Image Quality Analysis

Reference Handbook

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[BETA release]

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Índice

This handbook has been automatically translated, so there may be grammatical and syntactical errors that make it difficult to understand. In future versions I will try to improve this translation.

Contract Terms

ImageQA is currently released under a BETA development license. This means that the software is under development and testing and is supplied "as is" which probably means that there are defects and bugs in the development.

The purpose of that version is to obtain information about performance and usability from potential users.

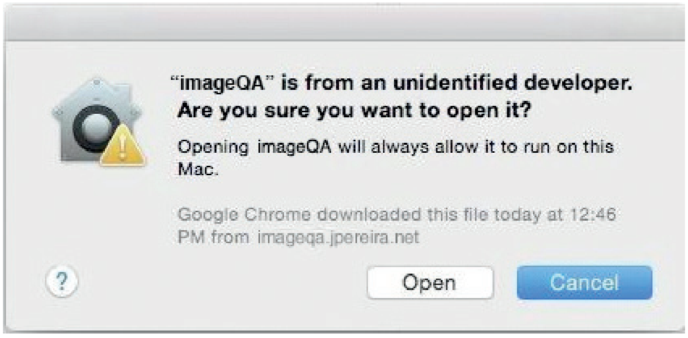
ImageQA does not install any kind of tool that accesses personal data or sensitive parts of your computer, all files needed for its operation are included in the installer itself, so its operation and removal should not pose any problem for the stability of your computer. Nevertheless, THIS TOOL, AS A DEVELOPMENT VERSION, IS DISTRIBUTED WITHOUT ANY WARRANTY OR SUPPORT REGARDING ITS OPERATION, INSTALLATION OR DISINFRAMEMENT AS WELL AS ANY INCIDENCE THAT MAY APPEAR DURING ITS INSTALLATION OR DISINFRAMEMENT ON YOUR EQUIPMENT. Do not use ImageQA in its BETA version for any professional task as the algorithms implemented so far may contain errors or lack of precision.

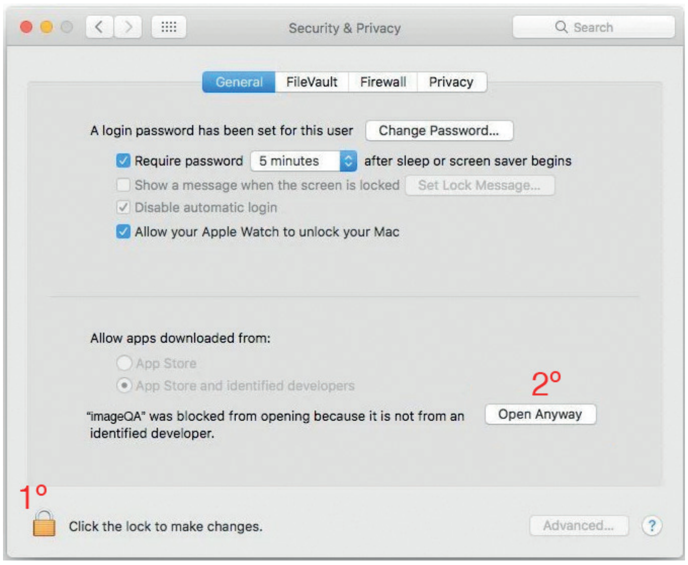
If you need support a group has been enabled in the social network Facebook:

https://www.facebook.com/groups/674482120019374/

In order to establish discussions and contribute errors about the operation of ImageQA. You can also contact *imageqa@jpereira.net* with any comments you may have on how the tool works.

Installation





From the System Preferences panel, we must access Security and Privacy and from there accept the execution of imageQA

Requirements in MacOs

ImageQA in its MacOs version only works with versions > 10.11 (Capitan, Sierra and Mojave) for now does not work with Catalina.

ImageQA is downloaded packaged in a DMG, just run the DMG and drag the ImageQA.app into the applications directory.

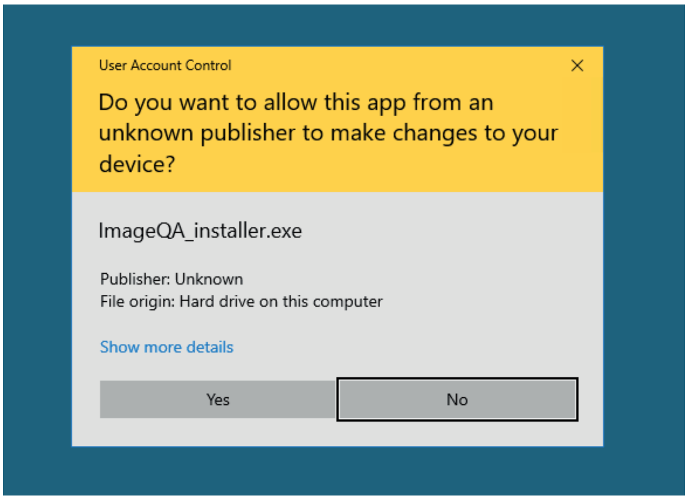
When you run it for the first time the program could indicate that the developer is not verified and will not give you the option to open it.

We must go to *System Preferences* and in *Security and Privacy* in "Allow Applications Downloaded from" we will allow the execution of ImageQA.
Then, depending on the operating system imageQA will be opened or we must run the program again and a new alert will allow us to open it.

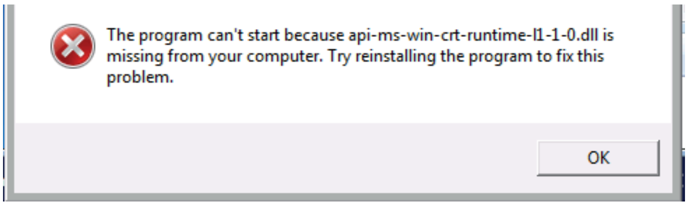
To uninstall the program, just drag the ImageQA directory to the trash. The program will leave a .plist file with its configuration, if we want to delete it this is in the directory:

/Users/[usuario]/Library/Preferences/com.jpereiranet.imageQA.plist

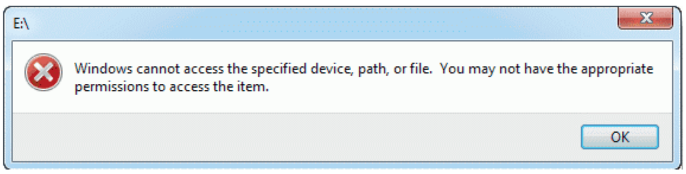
Windows requirements



Al igual que en MacOs debemos pemitir la instalación de heramientas hechas por desarrolladores no identficados



If we get the error "api-ms-win-crt-runtime-l1-1-o.dll", we must install the libraries "Visual C++ Redistributable for Visual Studio 2015



If we get the error that Windows cannot access the specified device..., it is possible that our antivirus has blocked it. Even if the file is virus-free, anti-viruses can block it while scanning. The solution is to disable the antivirus during installation and then re-enable it.

On Windows ImageQA has been successfully tested in version 7 and 10.

During the installation in Windows it can appear the error indicating that ImageQA cannot start because the DLL "api-ms-win-crt-runtime-l1-1-o.dll" is missing, to solve this error it is necessary to install the tools "Visual C++ Redistributable for Visual Studio 2015" from the own page of Microsoft:

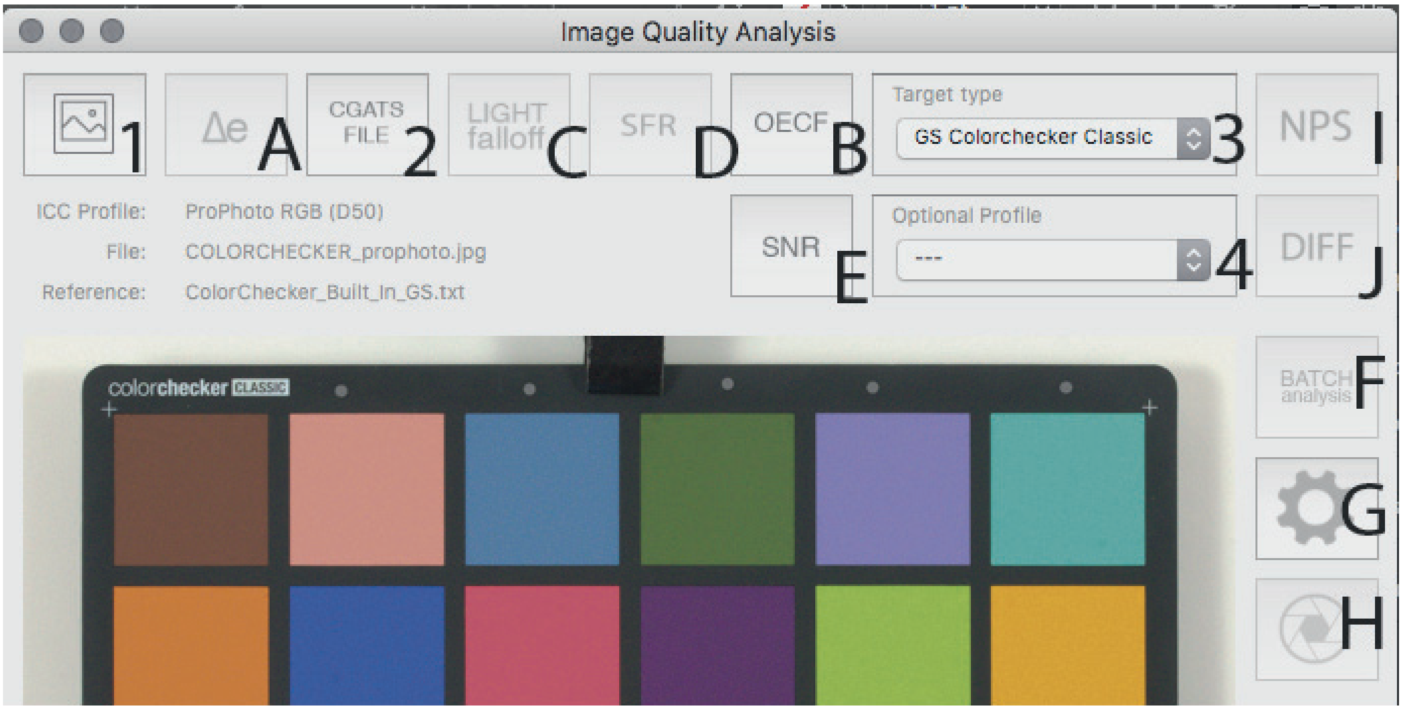
https://www.microsoft.com/es-es/download/details.aspx?id=48145

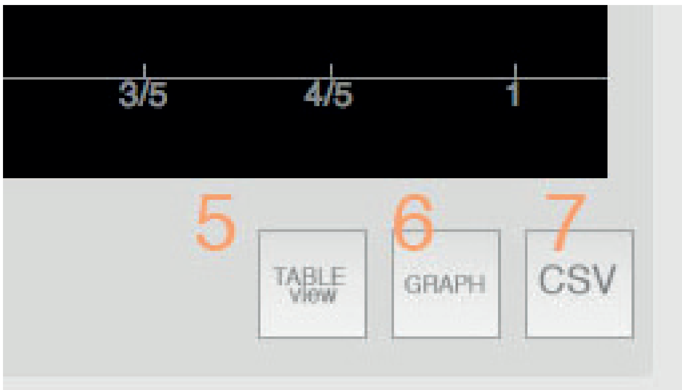
In the version for Windows the program is provided in an installer that will copy the files of ImageQA to the directory C:\Program Files (x86)\jpereira_net\ImageQA, as well as create a shortcut on the desktop and the start menu. Within that path is the uninstall.exe which will remove that directory and the links created. However, certain entries will remain in the registry, which for security reasons cannot be removed. If we want to delete them, we must use the Registry Editor "Regedit" and go to the path HKEY_CURRENT_USER > Software > jpereiranet > imageQA, deleting manually all the jpereiranet entry.

Before the installation we must accept the security alert of unknown developer that windows may launch our operating system

To debug possible ImageQA errors we can launch imageQA.exe from the Windows terminal.

Instrucciones





From each analysis we have several display options:

View the data of the graph or test in table form.

6.- Export our graph as a PNG image

7.- Export the data in CSV format

1.- Open Images. One image or multiple images are accepted
2.- Upload reference file in CGATS format
3.- Select the type of target or pattern to use to identify the area of interest
4.- Load optional ICC test profile

A.- Delta-e analysis
B.- OECF Analysis
C.- Light Falloff
D.- MTF Analysis
E.- SNR Analysis (Noise)
F.- Batch Analysis
G.- Settings
H.- Camera information
I.- Noise Power Spectrum
J.- Full Reference Image Difference

Load images

ImageQA supports TIFF, JPEG and PNG images in RGB or grayscale mode, but the latter format is only used for MTF and LightFall analysis. For OECF and Noise it is in development.

Load reference documents

Supported reference documents must be in IT8/CGATS format and contain the colorimetry in Lab mode, other spaces such as XYZ will be discarded, and ImageQA does not convert from XYZ to Lab at this time. The illuminant must be D50 as this is the default, it can be adjusted later.

Select a Target Type

The cards supported at the moment are:

- Colorchecker family (Classic, Mini, Passport, etc)
- Colorchecker SG
- Kodak Q13
- IT8
- ROI

The ROI (Region Of Interest) pattern is used to calculate the Light Falloff and determine the area for calculating the MTF.

For Colorchecker targets a reference file is attached by default, although it is equally recommended to upload our own file. For IT8 targets and Q13 scales it is necessary to upload our reference files. The default reference files are stored in the "reference" directory in the program folder.
There is a target type called "GS Colorchecker Classic" which is for studies on the gray scale of the Colorchecker Classic, in order to study the OECF and Noise.

Optional Profiles

ImageQA supports color management, so it interprets the ICC profiles embedded in the image itself, as well as other input profiles we have installed in our system. By default ImageQA looks for such profiles in the default directories of Windows and MacOs:

Windows:

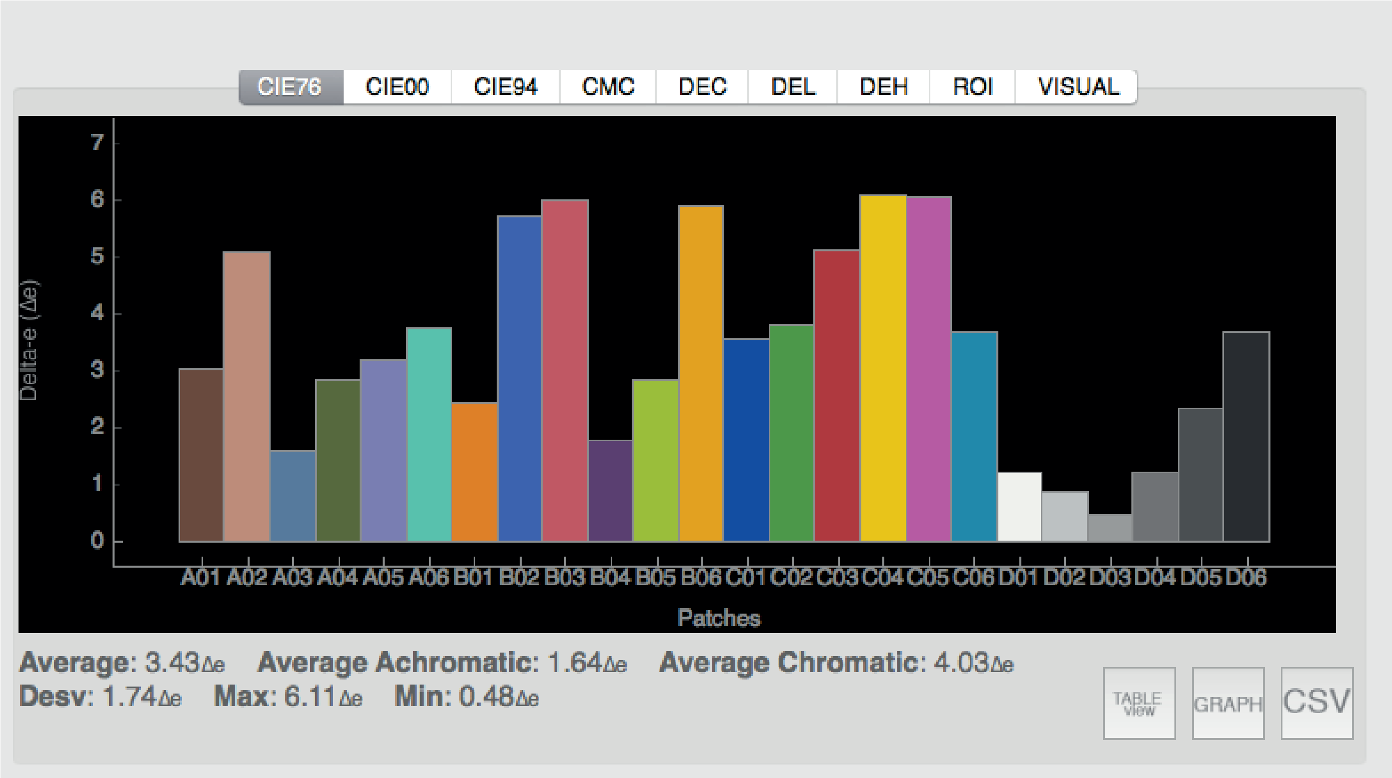
C:\Windows\System32\spool\drivers\color

MacOs:

Library/ColorSync/Profiles/
or
/Users/[usuario]/Library/ColorSync/Profiles/

However in the settings button we can select another route where we store our ICC profiles for testing purposes. Only input ICC profiles are accepted

Delta-e



Using Delta-e metrics we calculate the difference between two colors, i.e. the difference between a sample color, taken from our image, and a reference color taken from a document (reference document in CGATS format) that describes the colorimetry of our color target.

In this way, after photographing a color target, with its colorimetry known as a Colorchecker family target, and subjecting it to a particular workflow, we can easily estimate the color difference between the reality and its digital representation.

For delta-e analysis it is necessary to have images in RGB mode and target patterns that include patches with a color hue. CMYK and grayscale images cannot be used.

The implemented metrics are:

CIE76: which is the oldest metric, but also the most used in a lot of standards and recommendations

CIE00: o CIE 2000 is the most up-to-date version of the estimation of the difference between colours, with the difference from CIE 76 being perceptually uniform, i.e. the differences are estimated on the basis of human perception rather than mere Euclidean distance as in CIE76

CIE94: is a disused metric, resulting from the evolution towards a perceptually uniform metric that was left behind by the ICD00 proposal

CMC: is a metric of the Color Measurement Committee related to the world of printing and textile inks. It is the first perceptually uniform metric, but has only been used in the field of the textile industry.

In addition to the metrics that estimate the stimulus difference, or error in color, a detailed representation for each color attribute of the LCH space is added.

DEC (Delta Chroma) where the error in chromatism is expressed.

DEL (Delta Lightness) where the clarity error is expressed.

DEH (Delta Hue) where the error in hue is expressed
The following statistics are extracted from each metric:

Average: or average error, where the errors of all the patches are averaged.

Average Achromatic and Average Chromatic: here the error is separated between chromatic patches (patches with a color shade, and achromatic or neutral patches. This is necessary because often neutral patches accumulate less error, and cause the Delta-e mean to drop, giving unrealistic error means with the color deviation for samples with a certain chromaticity.

Max and Min: show the maximum and minimum error. In particular, the maximum error must be taken into account, since if our works have a shade close to the samples that accumulate more error, our average will not be representative of the quality of the resulting work.

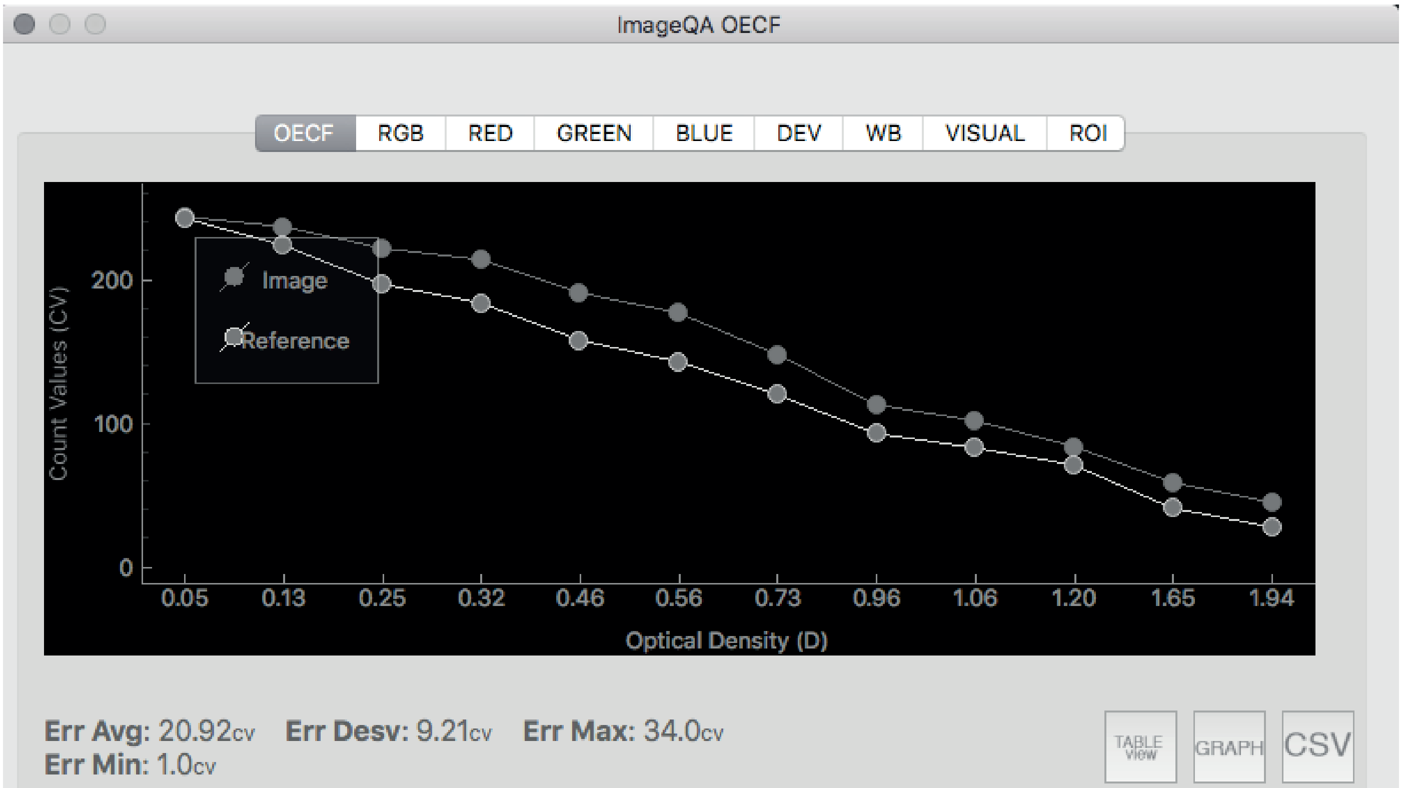
Finally, several representations are shown:

ROI (Region Of Interest) leaves testimony where the samples have been taken on the image.

VISUAL: it generates a patch with the colorimetry of the target on the image, to estimate its visual difference. If the error is low, this estimate will be difficult to perceive.

Example of the Colorchecker Classic card type with its 24-patch identification pattern.

OECF



The OECF (Opto Electronic Conversion Function) metric tells us about the relevance of the tone transfer, between the scene (our target) and the image, and evaluates whether each area of the image (highlights, half-lights and shadows) is in place.

The OECF allows us to make estimates about the relevance of the camera exposure, presence of curves introduced during image processing or to evaluate the neutrality, or balance between the different RGB channels.

Unlike Delta-e evaluation, the OECF is only done on neutral patches and is especially oriented for use with densitometric scales. Since the OECF has to be related to a reference, it is necessary to load a reference document in CGATS format with the colorimetry of the samples to be studied.

For the OECF only the densitometric or grey scale is studied. For the calculation of the OECF on a Colorchecker Classic color chart, the chart type GS Colorchecker Classic (GS, Grey Scale) is used. It is necessary to include a reference file with the Lab mode colorimetry of the gray scale to be studied, in ImageQA a default file of the gray scale of the Colorchecker Classic is incorporated.

The implemented metrics have been expressed as follows:

OECF: represents the transfer of everything in relation to the reference provided in the reference document. The Y-axis is expressed in the standardized Luma in percent.

RGB: The average for each sample is shown graphically for each R, G and B channel so that we can discern the channel balance for each sample

RED, GREEN and BLUE show the OECF for each channel compared to its reference. The Y axis is expressed in CV or Count Values for 8 bits (0-255 units)

DEV: expresses the exposure error in terms of EV, i.e. how much error we have made in the exposure (relationship between camera and processing) when generating the image. In an image, where there are no tone curves applied, all samples should have an approximate error, in images with tone curves, high lights and shadows will have disparate errors.

The statistics shown along each metric are as follows:

Err Average: shows the average difference between the values of each sample and its reference.

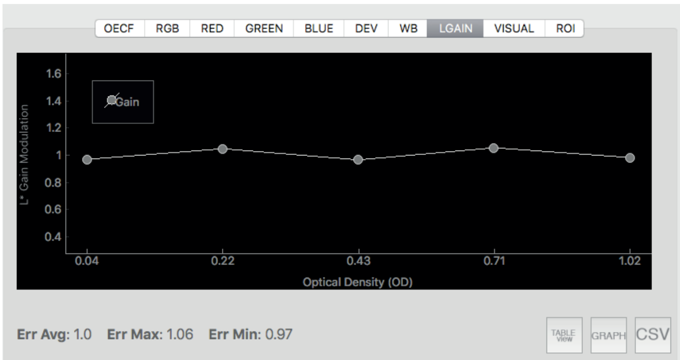
Err Dev: is the standard deviation of the average error for each sample.

Err Max and Err Min: are the maximum and minimum errors in the set of patches studied.

Avg Dev, Max Dev and Min Dev: they only appear in the RGB panel and indicate the maximum and minimum average deviation for each sample. The higher the average deviation, the more error in neutrality there is in our samples.

Along with the OECF panels, other relevant metrics are displayed such as the exposure error (DEV, Delta EV) for each sample, WB (White Balance) this error per sample, or LGAIN (Gain Modulation and L*) with respect to the reference

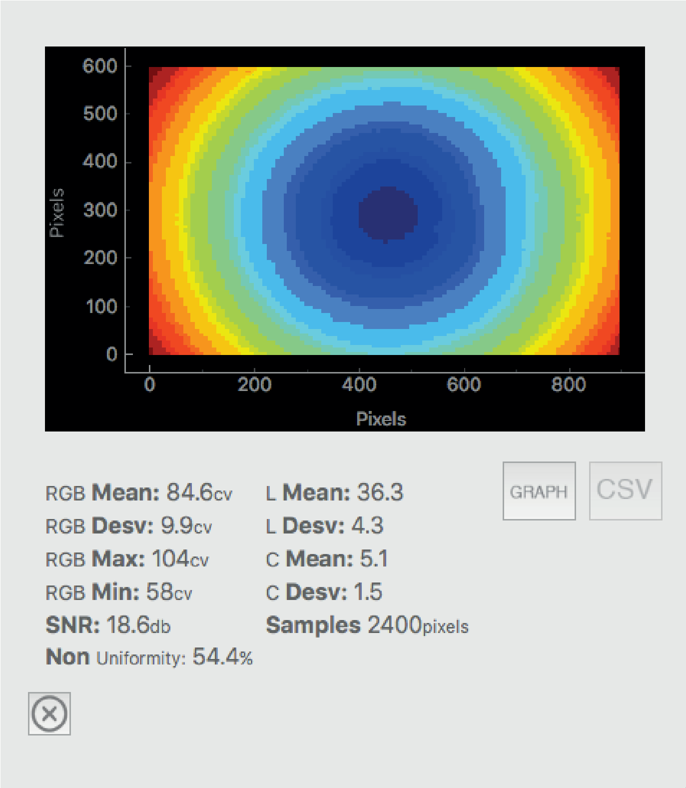
Example of the Colorchecker Classic card type with its 24-patch identification pattern.



In the LGAIN panel (Gain Modulation over L) this concept is represented with respect to the reference values. An optimal gain will be arround 1*

NOTE: ImageQA works in gamma 2.2, for images rendered. If ImageQA fails to correctly deduce the gamma from the ICC profile used, the default 2.2 gamma will be used, which may create discrepancies in the OECF.
If errors are evident in the OECF it is advisable to use ICC profiles with gamma 2.2 such as AdobeRGB, etc.

Light Falloff

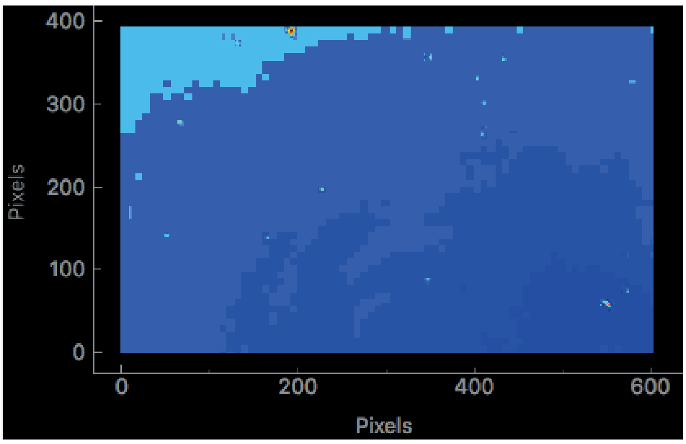


Light Falloff allows us to quantify the variation of light intensity along a uniform surface in reflectance.

Light falloff allows us to quantify lens vignetting for different apertures as well as uniformity of illumination along a plane if we discount light falloff from lens vignetting.
The study of light falloff is essential before the capture of our charts, to ensure that the light falloff does not affect our chart in an uneven way causing errors when quantifying the OECF or Delta-e.

The fall of light has been represented by a “JET” type LUT where between the red and blue values are represented the most distant. The image is previously normalized in order to correctly represent the whole gradient.

For the fall of light it is necessary to have an image or photograph of a uniform area, without gradients or textures, in order to study only the distribution of the light and that this is not distorted by textures, it is convenient to slightly defocus the image.
To determine the area to be studied, the ROI (Region Of Interest) type pattern is used. This can occupy the whole image, or a part of it.



The statistics shown on the uniformity are:

RGB Mean: or average of the scene's pixels

RGB Dev: the standard deviation.

RGB Max and Min: the maximum and minimum values of the scene

SNR: the signal-to-noise ratio of the image.

Non Uniformity: this is in relation to ISO 17957:2015 and indicates in % the lack of uniformity, the more value the more light drop.

L Mean: Indicates the average L (LCH)

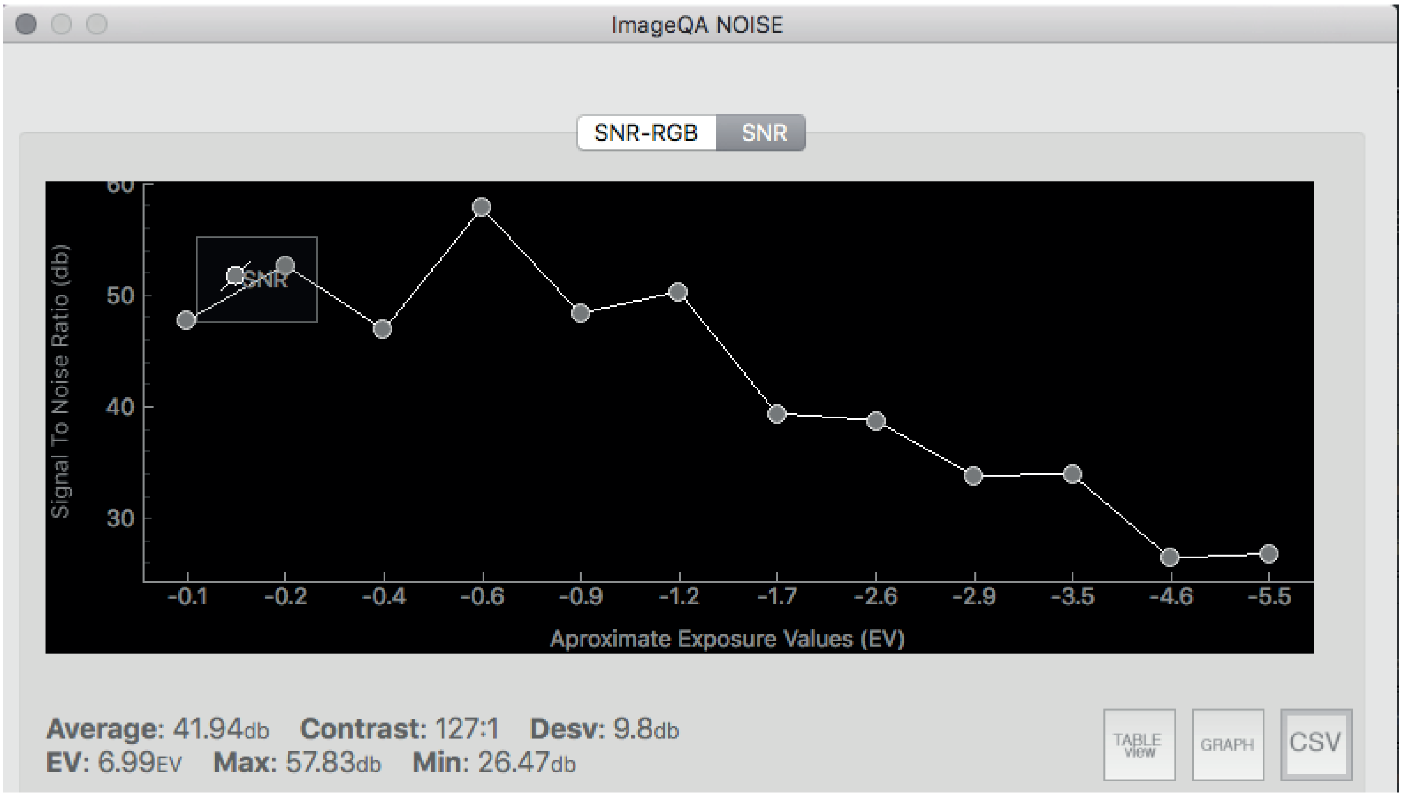
L Deviation: Indicates the standard deviation of L, it informs us about the lack of uniformity in lighting, the higher the value, the greater the variability.

C Mean: Indicates the measurement of chromaticity (LCH)

C Dev: Indicates the standard deviation of the chromaticity

Samples: Indicates the number of pixels that have been averaged for the above calculations.

Noise



The noise, measured in db (decibels), quantifies the Signal to Noise Ratio, i.e. the amount of signal as a function of the amount of noise. In this way, the higher the SNR, the greater the signal, which implies the absence of noise. Characteristically, any SNR graph taken on a tonal or densitometric scale will present less noise towards the high lights, and more noise towards the shadows. The lack of coherence in this evolution can inform us of noise reduction processes during image processing or defects in the signal processing of our equipment.

The noise is studied on a densitometric scale or gray scale as the OECF, therefore the same type of pattern is used as the OECF. For the noise calculation, it is recommended a slight blur in the image, to avoid that the possible texture or lack of uniformity of the scale is studied deviating the estimation of the SNR.

The SNR information is shown through the following dialogs:

SNR-RGB: shows the SNR for each R, G and B channel, so it is possible to evaluate which channel has the best signal-to-noise ratio and the coherence in its evolution. For example, neutrality adjustment processes (white balance) can induce more noise in some channels than others, due to the lack of signal.

SNR: shows the SNR along the luma.

RDEV: shows the dynamic range of the scene studied in terms of EV.

The statistics shown are:

Avg Dev: it is shown only for SNR-RGB and it shows the average deviation along each sample in relation to the difference between its channels.

Max and Min deviation: it is shown only for SNR-RGB and it indicates the maximum and minimum deviation along the channels and samples.

Average: it indicates the average SNR

Dev: indicates the standard deviation

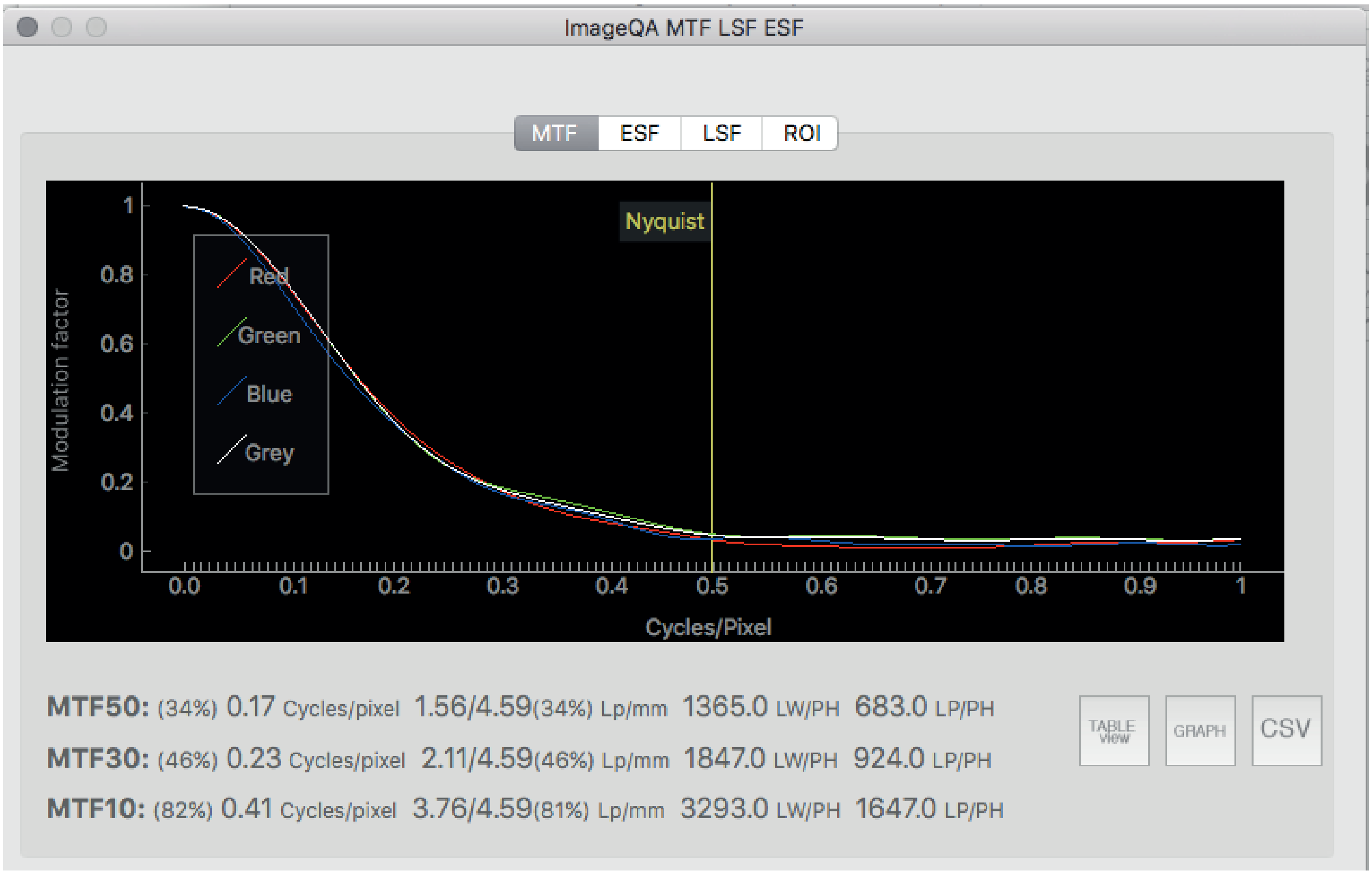
Max and Min: the maximum and minimum SNR peaks.

EV: Expresses the DR in f-stop units (EV)

Contrast: Indicates the contrast ratio.

Ejemplo del uso del patrón de reconocimiento GS Colorchecker Classic para detectar la escala de grises en exclusiva.

Spatial Resolution



The MTF (Modulation Transfer Function) tells us about the spatial resolution, or ability to resolve the detail of a system regardless of its resolution in terms of pixels. Thus, an image may have many pixels, but may not have detail due to lens effect, shaking, depth of field, etc.

The MTF can not only be used to quantify in absolute terms the sharpness of a system, but it can also be used to evaluate other circumstances such as loss of detail due to trepidation or depth of field.

An RGB or grayscale image can be used to calculate the MTF, but it will always be studied in monochrome mode. To define the area to be studied, the ROI type pattern is used. If we study images that approach a large surface, and we define a very wide ROI, ImageQA may give an error, the same as if the edge is not well centered.

To calculate the MTF we need a “sloped edge” target

The dialogs show:

MTF: indicates the MTF characteristic curve in cycles/pixel

ESF: tells us about the “softness” of our edge, where it is also easy to highlight the work of focus improvement filters and the formation of “halos” during these processes.

LSF: Shows the sharpness of the edge.

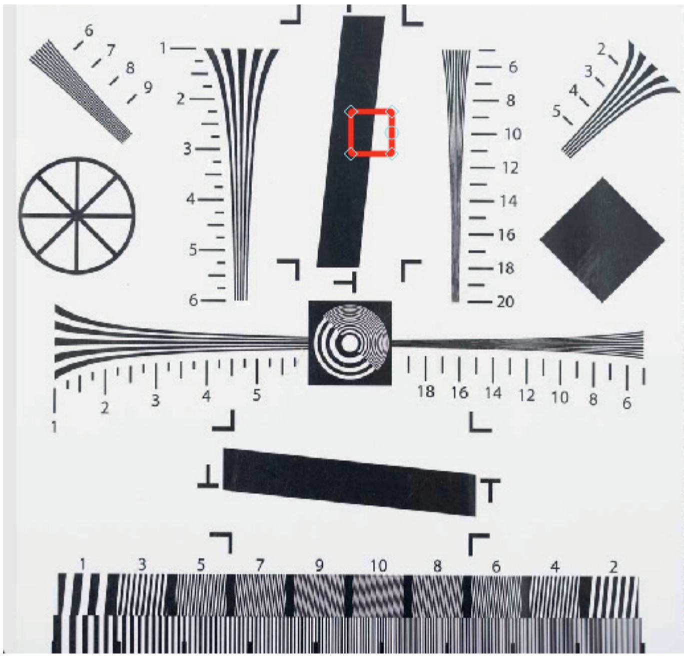
The MTF statistics are shown in the following metrics for the MTF50:

C/p or Cycles / pixel
Lp/mm or Line pair / millimeter
Lw/Ph or Lines Width / Picture Height
LPH or Lines Picture Height

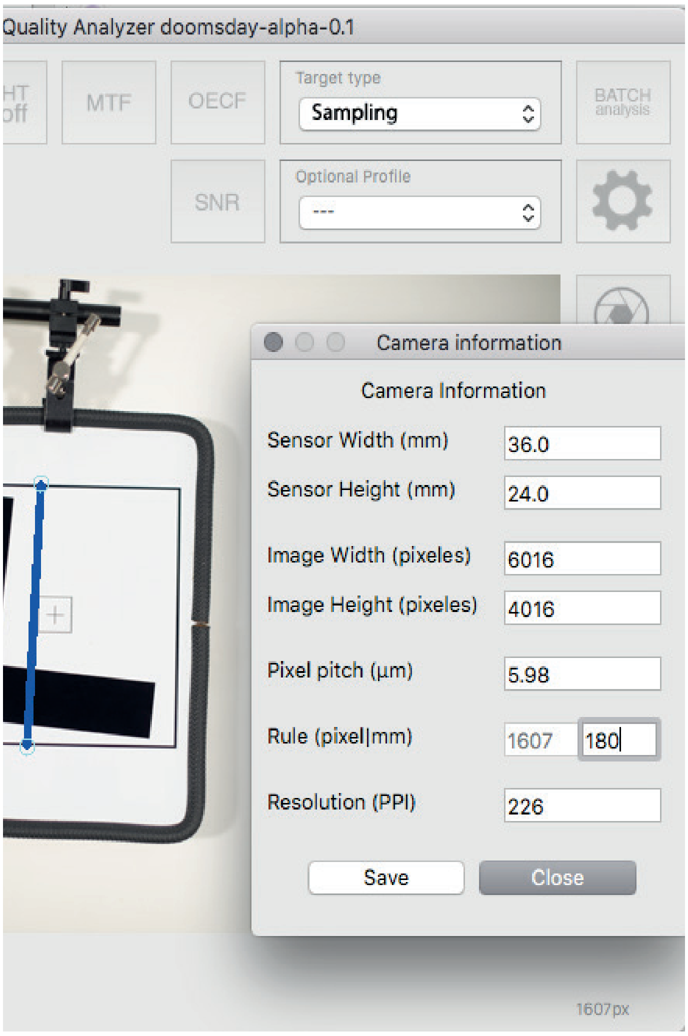
Lp/mm, Lw/Ph and LPH metrics use the sensor data, such as its size and derived pixels, so they must be set in advance in the camera information panel.

The camera information panel is only active with the Region Of Interest (ROI) pattern model that is used to determine the area where the MTF will be calculated. The camera information pane will ask for sensor size data in millimeters and in pixels, which will be used to calculate the pixel pitch used for metrics such as Lp/mm.

The camera information is partially extracted from the metadata and from the size of the image under test, so if our image is a clipping these data will be wrong and it will be necessary to adjust them manually.



ROI on a sloping edge. It can be drawn on both vertical and horizontal edges. An inclined edge is defined as one that has a 5º slope
ImageQA works with images that have a white or light gray background. Images with a dark gray can be misleading.



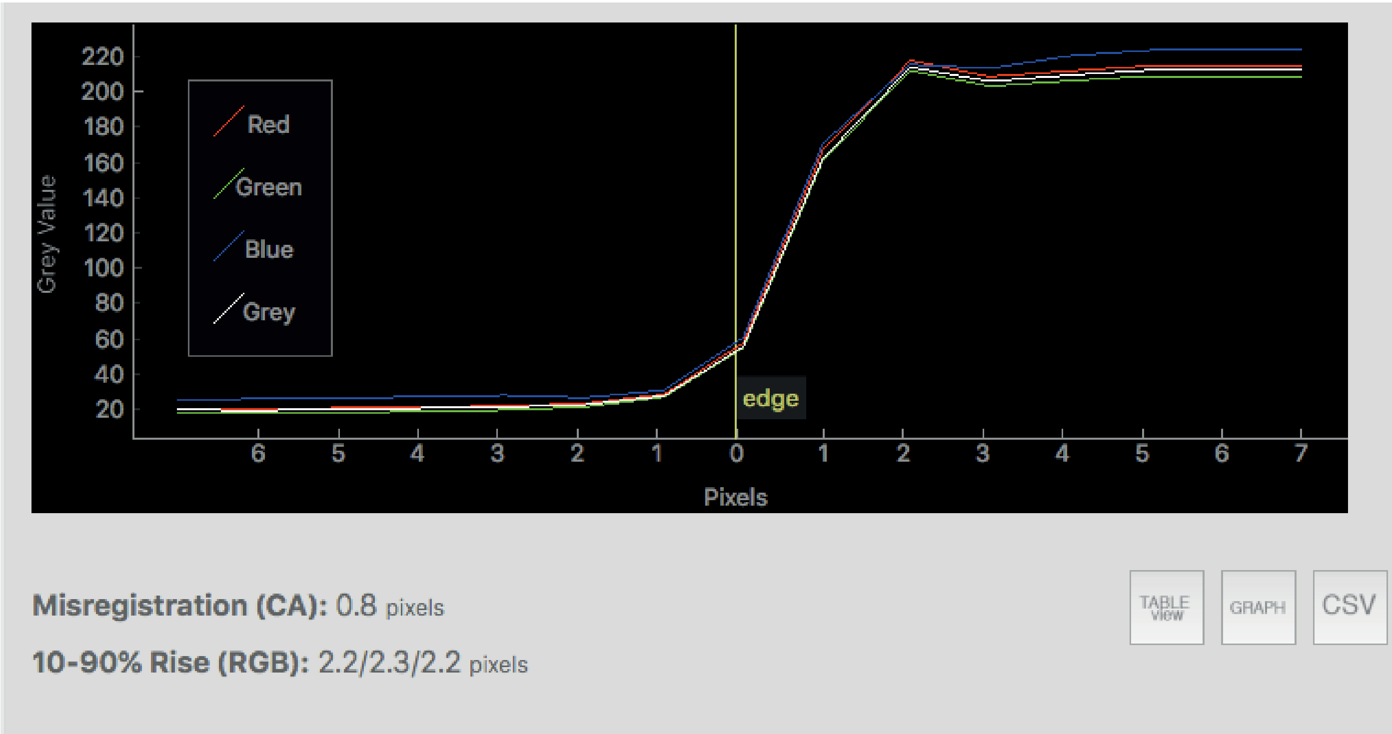
The different metrics are provided for the MTF50 (more suitable for human perception) MTF30 and MTF10 or resolution limit, which given the aliasing present in some images may not be available, so the MTF30 is offered.

Along with the different metrics, a relative % of the number of cycles or Lp reached over the total is provided, since certain standards such as ISO-TS 19264-1 (2017)_Phtography - Archiving systems - Image quality analysis - Part 1, reflective originals usually indicate the quality thresholds in terms of both percent over the maximum available. That is to say, 100% will be in cycles/pixel 0.5 and in even lines, depending on the resolution of the image. Thus, in the image shown, where 1.56/4.59 is indicated, 1.56 would be the even lines reached, and 4.59 the Nyquist limit for the resolution in PPI of the image analysed.
Thus, an image with a minimum quality for MTF50 must reach more than 50% of the available resolution, or at MTF10 must have more than 90%.

In order to have all the metrics offered in this analysis, we have to indicate in the camera information dialog, in addition to the sensor's width/height parameters, etc., the PPI resolution of the image to be analyzed. This is necessary for a precise calculation of Lp/mm on the image level. In the tabular view of the data, the resolution in Lp/mm at the sensor level is also available, although this value is less representative.

For the correct calculation of the Lp/mm we can help ourselves from the following workflow:

Before opening the MTF dialogue, activate the Target Type "Sampling", this creates a "rule" that we can fix on a known dimension in the image and then we open the camera information dialogue and in "Rule pixel | mm" it will indicate us the distance in pixels measured and we must indicate its correspondence with reality, for example 1607pixels correspond to 180mm, so the calculation will be done in PPI accurately. If we know the PPI data we can enter it directly.



In the ESF panel, besides offering the characteristic curve on the edge transition for the R, G and B channels as well as the grey one. It offers the CA metric (Chromatic Aberration) which is calculated as the area between the most separated channels measured in pixels. This metric is also called Color misregistration, i.e. the registration error of the three channels.

The slope (Rise) between 10% and 90% of the curve describing the SFR is also provided. This pentient describes the sharpness of the system, the more vertical that segment of the curve is, the sharper the system is.

Download test charts:

You can download a slanted edge chart to be printed on A4 at:

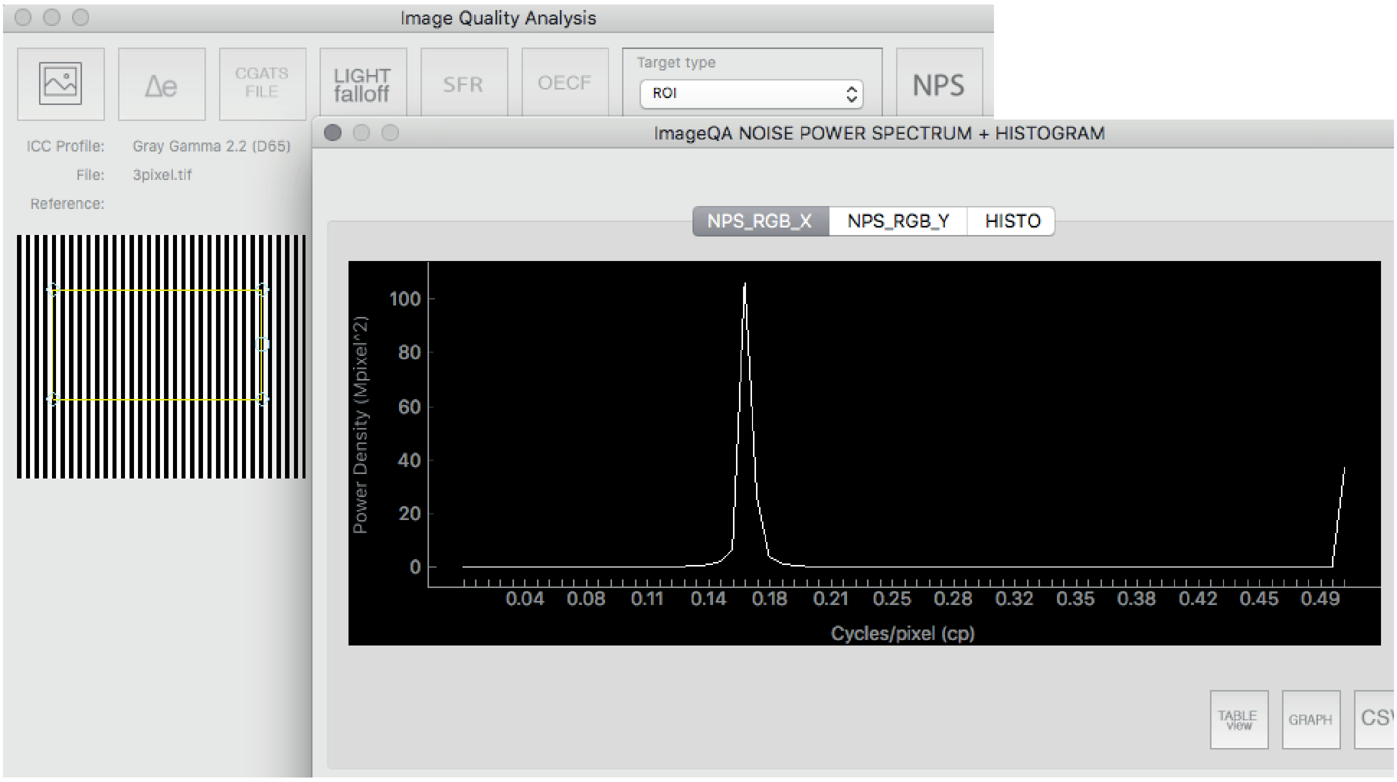
http://imageqa.jpereira.net/charts/slanted_edge_chart.pdf

You can download a chart with multiple slanted edges to be printed in A3 at:

http://imageqa.jpereira.net/charts/slanted_edge_multi.pdf

Both cards should be printed in black and white, without using any color mode in the printer to avoid halos from other inks that may distort the perfection of the border.
The cards should be trimmed and positioned so that the slanted edge is rotated by 5º.

Noise Power Spectrum



The representation of noise in the frequency spectrum (Noise Power Spectrum, NPS), also called the density spectrum (Power Spectrum Density, PSD) shows the distribution of noise, in terms of density, in relation to its frequencies. That is, the frequency of the noise in the image will take more or less presence depending on its spatial frequency. As in the SFR-MTF the frequency is the strategy to quantify the capacity to reproduce the detail, those artifacts that exceed certain frequencies will be barely perceptible by our vision system. Therefore, the representation of the noise through its frequency spectrum has an important correlation with the appearance of the noise.

In reality we do not only represent noise but we represent any kind of spatial feature present in the image. It can be useful to estimate the frequency of appearance of elements present in the image as well as issues related to the perception of detail, etc.

Thus an image can be represented through the domain of space, that is in its conventional x and y coordinates, or in the domain of frequency. In both domains, we can discern different aspects of the noise.

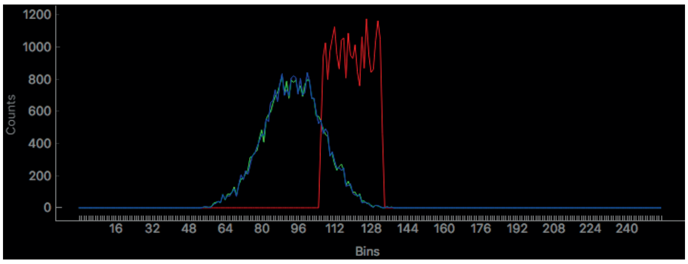
Noise of random nature, which attends to models such as Gauss, can be studied by means of the representations in the histogram, which organize the information of the image by frequency of appearance, that is why the possibility of the representation in histogram in this panel is offered.

The frequency spectrum describes the density (Y-axis) of appearance of certain frequencies (X-axis) in the image. In this way, it is possible to describe the presence of noise in a certain area of the image according to its frequency.

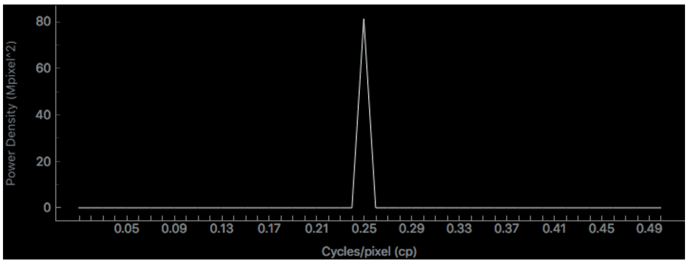
As an example, we can start with a synthetic image with a pattern of lines separated by 1mm, 2mm and 3mm, which will have peaks for the frequencies of 0.5c/p, 0.25 c/p and 0.16c/p respectively. Where 0.5c/p would represent high frequency areas, that is, areas with very high detail, while 0.16c/p would present areas with lower or thicker frequencies.

To use the NPS tool, simply select an area of the image to be studied with the ROI type selection. The information is provided on the horizontal X axis, on the vertical Y axis and through the histogram for that area.

More information about this technique can be found at: http://imageqa.jpereira.net/ES/blog1_power_spectrum.php

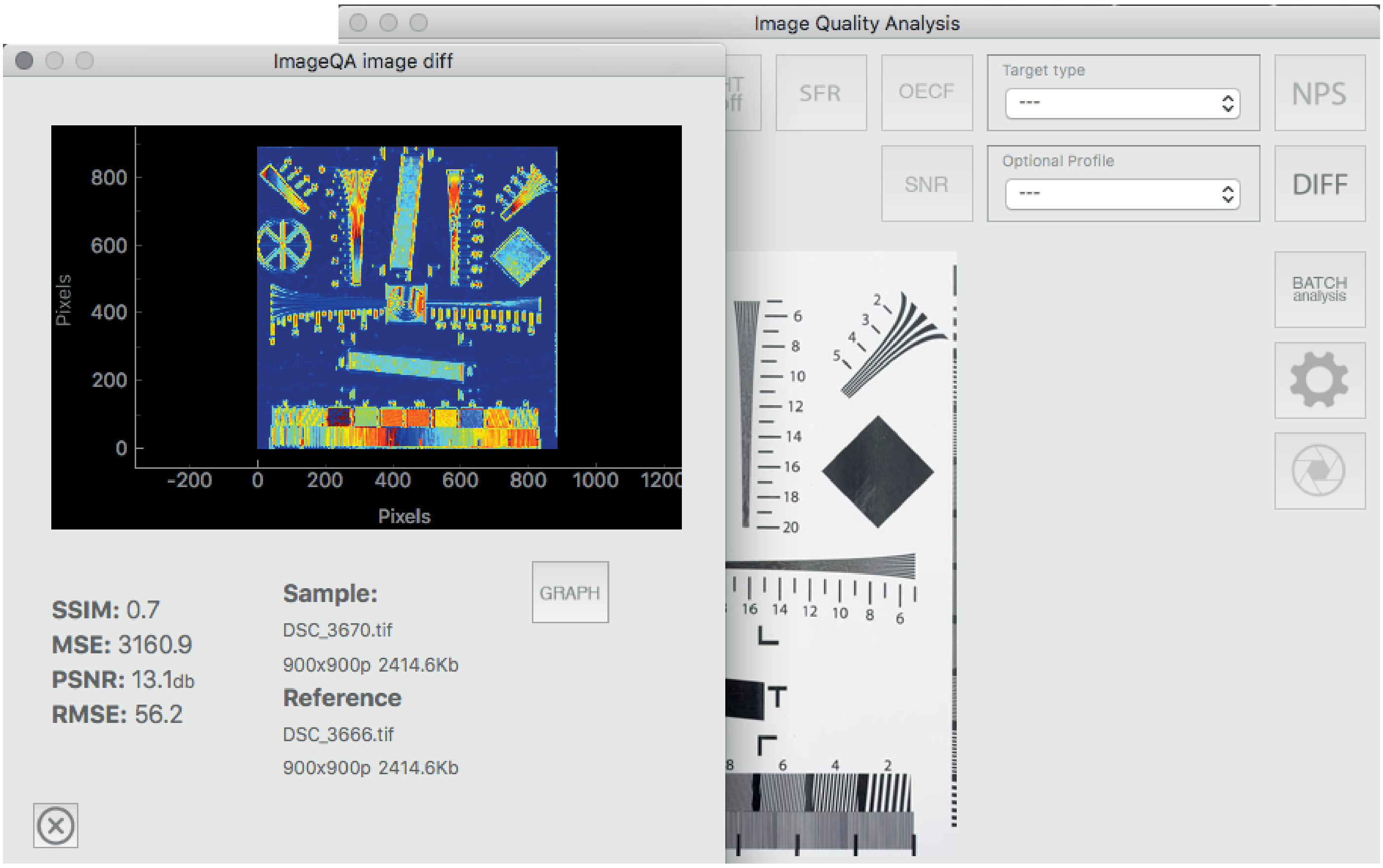


Histogram representation of two different types of noises



Evidence of a pattern at 0.5c/p in the area studied

Comparison between images

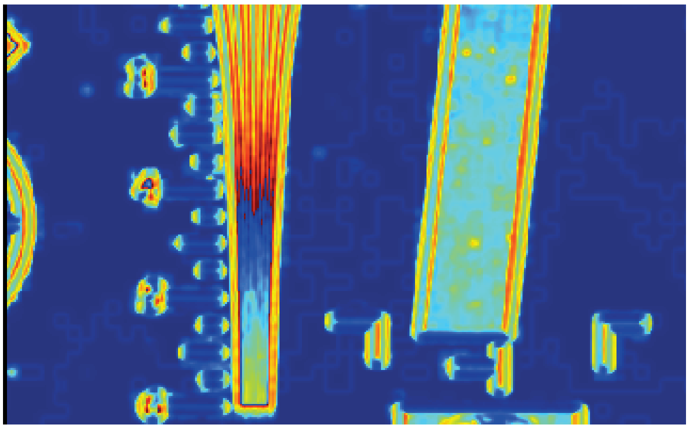


The DIFF function allows you to set full reference metrics between pairs of images, using the MSE (Mean Square Error), RMSE (Root Mean Square Error), PSNR (Peak Signal Noise Ratio) and SSIM (Structural Similarity Index) metrics.

This requires opening two images simultaneously in ImageQA, no ROI is required as the images are fully compared.

The image shown is an SSIM map where the blue zones represent the most similar areas and the red zones the most different ones.

In the SSIM difference map you can determine areas affected by lack of focus in the absence of depth of field, compression artifacts and areas that have lost sharpness due to it, noise, etc.



The red areas are those that present a greater discrepancy, in the image, by moiré formation between the images submitted for comparison.

These metrics are mostly used to estimate the quality deterioration as a function of a reference image when using lossy compression algorithms, but, as seen before, it has more functions.
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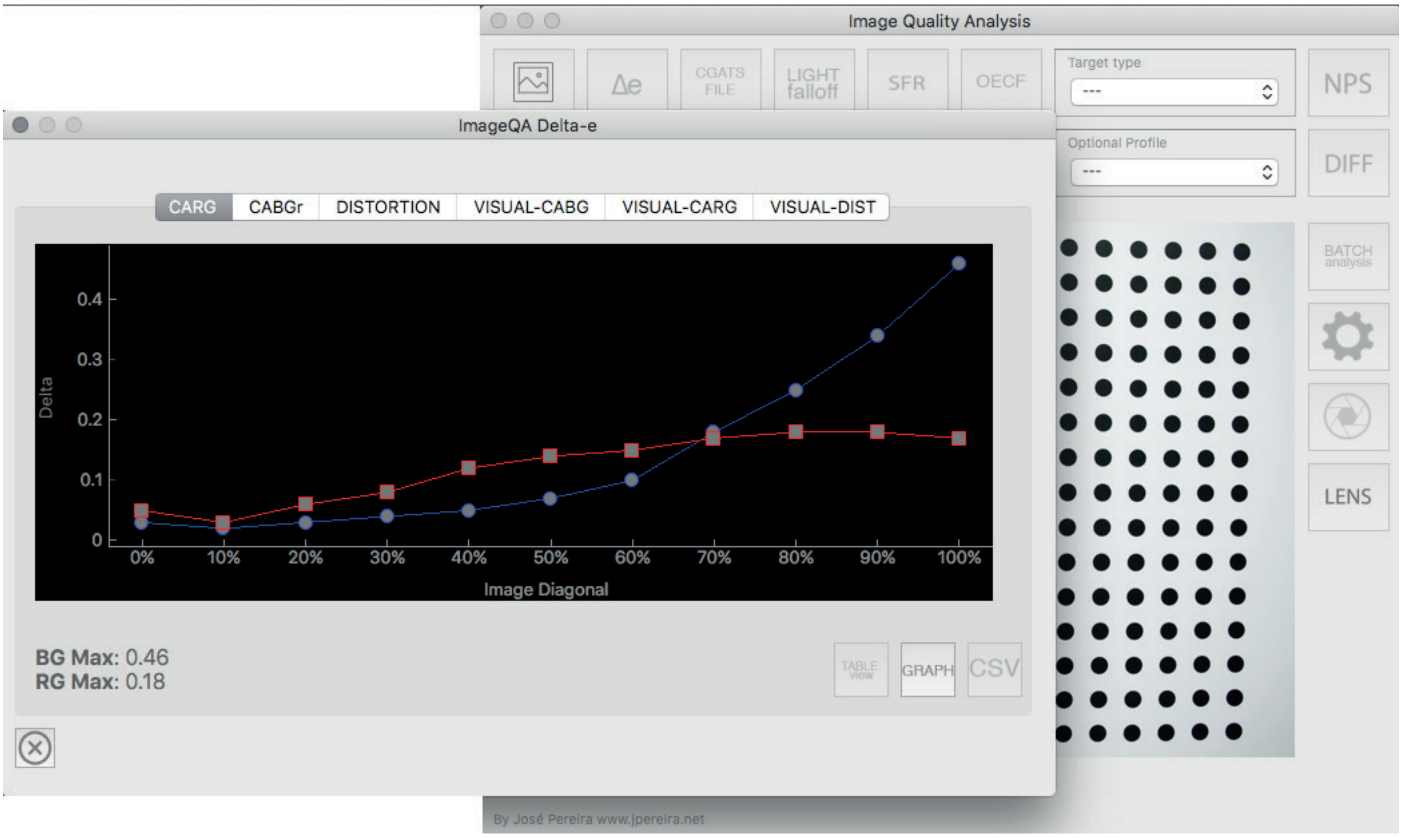
Lens analysis



Through the lens analysis option, optical distortions of the barrel or pincushion type, and chromatic abe-rrations can be quantified.

The analysis meets the recommendations of ISO 19084 Photography - Digital cameras - Chromatic displacement measurements and ISO 17850 Pho-tography - Digital cameras - Geometric distortion (GD) measurements to establish these metrics.

For the analysis, the chart proposed in ISO 17850 is used, consisting of 300 disks organized in 20 colum-ns and 15 rows, the optical distortion estimations are made on the diagonal in the upper right corner.

Only images smaller than 1500 pixels on the larger side can be used. If working from raw images, you should generate images at this size from the raw processor to avoid sampling errors when reducing the images.

The graphs provided are as follows:

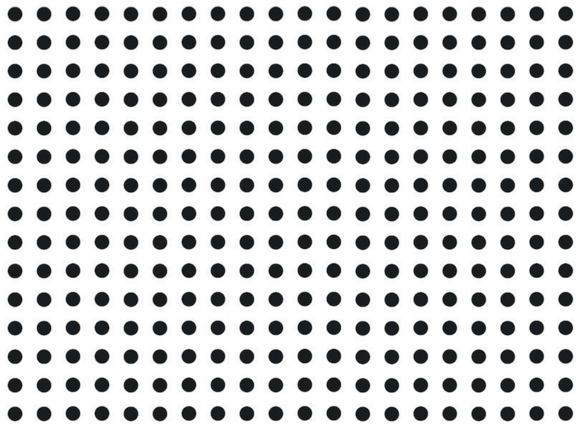
CARG (Chromatic Aberration Red-Green and Blue-Green) Shows the distance between red and green channel (in red line) and the distance of blue from green (in blue line) along the diagonal of the upper right corner. The most extreme values for each channel are represented by the metrics BG Max and RG Max.

CABGr (Chromatic Aberration Red-Green and Blue-Green Radial) Shows the distance between these channels but based on the radial metric described in ISO 19084.

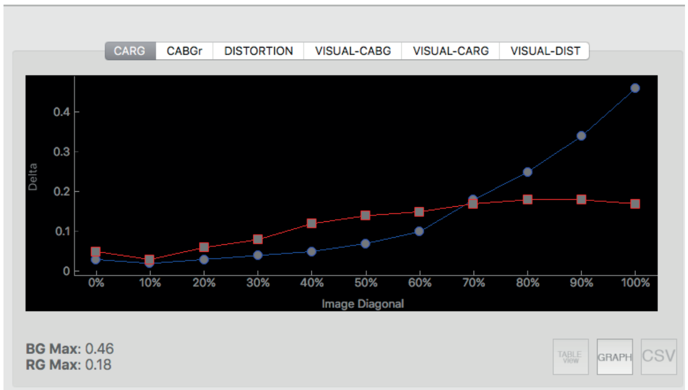
DISTORTION Shows the distance along the upper right diagonal of the position of the disks obtained in the image with respect to their expected position. The distortion is classified by Barrel if it is negative and Pad if it is positive.

VISUAL-CABG and **VISUAL-CARG** It is the synthetic representation of the disks used and their deviation. The number accompanying each disk is the distance between the disks.

VISUAL-DIST It is the synthetic visual representation of the optical distortion between the disks deduced from the image and the expected disks based on the distance from the image center. The accompanying number is the distance between the pair of disks.



ISO 19084 chart used for the analysis of optical distortions and chromatic aberrations should be a 20 x 15 point chart



Graphical representation of the presence of chromatic aberrations with respect to the green channel from the blue and red channels.

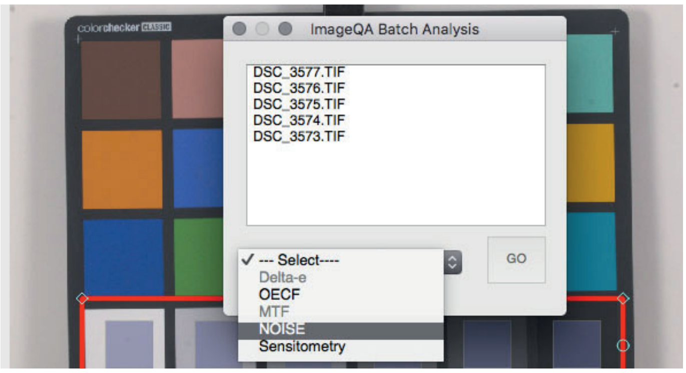
Download the test chart

At this URL:

http://imageqa.jpereira.net/charts/carta_ISO_19084.pdf

You can download a test chart to be printed in A3 black and white. The chart should be mounted on a very flat surface, to avoid distortions when capturing it.

Batch



It is used to evaluate a set of images whose color management is disparate, for example with color profiles designed under different parameters or tools, or where different parameters have been introduced in the processing that affect color.

For batch processes, we must capture all the images with the same frame so that the pattern to be detected is in the same area. Then, the "Batch Analysis" button is activated and we select the test to be performed. The tests are filtered by the possibilities of each type of pattern.

OECF

Through this test, we can study differences in tonal reproduction for a set of images, for example, images taken with different exposure or images taken with different processing formulas where different curves are involved.

NOISE

Similarly we can evaluate the evolution of the noise through images taken with different ISO to discern which ISO setting is more efficient for our equipment. It can also be used to evaluate the noise resulting from different noise reduction filters.

SENSITOMETRY

It is used to extract a sensitometric curve, i.e. to relate exposure settings to the intensity taken by the resulting pixels. These curves can be made by keeping the aperture fixed and varying the speed, or vice versa, but we can also make them for light sources that have intensity regulation such as flashes or LED panels.

Another frequent use is to study the stability of flashes, so that several shots can be taken at the same power and see if they develop the same intensity or make a curve along all the "power" steps available in our equipment and verify the linearity of it.