1 mtf_mapper

mtf_mapper — compute MTF50 edge sharpness measure in images

Synopsis

mtf_mapper [*OPTIONS*] *INPUT_IMAGE OUTPUT_DIR*

DESCRIPTION

mtf_mapper computes the edge acuity (sharpness) of slanted edges in images. It automatically detects dark rectangular objects on light backgrounds, and computes the MTF50 values across each of the edges. Output takes several forms (see **-p**, **-s**, **-a** and **-q** output options). To test **mtf_mapper**, images with rectangles containing known MTF50 values can be generated with **mtf_generate_rectangle**.

OPTIONS

-t *threshold*, --threshold *threshold*
: Specify the dark object threshold, with a default of 0.55. Lower values are required if your dark objects are light relative to the background, e.g., gray rectangles rather than black rectangles. You can try lower values, e.g., 0.3 or even 0.2 if MTF Mapper does not appear to detect any dark objects.

-l, --linear
: Linear input mode; assumes that an 8-bit input image has a linear intensity scale. The default is to assume that 8-bit input images have an sRGB gamma intensity profile (approximately gamma 2.2).

--pixelsize *size*
: Specify the sensor's pixel size (pitch) in microns. This option implicitly switches the MTF50 output units (for some output types) to line pairs per mm, or lp/mm (the default is cycles per pixel, or c/p).

--bayer *red|green|blue|none*
: Process only the specified Bayer sites. This option can be used to bypass the effects of Bayer demosaicing interpolation when suitable raw images (e.g., dcraw -d output) are used. Specifying this option when a demosaiced image is provided will not produce the expected result, i.e., you must provide a raw image for this option to work correctly. Keep in mind that Bayer red and blue each cover only 25% of the sensor, so your edges will have to be 4 times longer to maintain the same signal-to-noise ratio. Minimum recommended edge lengths are thus 35 pixels for gray or interpolated images, 70 pixels for green Bayer sites, and 140 pixels for red and blue Bayer sites. Aim for edges of at least 200 pixels for best results on red and blue sites. See **--cfa-pattern** so specify the Bayer pattern of your raw image.

--cfa-pattern *rggb|bggr|grbg|gbrg*
: Select the Bayer pattern to use when the **--bayer** option has been specified. The default is rggb, which appears to be the most popular choice amongst DSLRs.

--single-roi
: Treat the entire input image as the region of interest (ROI). This option is only intended for use with small cropped images containing only a single edge, typically if you cropped your ROI out of some larger image. Use this if you are performing your slanted-edge measurements with a backlit razor blade, or if you are working with an incompatible test chart (e.g., an older ISO 12233 chart). This option has largely superseded the **-b** option.

--zscale *scale-factor*
: Adjust the minimum value of the z-axis scale of the 3D plots produced with the **--surface** output option. A value of 0 means the z-axis scale starts at zero, and 1.0 means the z-axis starts from minimum MTF50 measurement (thus emphasizing local differences).

--logfile *filename*
: Logger output written to *filename* in stead of standard out.

--gnuplot-width *pixels*
Width of images rendered by gnuplot, typically affecting the output images of **--lensprofile**, **-s**, and **-p**.

-b, --border
Add a white border of 100 pixels to the image. This option might be useful if your image contains only a single black target (e.g., rectangle) with a thin white border, or if your image sides clips some of your black test chart targets. Actually, this option is a kludge to fool MTF Mapper's automatic target detection, so you should not normally need this. Also see **--single-roi** for the correct way of dealing with single-edge images.

--snap-angle *angle*
Snap all edge angles to *angle*. Angles are snapped to the closest value modulo 90 degrees, i.e., specifying an angle of 4 degrees will force edge orientations to one of the following: 4, -4, 86, or 94 degrees. This option should be used with care, and is only appropriate if you are using synthetic images with a known edge orientation.

-g *angle*, **--angle** *angle*
Only report MTF50 values on edges with an orientation of *angle* degrees in raw output mode (-r)

--autocrop
Automatically crop the input image to the chart area. The chart is assumed to be brighter than the background; the automatic cropping will try to remove the darker background. This option is mostly intended to speed up processing, and really should only be used if the background area is large in comparison to the test chart area.

--gnuplot-executable *filepath*
Specify the full path to the gnuplot executable. Defaults to */usr/bin/gnuplot*, which is usually correct on most Linux distributions

-h
Displays usage information

OUTPUT TYPE RELATED OPTIONS

-a, --annotate
Annotated output mode. If Annotate mode is enabled, **mtf_mapper** produces an output file called *annotated.png* wherein each edge is annotated with its MTF50 value. Good quality edges are annotated in Cyan, with Yellow and Red annotation indicating progressively poorer edge quality (usually related to edge orientation and length).

-s, --surface
Surface output mode. Surface mode (enabled by default) generates two output plots: a color-graded 2D view of the MTF50 values across the image, and a 3D surface plot of the same data.

-p, --profile
Profile output mode. If Profile mode is enabled, **mtf_mapper** produces a plot (*profile_image.png*) showing a side-view of the MTF50 values. This mode is used to determine whether a camera is front- or back-focusing. A special test chart must be generated with **mtf_generate_test_chart** for this mode to work correctly.

-r, --raw
Raw output mode: Dumps MTF50 values to a file called *raw_mtf_values.txt*.

NB: The **-q** output option also produces files containing the MTF50 values, but each entry of that output also provides the image coordinates of the measurement.

-e, --esf
Produce edge spread function (ESF) outputs. Each edge will correspond to one row in an output file called *raw_esf_values.txt*. Each row will contain 256 samples, corresponding to a window of 32 pixels centered on the edge, oversampled by a factor of 8, i.e., consecutive samples are 1/8 pixel apart. There is currently no simple way to identify which edge in the input image ends up in a particular row. If your input image contains a single square, then you can pick any row.

-f, --sfr

Produce spatial frequency response (SFR) curve outputs. Each edge will correspond to one row in an output file called *raw_sfr_values.txt*. Each row starts with the edge orientation (in degrees), followed by 64 values corresponding to the contrast measured at a frequency resolution of 1/64 cycles per pixel. In other words, the 64 values span the frequency range [0,1) cycles per pixel. See **-e** for advice on matching rows to edges.

By default, this is an SFR curve, i.e., the DC component is always normalized to 1.0. See **--absolute-sfr** switch for producing true MTF curves.

NB: The **-q** output option also produces files containing the SFR curve, but each entry of that output also provides the image coordinates of the measurement.

--absolute-sfr

Do not normalize SFR curve, i.e., DC component is not normalized to 1.0. This is useful when evaluating the MTF response of algorithms that may reduce overall edge contrast.

--nosmoothing

Disable SFR curve (MTF) smoothing. By default, MTF Mapper will apply Savitzky-Golay filters to the SFR curve to improve its appearance. The only known disadvantage of this smoothing is that the sharp valley surrounding the first zero of the SFR (if present) can be over-smoothed, in which case the **--nosmoothing** option is recommended.

-q, --edges

A better choice than either **-r** or **-f**. This option produces two output files called *edge_mtf_values.txt* and *edge_sfr_values.txt*, both of which combine edge location with the MTF measurement.

Each row of the *edge_mtf_values.txt* file contains six space-separated columns: *block_id edge_x edge_y mtf50 corner_x corner_y*. The *block_id* can safely be ignored (it depends on the order in which target squares were processed). The pair (*edge_x*, *edge_y*) denote the pixel coordinates of the centroid of the edge, and *mtf50* is the MTF50 value in cycles per pixel (default), or in lp/mm if the **--pixelsize** option was specified. Lastly, the pair (_corner_x, _corner_y) denote the pixel coordinates of the corner of the target (black square) associated with this edge, and can be safely ignored.

The format of the *edge_sfr_values.txt* file is similar: each row starts with five columns: *block_id edge_x edge_y edge_angle radial_angle*, followed by 64 more floating point values denoting the SFR. The *edge_angle* column denotes the orientation of the edge relative to the image rows/columns, modulo 45 degrees. This angle should perferably be at least 2 degrees but less than 44 degrees for best results. The fifth column, *radial_angle*, is just the angle of the radial line from the image centre to the edge centroid, thus it can be used to determine whether an edge is in a Sagittal or Meridional orientation with respect to the image centre, which is assumed to be centered on the test chart.

The SFR part (the last 64 values on each line of *edge_sfr_values.txt*) represents the contrast values of the SFR (or MTF, if you prefer) sampled at spatial frequencies of i/64 cycles per pixel for i from 0 to 63 inclusive.

If you use the **--full-sfr** option together with **-q**, the SFR component of each line of *edge_sfr_values.txt* will comprise 128 values (rather than 64), and the corresponding spatial frequencies are i/64 cycles per pixel for i from 0 to 127 inclusive.

NB: The only reliable, safe way to compare the output of MTF Mapper between different images captured using the same camera (say, an f/2.8 vs an f/4 image capture) is to use the pixel coordinates (*edge_x*, *edge_y*) of a measurement from image A to find the closest corresponding measurement from image B, assuming you do not move around the camera too much, or rotate the chart or something like that (in which case you can use the Monkres assignment algorithm to calculate the correct pairing). Please do not rely on the order of the rows of the *edge_mtf_values.txt* and *edge_sfr_values.txt* files.

--full-sfr

Output the full SFR/MTF curve (up to 2 c/p) when combined with **-q** or **-f**. The default is to only output the curve up to 1 c/p. Relatively few cameras have meaningful contrast after 1 c/p, so take note that noise tends to dominate the MTF curve there.

--lensprofile

This output option produces a Meridional / Sagittal MTF chart similar to those published by lens manufacturers. It requires a *lensgrid* type MTF Mapper test chart image (but will work with older *grid* style charts too). The resulting output *lensprofile.png* is a plot of contrast vs radial distance from the centre of the image, at three specified spatial resolutions (see **--lp1**, **--lp2**, **--lp3**). It is recommended that the **--pixelsize** option is used in conjunction with the **--lensprofile** option so that the units of the chart are in mm for the x-axis, and that the spatial resolutions are in lp/mm (otherwise the x-axis units are pixels, and the spatial resolutions are in c/p, which is not a common choice for this type of chart).

--chart-orientation
Visualize chart orientation relative to the camera to assist in aligning the camera perpendicular to the chart. This option requires that the input image contains circular fiducial markers (e.g., *focus* and *lensgrid* MTF Mapper chart types), and produces an output file called *chart_orientation.png* which illustrates graphically the yaw/pitch/roll angles of the test chart relative to the camera. The objective is to iteratively adjust the chart orientation to bring the yaw and pitch angles as close to zero as possible, preferrably below 0.5 degrees, to ensure that the camera's optical axis is perpendicular to the test chart. Once the alignment is satisfactory, other outputs (e.g., **-a**, or **--lensprofile**) can be derived from subsequent images of a *lensgrid* style chart. For this option to work the correct lens focal ratio must be specified (see **--focal-ratio**).

--focal-ratio ***ratio***
Specify the focal ratio for use in chart orientation estimation. The focal ratio is computed as focal_length / sensor_width, e.g., 50 mm / 23.6 mm when using a 50 mm lens on an APS-C sized DSLR. This option is only needed if you combine it with the **--chart-orientation** option.

--lp1 ***resolution*****, --lp2** ***resolution*****, --lp3** ***resolution***
Specify the three spatial resolutions to use when plotting a **--lensprofile**.

--focus
This output type produces a visualization of the peak focus location. A special MTF Mapper chart type is required (*focus*), which should be imaged at a 45-degree tilt with respect to the camera. This chart is not suitable for use with camera autofocus; rather, it is intended to calibrate a manual focus lens, or to measure focus shift in a lens. Please see the MTF Mapper user guide for more information.

NB: Note that the **--focus** output option is incompatible with most other output options (e.g., **-a**, **-s**, **--lensgrid**, **-q**, etc.), so do not use this option unless you are sure you want to.

--mfprofile
This output type produces a visualization of the curve formed by the intersection of the "*surface of best focus*" and the test chart. A special MTF Mapper chart type is required (*mfperspective*), which should be imaged at a 45-degree tilt with respect to the camera. This chart is intended for manual focus operation since the chart does not contain suitable central features for autofocus operation.

NB: Note that the **--mfprofile** output option is incompatible with most other output options (e.g., **-a**, **-s**, **--lensgrid**, **-q**, etc.), so do not use this option unless you are sure you want to.

LENS DISTORTION RELATED OPTIONS

--esf-sampler ***line|quadratic|piecewise-quadratic|deferred***
Choose the approximation used to model the curve of image edges (default is *piecewise-quadratic*). If your image has absolutely no radial lens distortion, then *line* is optimal. The *quadratic* and *piecewise-quadratic* approximations do what their names suggest: the (assumed) straight edges of the target objects on the test chart are modelled using a (piecewise-) quadratic curve. The *deferred* aproximation is only available when an overall lens distortion model is specified using **--equiangular**, **--stereographic**, or **--optimize-distortion** options; selecting one of these options automatically forces **--esf-sampler**=*deferred*.

--stereographic ***focal length(mm)***
Treat input image as stereographic mapping (fisheye) with the specified focal length in mm. With this option, the annotated output image (output option **-a**) will be unmapped, i.e., in its rectilinear equivalent mapping, but MTF measurements are still made in the original (distorted) image. Note that this option requires a pixel pitch to be specified using the **--pixelsize** option.

--equiangular ***focal length(mm)***
Treat input image as equi-angular mapping (fisheye) with the specified focal length in mm. With this option, the annotated output image (output option **-a**) will be unmapped, i.e., in its rectilinear equivalent mapping, but MTF measurements are still made in the original (distorted) image. Note that this option requires a pixel pitch to be specified using the **--pixelsize** option.

--optimize-distortion
A two-step process is followed to compensate for radial lens distortion. First, a two-parameter division model is fitted

to obtain a distortion model of the lens, followed by MTF measurements in the original (distorted) image, but using the undistorted image to guide the process. The annotated output image (output option **-a**) is based on the undistorted image. This option works best when the test chart (preferrably the *lensgrid* chart) fills the frame, and the average edge length is 200 pixels or more.

Note that this option can, in practice, replace the use of the **--stereographic** and **--equiangular** undistortion methods. Also note that it is not necessary to undistort the image (to produce straight target edges) to obtain accurate MTF measurements. By default, MTF Mapper now uses a piecewise-quadratic curve to model target edges, so the three undistortion methods (**--stereographic**, **--equiangular**, and **--optimize-distortion**) are mostly for research purposes.

--no-undistort-crop

By default, MTF Mapper will estimate which part of the undistorted image is usable, i.e., not stretched too much, and crop the output accordingly. This option will override the cropping when used with the **--equiangular** and **--stereographic** options. This can produce very large output images, so use with care.

SEE ALSO

mtf_generate_rectangle, mtf_generate_test_chart, mtf_mapper_gui.