Imatest I3A CPIQ support

SFR & Acutance – Color Uniformity – Lens Geometric Distortion & Chromatic Aberration – Texture

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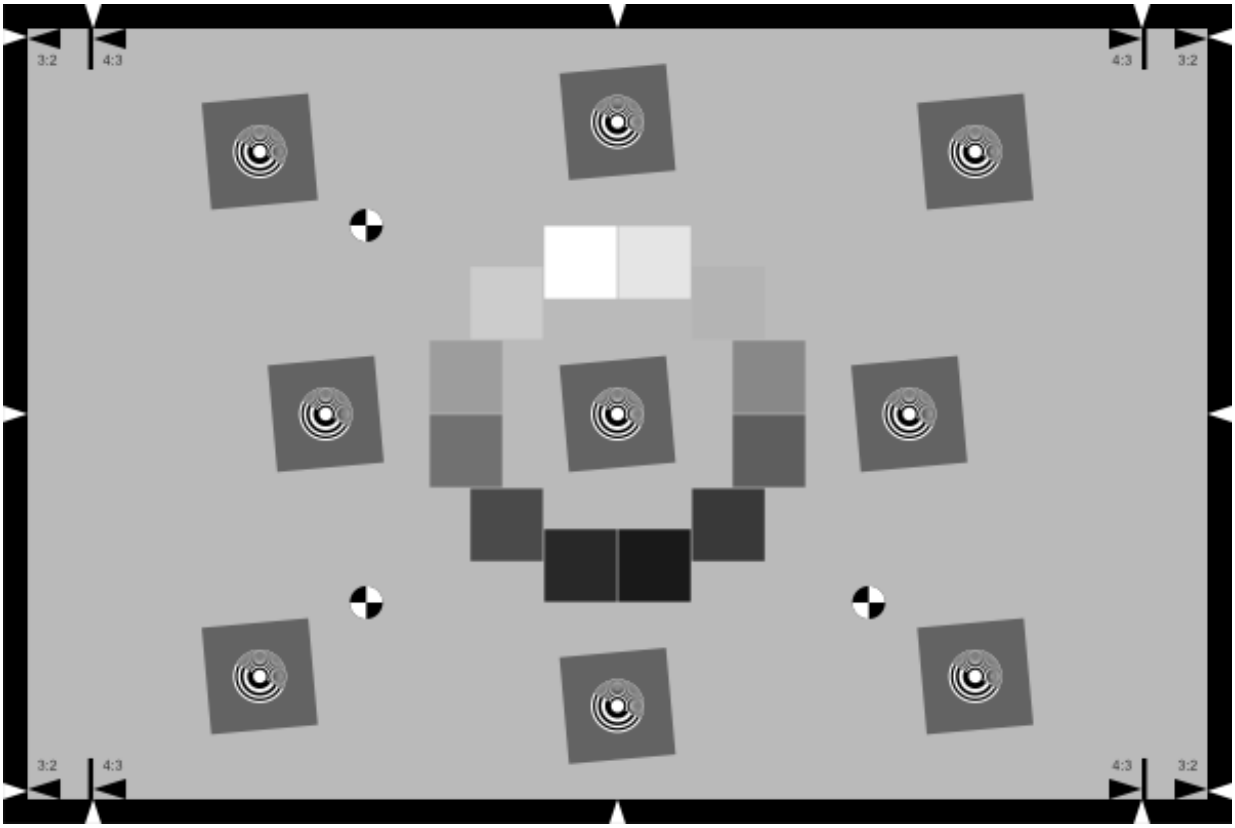
Starting with ***Imatest 3.9***, ***Imatest*** provides strong support for I3A (International Imaging Industry Association) CPIQ (Camera Phone Image Quality) **Phase 2** measurements. For further detail, you should purchase the CPIQ 2.0 Specifications & Test Methods document. We will start working on Phase 3 soon as soon as it's available.

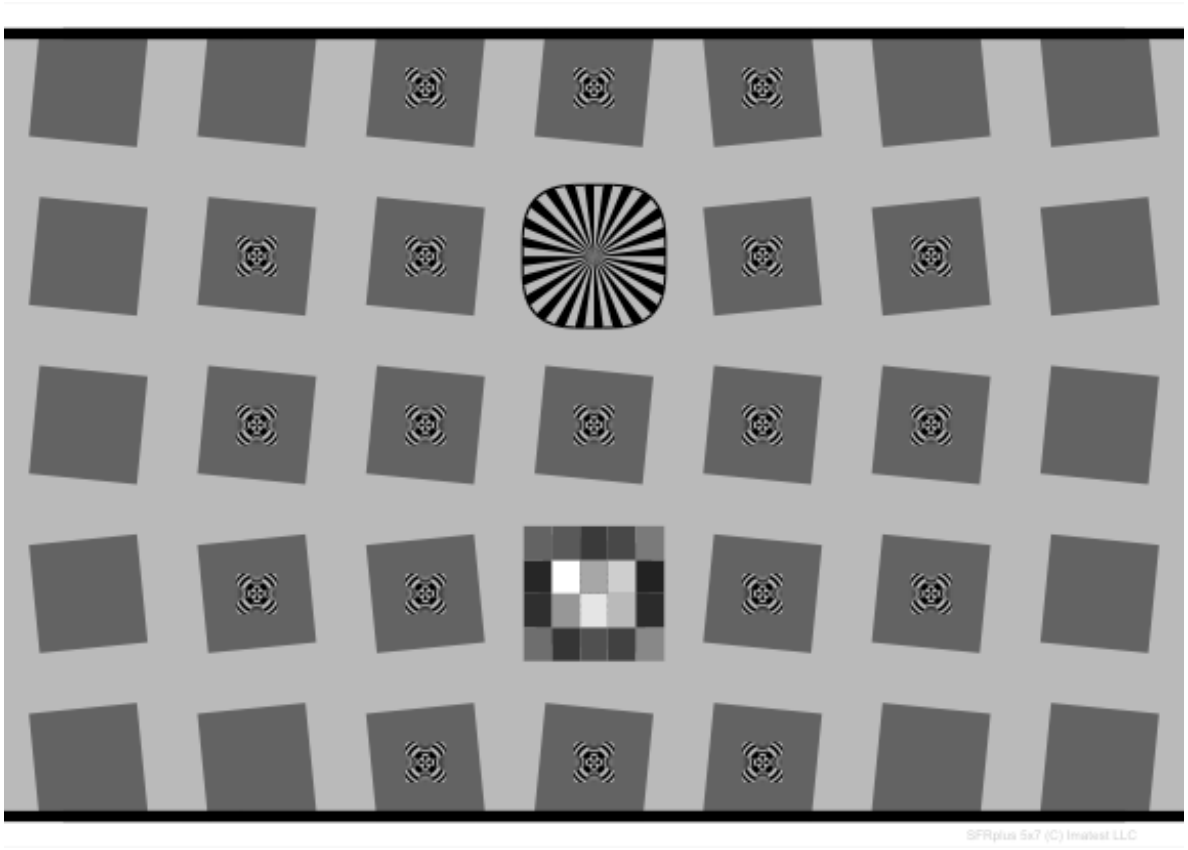
SFR and Acutance

For CPIQ, sharpness is measured as Spatial frequency response (SFR) (also called Modulation Transfer Function (MTF)) using slanted-edges with a contrast of 4:1. Either the SFR or SFRplus module can be used for this purpose. The CPIQ document recommends the new ISO 12233 low-contrast slanted-edge test chart (under development by the ISO TC42 committee, to be released in late 2011 or 2012). The version shown in the CPIQ document is somewhat out-of-date. Imatest offers the new chart in its store in either 24×36 or 40×60 inch print size. Here is a sample of the chart.



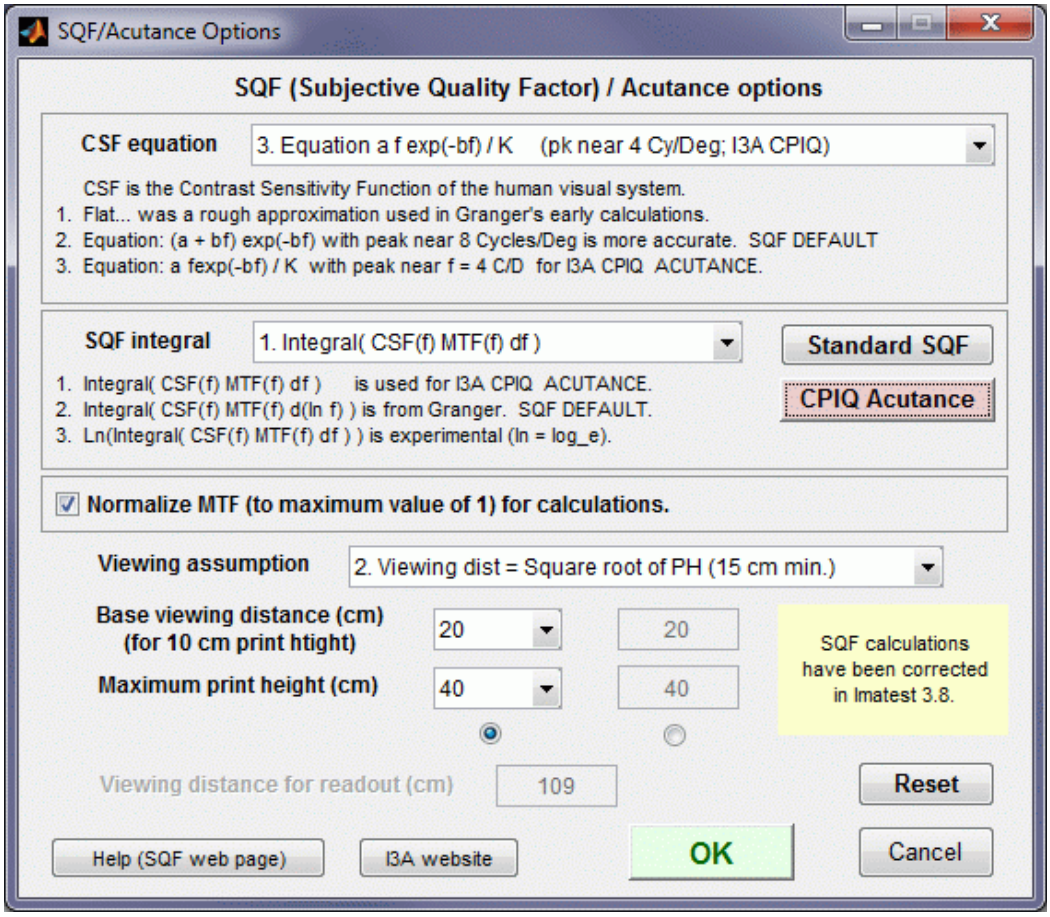
New ISO 12233 low-contrast slanted-edge chart

Although the new ISO-12233 chart produces perfectly good results with SFR, *Imatest* recommends a 4:1 contrast SFRplus test chart, which is compatible with the ISO chart, but offers better automation, more edges for a more detailed map of SFR over the image surface, and several additional measurements. This chart is available from the Imatest store.



SFRplus 5×7 4:1 contrast test chart (with focus star)

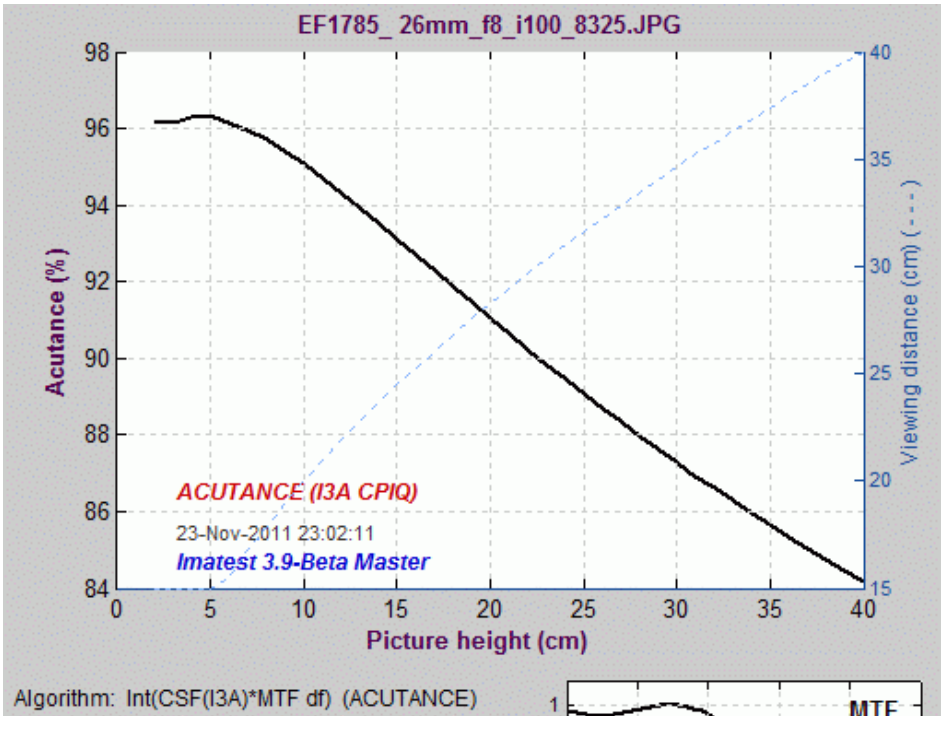
Acutance is a perceptual measurement designed to answer the question, "how sharp does the image look?" It is closely related to Subjective Quality Factor (SQF), differing only in the details of the equation. It is calculated from MTF (SFR), a model of the human visual system Contrast Sensitivity Function (CSF), and viewing conditions (image height and viewing distance). The CPIQ 2.0 document defines it but gives little indication of how it should be displayed. In Imatest it is displayed in exactly the same way as SQF, which provides many of options. To obtain Acutance measurements, open **SFR** or **SFRplus**, then click on the button in the **Settings** window (**More settings** in SFRplus). Click on the button to select the acutance calculation. You'll have to make some assumption on the viewing conditions. See SQF/Acutance for details.

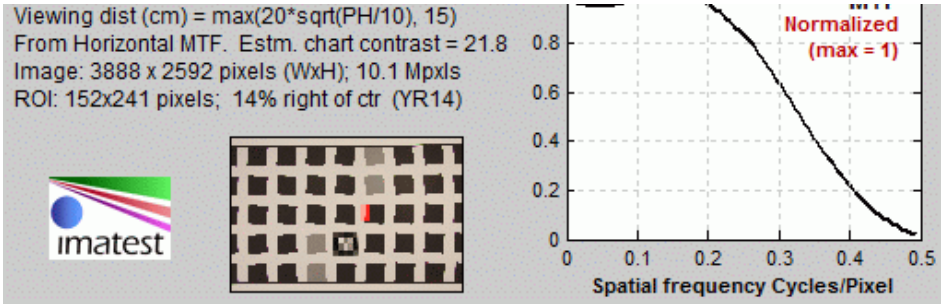


SQF/Acutance settings window

Here are results. We have assumed that viewing distance is proportional to the square root of the print height (which fits my (NLK's) experience of photography galleries). It can be fixed or have a cube root function.

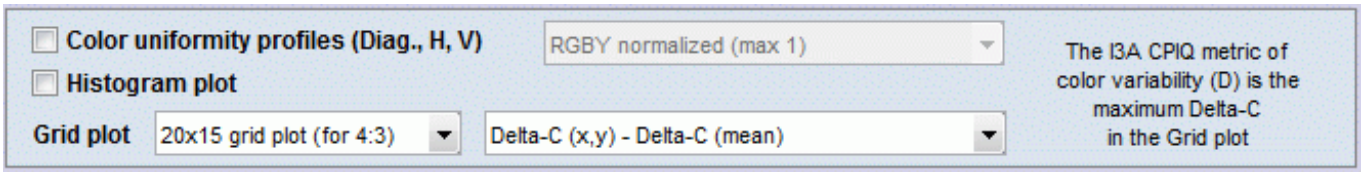
Acutance results for viewing distance = 20*sqrt(PH/10) or 15 cm, whichever is larger
for Picture height from 2 to 40 cm (0.8-16 inches)





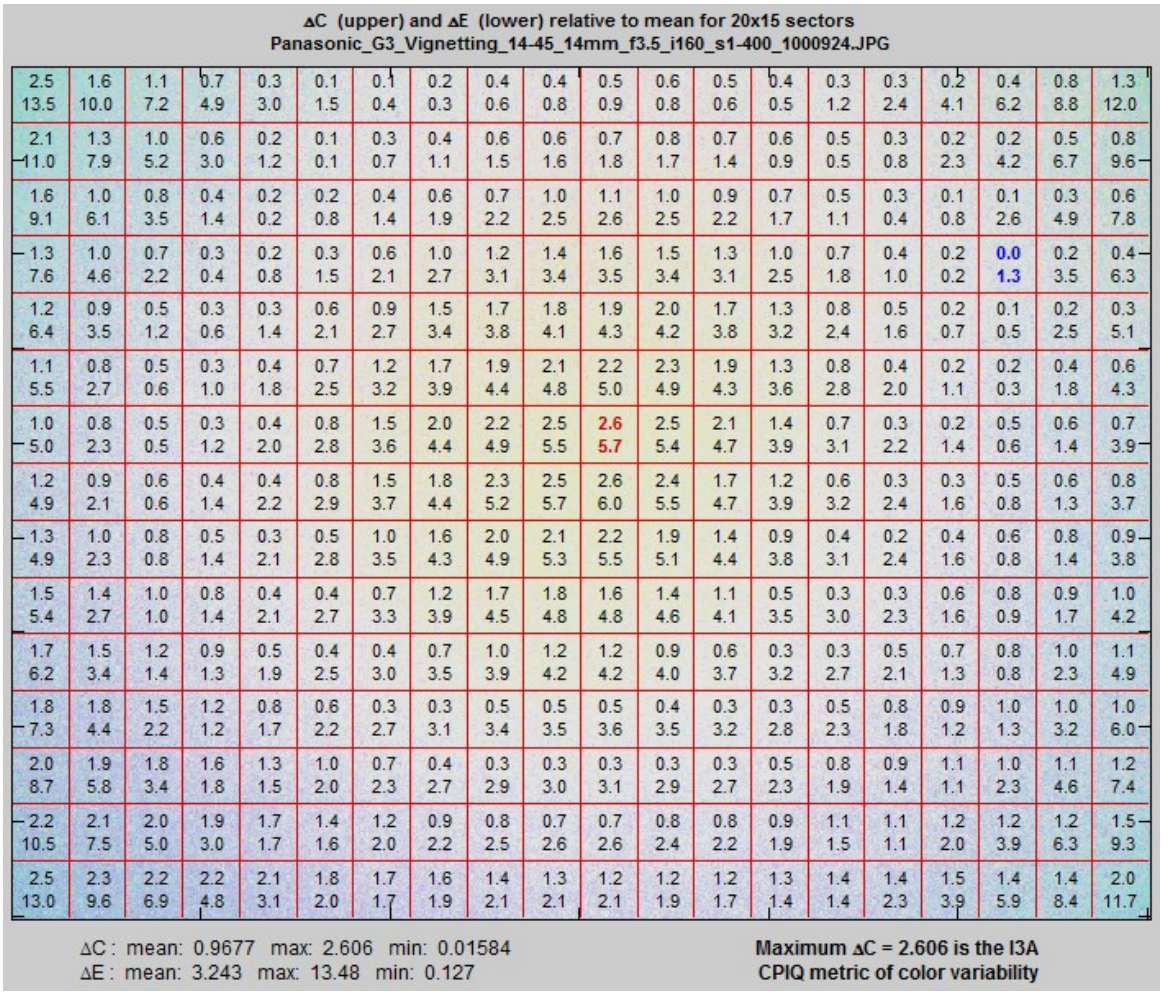
Color variability

The CPIQ color variability metric, maximum ΔC, is displayed in Light Falloff and Uniformity-Interactive when **Grid plot** is set as follows.



Grid plot settings

Here is the resulting grid plot.



2.5 13.5	1.6 10.0	1.1 7.2	0.7 4.9	0.3 3.0	0.1 1.5	0.1 0.4	0.2 0.3	0.4 0.6	0.4 0.8	0.5 0.9	0.6 0.8	0.5 0.6	0.4 0.5	0.3 1.2	0.3 2.4	0.2 4.1	0.4 6.2	0.8 8.8	1.3 12.0
2.1 11.0	1.3 7.9	1.0 5.2	0.6 3.0	0.2 1.2	0.1 0.1	0.3 0.7	0.4 1.1	0.6 1.5	0.6 1.6	0.7 1.8	0.8 1.7	0.7 1.4	0.6 0.9	0.5 0.5	0.3 0.8	0.2 2.3	0.2 4.2	0.5 6.7	0.8 9.6
1.6 9.1	1.0 6.1	0.8 3.5	0.4 1.4	0.2 0.2	0.2 0.8	0.4 1.4	0.6 1.9	0.7 2.2	1.0 2.5	1.1 2.6	1.0 2.5	0.9 2.2	0.7 1.7	0.5 1.1	0.3 0.4	0.1 0.8	0.1 2.6	0.3 4.9	0.6 7.8
1.3 7.6	1.0 4.6	0.7 2.2	0.3 0.4	0.2 0.8	0.3 1.5	0.6 2.1	1.0 2.7	1.2 3.1	1.4 3.4	1.6 3.5	1.5 3.4	1.3 3.1	1.0 2.5	0.7 1.8	0.4 1.0	0.2 0.2	0.0 1.3	0.2 3.5	0.4 6.3
1.2 6.4	0.9 3.5	0.5 1.2	0.3 0.6	0.3 1.4	0.6 2.1	0.9 2.7	1.5 3.4	1.7 3.8	1.8 4.1	1.9 4.3	2.0 4.2	1.7 3.8	1.3 3.2	0.8 2.4	0.5 1.6	0.2 0.7	0.1 0.5	0.2 2.5	0.3 5.1
1.1 5.5	0.8 2.7	0.5 0.6	0.3 1.0	0.4 1.8	0.7 2.5	1.2 3.2	1.7 3.9	1.9 4.4	2.1 4.8	2.2 5.0	2.3 4.9	1.9 4.3	1.3 3.6	0.8 2.8	0.4 2.0	0.2 1.1	0.2 0.3	0.4 1.8	0.6 4.3
1.0 5.0	0.8 2.3	0.5 0.5	0.3 1.2	0.4 2.0	0.8 2.8	1.5 3.6	2.0 4.4	2.2 4.9	2.5 5.5	2.6 5.7	2.5 5.4	2.1 4.7	1.4 3.9	0.7 3.1	0.3 2.2	0.2 1.4	0.5 0.6	0.6 1.4	0.7 3.9
1.2 4.9	0.9 2.1	0.6 0.6	0.4 1.4	0.4 2.2	0.8 2.9	1.5 3.7	1.8 4.4	2.3 5.2	2.5 5.7	2.6 6.0	2.4 5.5	1.7 4.7	1.2 3.9	0.6 3.2	0.3 2.4	0.3 1.6	0.5 0.8	0.6 1.3	0.8 3.7
1.3 4.9	1.0 2.3	0.8 0.8	0.5 1.4	0.3 2.1	0.5 2.8	1.0 3.5	1.6 4.3	2.0 4.9	2.1 5.3	2.2 5.5	1.9 5.1	1.4 4.4	0.9 3.8	0.4 3.1	0.2 2.4	0.4 1.6	0.6 0.8	0.8 1.4	0.9 3.8
1.5 5.4	1.4 2.7	1.0 1.0	0.8 1.4	0.4 2.1	0.4 2.7	0.7 3.3	1.2 3.9	1.7 4.5	1.8 4.8	1.6 4.8	1.4 4.6	1.1 4.1	0.5 3.5	0.3 3.0	0.3 2.3	0.6 1.6	0.8 0.9	0.9 1.7	1.0 4.2
1.7 6.2	1.5 3.4	1.2 1.4	0.9 1.3	0.5 1.9	0.4 2.5	0.4 3.0	0.7 3.5	1.0 3.9	1.2 4.2	1.2 4.2	0.9 4.0	0.6 3.7	0.3 3.2	0.3 2.7	0.5 2.1	0.7 1.3	0.8 0.8	1.0 2.3	1.1 4.9
1.8 7.3	1.8 4.4	1.5 2.2	1.2 1.2	0.8 1.7	0.6 2.2	0.3 2.7	0.3 3.1	0.5 3.4	0.5 3.5	0.5 3.6	0.4 3.5	0.3 3.2	0.3 2.8	0.5 2.3	0.8 1.8	0.9 1.2	1.0 1.3	1.0 3.2	1.0 6.0
2.0 8.7	1.9 5.8	1.8 3.4	1.6 1.8	1.3 1.5	1.0 2.0	0.7 2.3	0.4 2.7	0.3 2.9	0.3 3.0	0.3 3.1	0.3 2.9	0.3 2.7	0.5 2.3	0.8 1.9	0.9 1.4	1.1 1.1	1.0 2.3	1.1 4.6	1.2 7.4
2.2 10.5	2.1 7.5	2.0 5.0	1.9 3.0	1.7 1.7	1.4 1.6	1.2 2.0	0.9 2.2	0.8 2.5	0.7 2.6	0.7 2.6	0.8 2.4	0.8 2.2	0.9 1.9	1.1 1.5	1.1 1.1	1.2 2.0	1.2 3.9	1.2 6.3	1.5 9.3
2.5 13.0	2.3 9.6	2.2 6.9	2.2 4.8	2.1 3.1	1.8 2.0	1.7 1.7	1.6 1.9	1.4 2.1	1.3 2.1	1.2 2.1	1.2 1.9	1.2 1.7	1.3 1.4	1.4 1.4	1.4 2.3	1.5 3.9	1.4 5.9	1.4 8.4	2.0 11.7

Light Falloff (or Uniformity-Interactive) 15×20 grid plot for ΔC and ΔE

The CPIQ color uniformity metric is displayed on the lower-right: **Maximum ΔC = 2.606 is the I3A CPIQ metric of color variability.**

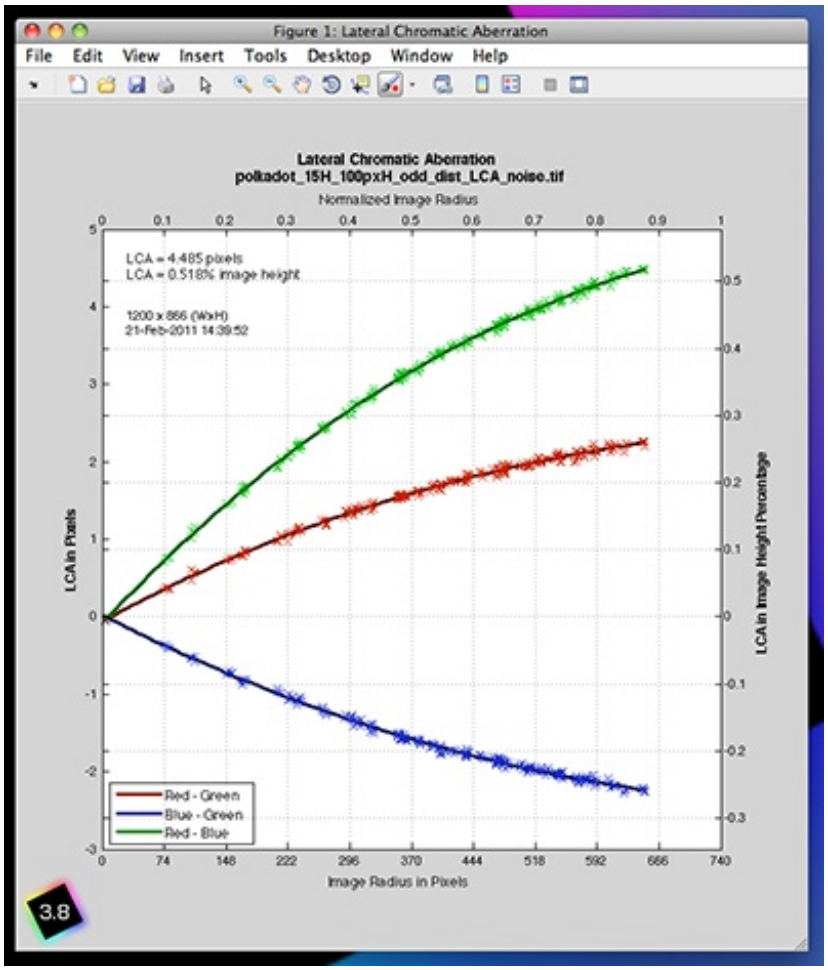
Lens Geometric Distortion & Chromatic Aberration

Both lens distortion and chromatic aberration are measured by photographing a dot pattern chart and analyzing it with the Dot Pattern module.

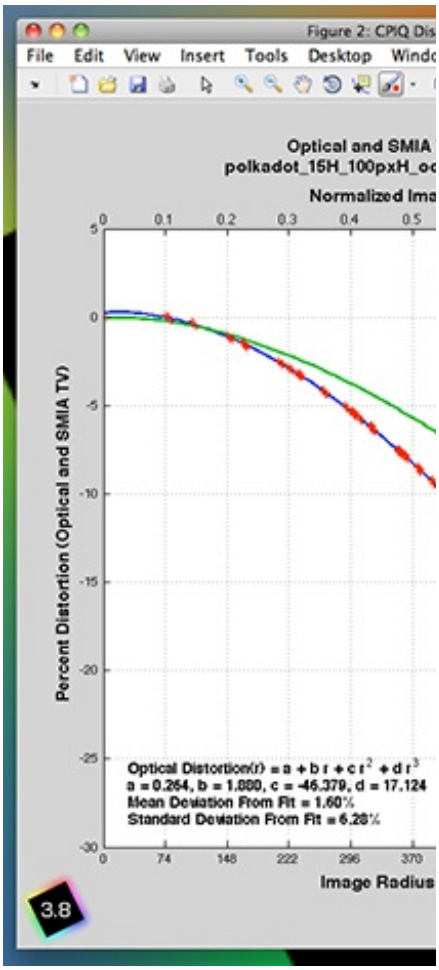
The image on the left, below shows Lateral Chromatic Aberration as a function of image radius in pixels. The image on the right,below shows optical and SMIA TV distortion.

Dot pat

Lateral Chromatic Aberration



Optical and SMIA TV distortion



Texture

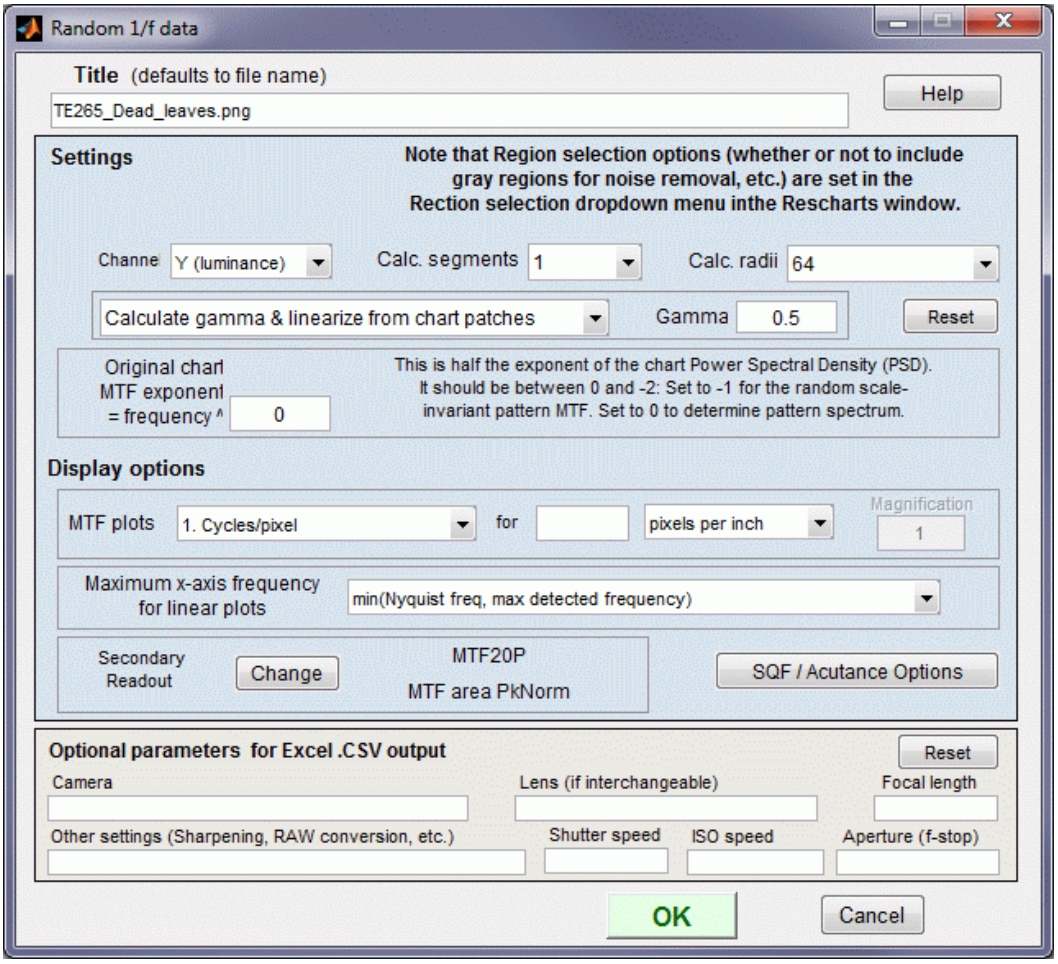
The CPIQ Phase 2 “Initial work on texture Metric” document calls for an analysis of the “Dead Leaves” pattern (“spilled coins” would have been more descriptive), but provides little detail about how the results are to be displayed. It mentions Noise Power Spectrum (NPS), which is also called the Power Spectral Density (PSD). PSD is the square of the MTF.

The MTF or PSD of Dead Leaves images can be measured by the Imatest Random Scale-Invariant module (a part of Rescharts). This module was designed for a different pattern— a random pattern filtered for a $1/f$ spatial frequency response, which is equivalent to $1/f^2$ Power Spectral Density (PSD). Such a pattern is scale-invariant, i.e., its spectrum is independent of magnification; it doesn’t change with changing distance from the chart. This makes extremely convenient for measurements. It is also the best (i.e., worst-case) pattern for measuring texture because it lacks any sort of edge feature; hence it maximizes noise reduction and minimizes sharpening. The Dead Leaves pattern, by contrast, has some (curved) edges; it has the attribute of being more representative of real images. It will often yield a more extended (i.e., better) MTF/PSD response than the scale-invariant random pattern.

The slanted-edge (particularly high contrast edges) is the opposite extreme: it minimizes noise reduction and minimizes sharpening, hence it gives little information about a camera’s texture response. CPIQ and the new ISO 12233 standard call for 4:1 edge contrast— much lower than the old ISO 12233 standard, which called for a *minimum* contrast of 40:1— an extremely high contrast level that created all sorts of problems (errors due to clipping, excessive sharpening, etc.)

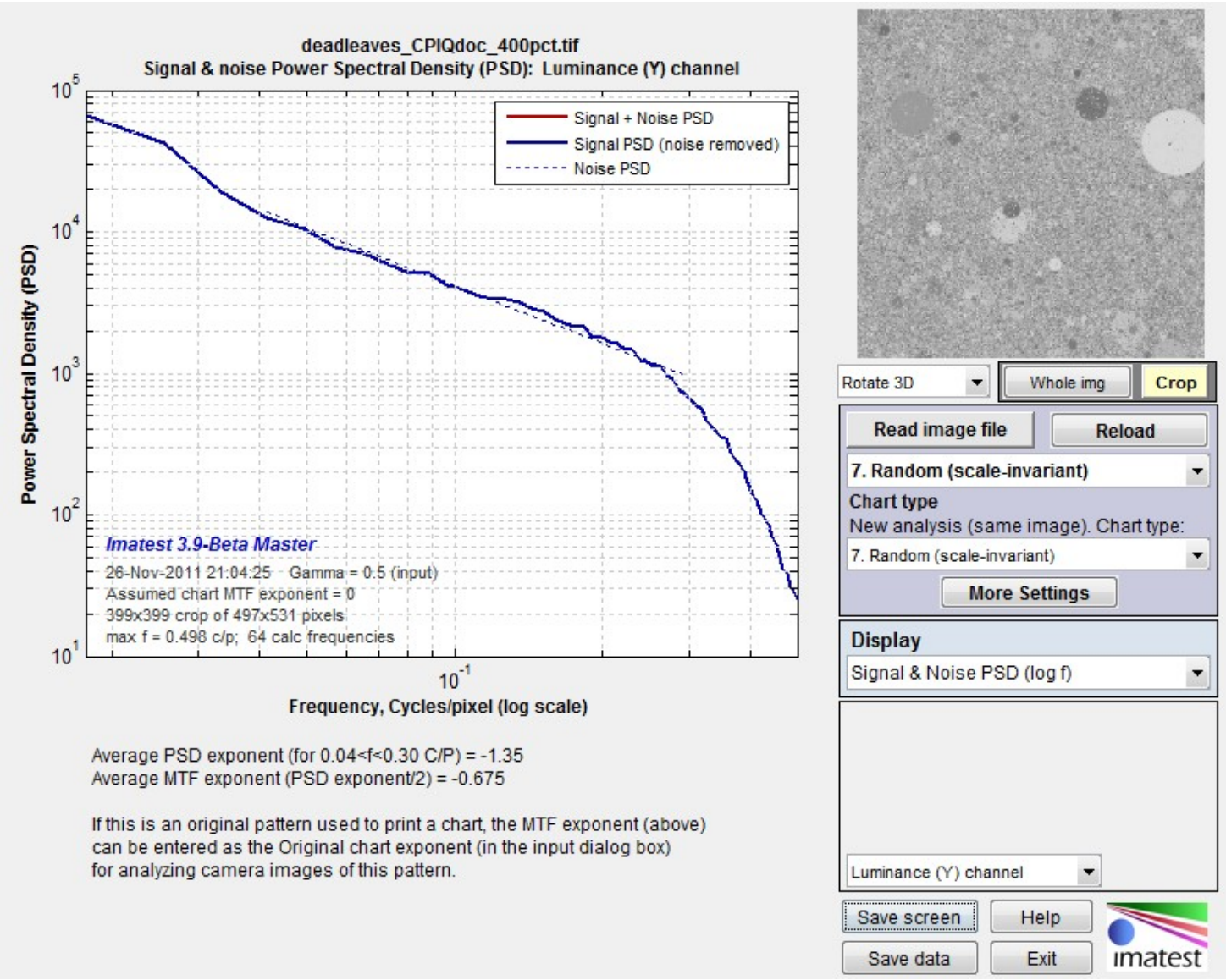
There are a few errors in Figure 2 (Culling Matrix) of the CPIQ texture document. White noise is *not* scale invariant, and is quite difficult to use because it becomes smooth gray at large distances. Log Frequency is nearly scale invariant and has a complete representation of texture (with the Log F-Contrast target).

The PSD (i.e., NPS) of the Dead Leaves target has an exponent close to that of the scale-invariant random target. In Figure 4 of the CPIQ document, the PSD exponent is -1.86 (close to -2 for a true spatial-invariant pattern). This number can be different for different implementations of the Dead Leaves pattern. It can be determined by running the Random Scale-Invariant module on an undegraded or original bitmap version of the pattern (which may be difficult to come by). To determine the exponent, set the Original chart MTF exponent to 0, as shown below.



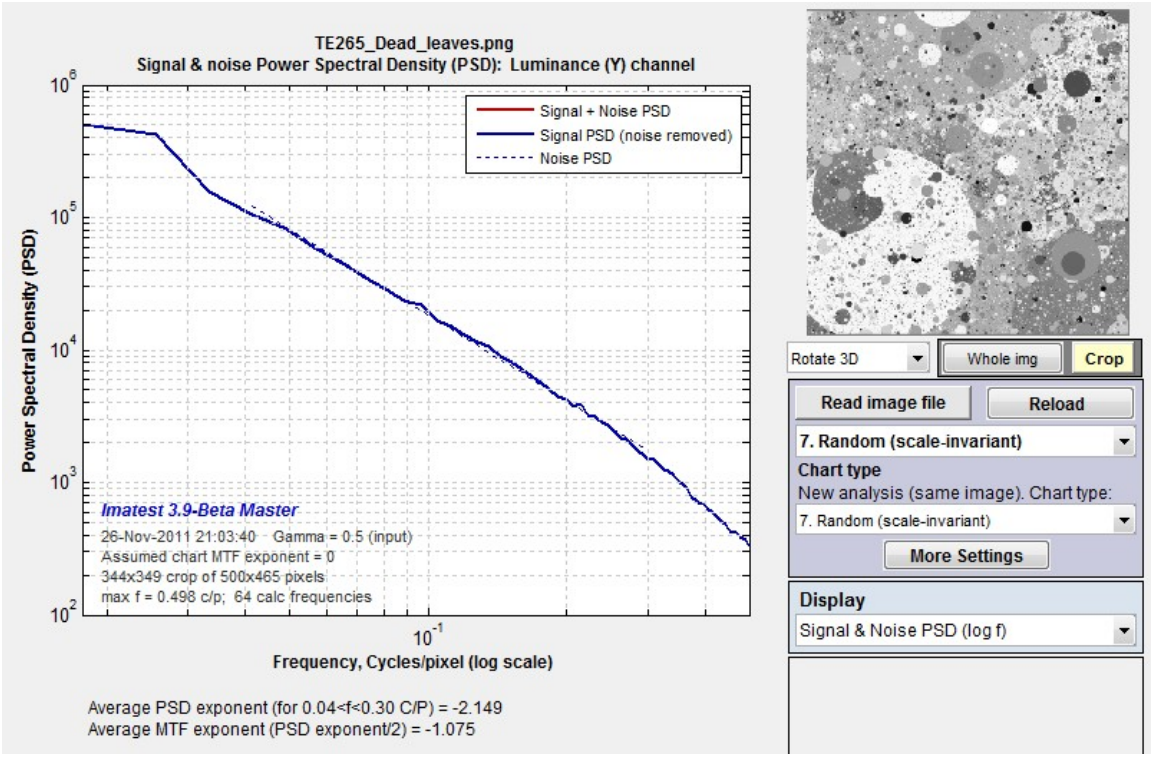
Random Scale-Invariant Settings window. Exponent set to 0 for finding the response (exponent) of an original or undegraded Dead Leaves chart.

The PSD exponent measured with this setting (-1.35, below) is the exponent of the chart itself (assuming the image is representative of the original chart, which it is not in this example). The results below for the pattern from the CPIQ document, enlarged 400% (almost certainly magnified more than the original image, which explains the rapid PSD drop above 0.3 cycles/pixel).



PSD (NPS) response for the Dead Leaves image in the CPIQ Phase 2 document

Their appearance of the image below is very different, and this difference corresponds to their different Power Spectra. It has more low frequency response, hence a steeper rolloff (i.e., a larger PSD exponent: -2.149). Of course neither of these images are pure untouched representations of the original, so we can't expect accurate results.



PSD (NPS) response for another Dead Leaves image. Very different exponent.

To run a proper system test, enter the measured MTF exponent for the chart (half the PSD exponent) into the **Random Scale-Invariant** Settings window. The Dead Leaves pattern is typically framed so it takes up about 1/3 of the image linearly (about 1/10 by area). This number may be vary depending on the chart design and the pixel size of the image (the pattern will require more space in low-resolution images such as VGA).

Imatest does not currently offer a Dead Leaves chart.