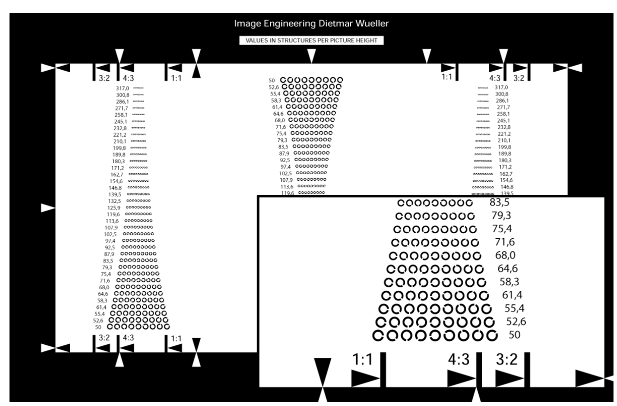

Figure 9. Circular structures for visual resolution evaluation

We also tried to use the low-contrast kodak reflection target, with similar results. Because of these problems we are evaluating other targets for visual analysis. We produced some testcharts with structures containing only parallel lines on it . The resolution is changing in 0.5 LW/PH. But these structures need space and so they are not always in the center position where you get the best resolution of the lens.

Furtheron we are trying to use black circular structures with a little white segment in it. So there is not the decision if the parallel lines are still separated but only the "yes" or "no" if the small segment is still visible.

Shading:

A milk glass plate is used to measure the shading from the optical axis to the corner of the field of view.

With standard consumer zoom cameras three pictures are taken with wide, standard and tele zoom factor. These pictures are taken in automatic exposure mode, so the grey value should be anywhere in the range of 100-150. The pictures are evaluated by measuring 2400 areas 8 by 8 pixels wide. The results are normalized to the range of 0 to 1 and graphically presented. Further on the minimum value is divided by the center value, this results in the percentage of the difference form center to the edge (Shading S).

$$I_{min} / I_{max} * 100 = S [\%] \quad (1)$$

A problem with cameras that do not allow manual focusing is that you will get different results depending on the focusing distance the autofocus determined. We always put the front lens of the camera directly in contact with the milky glass target, so most of the cameras do not know what to do and are focusing to infinity.

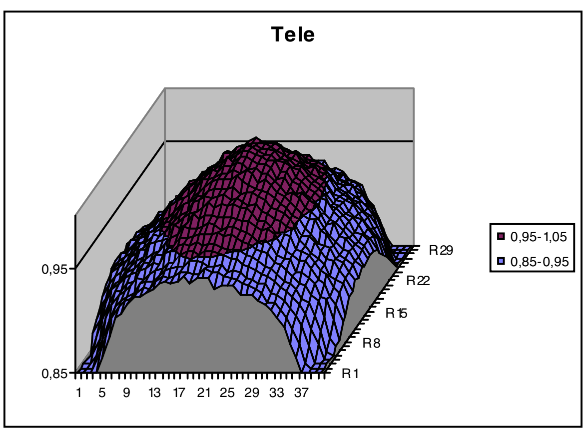

Figure 10. Shading of Fuji Finepix 4900 (normalized values)

Color Reproduction

The color reproduction quality is determined by taking pictures of the right part of an enlarged transmitting IT8 chart. The the spectral transmission of the patches has been measured and the Lab values were computed. As most of todays cameras are offering the image data in the sRGB color space they are transferred to the Lab color space and a color distance calculation of ΔE is done. To avoid problems with varying exposure values only th twodimensional ΔE on the a and b axis of the Lab colorspace is evaluated. The results show whether misreproduction of colors is caused by a saturation boost or by a problem of the spectral sensitivity or color calculation in the camera.

We are planning to change to the Gretag Macbeth Colorchecker DC, because this target is using more natural colors instead of the film dyes in the IT8 chart.

Conclusions

The measured parameters OECF, dynamic range, used digital values and white balance are giving a good idea of the characteristics of a tested camera. By knowing the parameters and having some experience it is possible to transfer the sesults of the cameras to a predicted behavior in real life photography.

The SFR evaluation is often giving different results between computed value and visible result. This is in our opinion the most difficult value on testing digital cameras right now. We decided to make a visual evaluation of the pictures but we are always computing the SFR too to get a better understanding of the SFR .

The lower S/Nx value which is used to determine the dynamic range of a digital camera should be set to a fixed value.

The color reproduction quality gives information about saturation enhancement of the digital cameras. The target has to be changed to ColorChecker DC and the results should be displayed as Luminance, Chroma and Saturation values.

Future

Overall picture quality increased a lot within the last three years and is satisfactory for most users.

Besides image quality easy using of the cameras, camera speed and behavior at low light conditions become more and more important.

Right now we are working on measuring parameters like lens distortion, camera power consumption and autofocus speed at different image contrasts.

References

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Biography

Christian Loebich studied electronic engineering from 1986 to 1993 at the TU Darmstadt (Germany), and photographic sciences from 1994 to 1999 at the Fachhochschule in Cologne (Germany). Since 1998 he paticipated building the digital camera test stand at Image Engineering Dietmar Wueller in Cologne.