Quick Start Calibration Chart Shooting Guide
For the Adobe Lens Profile Creator

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Adobe Systems Inc

Table of Contents

Introduction:

This document provides a quick overview of the calibration setup to characterize the optical aberrations of your lens using the *Adobe Lens Profile Creator*. It could also serves as a quick reference guide while you are shooting the calibration chart images.

In contrast to the traditional calibration setup that requires a more controlled studio environment, *Adobe Lens Profile Creator* employs the state-of-the-art multi-view image geometry algorithm to estimate the geometric distortion, lateral chromatic aberration and vignette model parameters in a simple setup. By analyzing multiple images of a single checkerboard chart from several different vantage points, *Adobe Lens Profile Creator* is able to recover the full lens aberration model parameters automatically. This new approach significantly simplifies the lens characterization workflow and makes it more accessible to majority of professional photographers who want to produce a complete lens profile for their lens.

Procedures:

Printing the Calibration Chart

1. Select a chart from the collection of checkerboard calibration chart PDF files that are included inside of the *Adobe Lens Profile Creator* application folder (path: Adobe Lens Profile Creator/calibration charts). If shooting for the first time, Adobe recommends choosing one of the following pdf files to print (choose the largest size you're able to print):

   Landscape ARCH_D - 24.00 In x 36.00 In (Square Print Dimension 54 Pts, Version 27 x 45)

   Landscape ARCH_C - 18.00 In x 24.00 In (Square Print Dimension 54 Pts, Version 21 x 29)

   Landscape Tabloid - 11.00 In x 17.00 In (Square Print Dimension 54 Pts, Version 11 x 21)

   Landscape Letter - 8.50 In x 11.00 In (Square Print Dimension 54 Pts, Version 9 x 13)

   Note: If you are shooting chart for a fisheye lens, use a chart with a 72 Pts or larger square print dimension would improve the success rate of the grid detection in the Adobe Lens Profile Creator.

2. Print the selected chart on a matte, white, heavy-duty or cardstock paper.
3. Mount or frame the printed chart for extra support to keep the print flat. If framing, remove the glass to prevent reflections.

Shooting Setup

1. Place or mount the chart on a wall or easel.
2. Choose two of the same lights.
3. Set each light facing towards the chart at opposing 45-degree angles (see Figure 1).

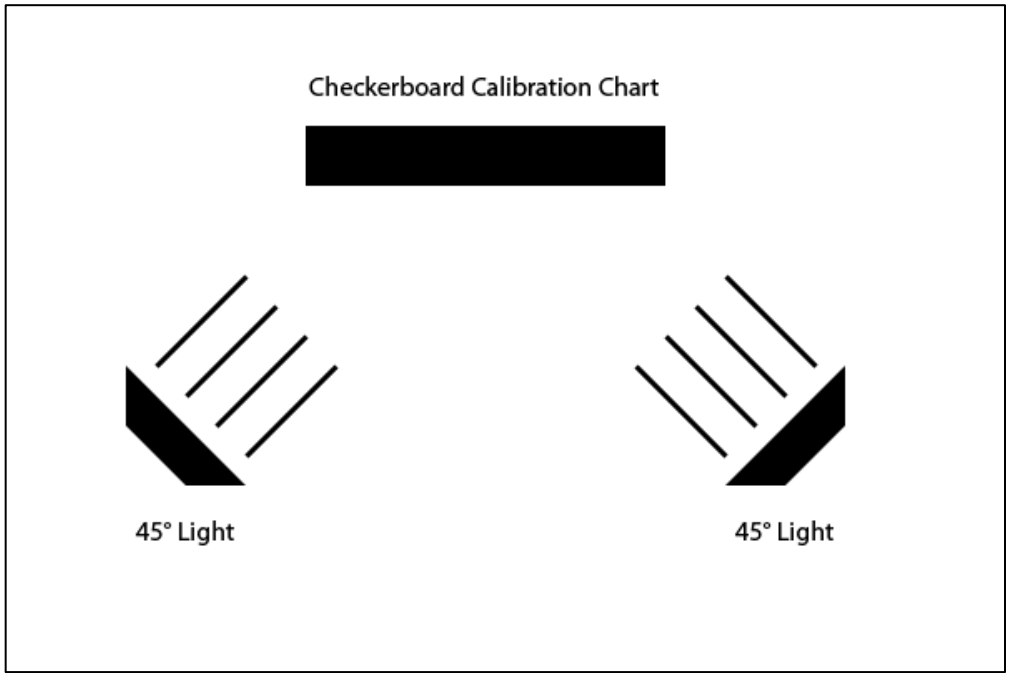

Figure 1: Top-view Lighting Setup for the Calibration Chart

4. If two lights aren't available, use room lighting or natural daylight.
5. Make sure the lighting stays constant (not necessarily uniform) for a given shooting session.

Capturing the Calibration Chart Image Sets

Planning the Required Image Sets

The amount and the type of lens distortions are direct functions of the camera settings, such as the focal length, the focus distance and the aperture. Therefore, to fully characterize the optical properties of a lens, one needs to create a lens profile for each of the many exemplary camera settings. To create one lens profile for one camera settings, one needs to shoot a multiple of calibration chart images (called one image set). Adobe® Lens Profile Creator is able to batch process all the image sets and append each of the generated lens profile (called the sub-profile) into a single lens profile LCP file.

If your lens is an APS-C type of lens, choose an APS-C type of camera to match it when shooting the calibration chart; else choose a full frame camera body.

We recommend the following guidelines when shooting the image sets to create a basic lens profile:

1. For wide angle/fisheye zoom lenses, shoot at the nominal focal length positions as marked on the ring of the lens with a fixed f/11 aperture.
2. For telephoto zoom lenses, shoot at the minimum, maximum and medium focal lengths positions with a fixed f/11 aperture.
3. For prime lenses, shoot at (1 × minimum focus distance) and (5 × minimum focus distance) focus distance positions with a fixed f/11 aperture.

As a step-up for advanced users, we recommend the following guidelines when shooting the image sets to create a more complete lens profile:

4. For wide angle/fisheye zoom lenses, shoot (6 focal length positions) × (3 focus distance positions) × (4 aperture positions) = 72 image sets.
5. For telephoto zoom lenses, shoot (3 focal length positions) × (3 focus distance positions) × (4 aperture positions) = 36 image sets.
6. For prime lenses, shoot (1 focal length position) × (3 focus distance positions) × (4 aperture positions) = 12 image sets.

The focal length positions will include minimum focal length, maximum focal length, and focal lengths in between which are marked/indicated in some way on the ring of the lens. The focus distance positions will include (1 × minimum focus distance), (2 × minimum focus distance) and (5 × minimum focus distance). You may vary based on your shooting setup space limitations. And the aperture positions will include the maximum aperture (the smallest f-number) up to f/8 for fast lenses (i.e. lenses that support f/2 or faster) and up to f/11 for slower lenses. The aperture positions will follow the 1-stop increments.

Prepping the Camera Body

1. Zero out in-camera processing settings (sharpening, color, contrast, etc.).
2. Set the image file-type to shoot RAW, highest-quality JPEG, or both.
3. Set the shooting mode of the camera to "manual" for keeping the exposure constant throughout the shooting iteration.
4. Set your camera to a constant ISO (too much noise could have an effect on the results of the calibration; consider using an ISO around 400 or less.)
5. Set the white-balance to Auto, or the desired preset appropriate for your shooting environment. White balance, unless extremely inaccurate, should have a minimum effect on lens profile quality. You may also customize white balance if you wish to.
6. Set the color profile to the profile you prefer to shoot with and keep them constant in the whole shooting session. Adobe RGB and sRGB are typically available on most camera bodies.
7. Keep the camera's orientation (i.e. "landscape" vs. "portrait") constant for the shooting session. Landscape is recommended.
8. Turn off any date/time imprint features.
9. Turn off any in-camera processing that may be switched off ("creative effects", image correction, vignette/exposure compensation, noise reduction, etc.).
10. Enable histogram and highlight-clipping indication, if available, in the image preview mode of the camera. Use this as an aid to determine if the white of the chart is being clipped due to the exposure level.
11. Set the camera to single-shot image capture.
12. Set the camera to the desired focus mode. A single-point focus may be easiest for keeping the chart in focus from shot to shot.
13. Insert a compatible memory card into the camera.

Prepping the Lens

1. Properly attach the lens to the camera body.
2. Set the lens to the preferred focus mode (auto vs. manual focus).
3. Adjust the lens to the desired focal length. Be careful not to accidentally adjust focal length by bumping or moving the focal length ring during shooting. This can alter the focal length metadata produced by the camera.
4. If shooting a zoom lens, adjust the lens to a single focal length for the shooting iteration. When using the *Adobe Lens Profile Creator*, you may run the creator for multiple shooting iterations for a single camera/lens combination, and append the data from additional shooting iterations to the same LCP. Shooting a separate iteration for the minimum, maximum, and middle focal lengths of a zoom lens is recommended. The six variables involved with a shooting iteration are: camera make, camera body model, lens make/model, focal length, aperture, and focus distance.

Prepping the Tripod

Note: Using a tripod is recommended for shooting environments that require slower shutter speeds. Combined with live-view, a tripod-mounted camera is also much easier to adjust for making tightly framed chart shots (see framing procedure below).

1. Adjust the tripod to the appropriate height.
2. Properly mount the camera to the tripod.

Capturing the Chart Images

1. Distance the camera so that the chart fits within the image frame. The entire checkerboard pattern must fit within the image frame and be completely unclipped in the captured image.
2. Have the chart take up approximately 1/2 to 1/4 of the area of the entire image frame of the camera when shooting.
3. Keep the subject distance (chart-to-camera) consistent for a given shooting iteration.
4. Adjust the aperture and shutter speed to achieve the best exposure possible. Take a test shot and preview the histogram of the image to make certain that an optimum exposure is achieved while not clipping (over-exposing) the highlights of any of the white squares of the chart.
5. Keep the manual exposure settings (aperture and shutter speed) constant throughout the shooting session.
6. Shoot nine different images for the shooting session. Imagine dividing the image frame into nine different sections, and shoot an image with the chart in each section, as shown the picture below. Try to frame the chart in the view such that checker board grids can sample more points along the image corners and edges. Keep all the checker boxes inside the image frame but as close to the image frame as possible without being clipped. Keep the chart stationary, but try to tilt and move the camera between the shots instead. Here is one typical framing sequence:
    a. First shoot centered straight on.
    b. Tilt the camera up, thereby effectively framing the chart at the bottom-center of the image.
    c. Tilt camera down, thereby effectively framing the chart at the top-center of the image.
    d. Move camera a bit to the left (so that when turning to the right to face the chart, it is about 10 to 30 degrees). Take a series of shots similar to the first three, above, except that the chart is framed at the center-left, top-left, and bottom-left areas of the image.
    e. Move camera to the right, and do the same for the center-right, top-right, and bottom-right areas of the image.

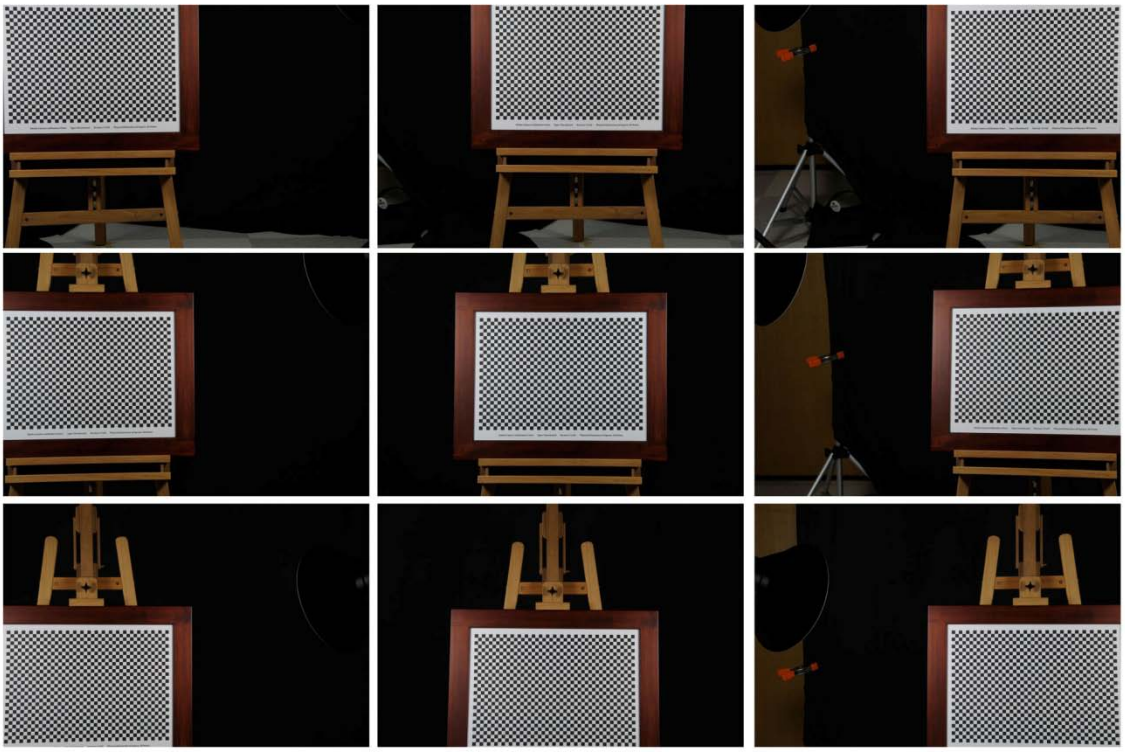

Figure 2: Image Set for the 70mm Focal Length of an 18-200mm Zoom Lens

7. Use the image preview and preview-zoom options on the camera to check on the focus of the chart, the framing of the chart, and confirm that no checker squares are clipped at the edge of the frame.
8. You now have a set of chart images ready to be loaded into the application for generating a lens correction profile!

Conclusion

After printing out a calibration chart, setting up the shooting environment, and capturing a set of chart images with a given camera/lens combination, you are now ready to make a customized lens correction profile using the *Adobe Lens Profile Creator* application! See the *"**Adobe Lens Profile Creator User Guide"*** document for info on using your captured images with the Adobe Lens Profile Creator.

If you would like to learn more on chart shooting, please see the *"**Calibration Chart Shooting Guides for the Adobe Lens Profile Creator"*** document for advanced shooting tips and explanations.

Appendix: Frequently Asked Questions

Q: *Why shoot nine images, filling up the frame at different angles per shot, when I can shoot one image with the chart filling up the entire frame at once?*

A: Adobe® Lens Profile Creator employs the state-of-the-art multi-view image geometry algorithm to estimate all the camera model parameters, such as the principal point (image center), focal length, and distortion parameters. It requires a minimum of three images of the checkerboard. We recommend shooting nine images instead of the minimum three because it would permit the use of a smaller checkerboard to sample data points closer to the edges of the image frame where the lens aberration are typically more pronounced, and provide fallback images if for some reason the Adobe® Lens Profile Creator fails to process all the images successfully. In general, additional images will improve the robustness and the accuracy of the camera model parameter estimates.
The multi-view image calibration setup utilized by the Adobe® Lens Profile Creator also eliminates the need of an expensive and controlled studio setup, making the technology more accessible to ordinary photographers. In this new setup, the camera and the calibration chart no longer need to be meticulously aligned, or the chart to be uniformly illuminated. There is no need to have a single chart to fill the entire field-of-view of the camera, which is difficult to do for wide-angle or fisheye lenses.

Q: *Should more than nine images be shot when using a wide angle or fisheye lens that requires a greater number of images to overlap the entire image frame?*

A: Choose a number of images to shoot so that, when grouped together, the chart images cover every part of the image frame. For wide-angle or fisheye lenses or for cases where you're shooting a chart further away that takes up less of the image frame per shot, it's recommended to shoot more than nine images.

Q: *Does the chart plane have to be completely parallel to the plane of the image sensor in the camera for all the chart images?*

A: No. Adobe® Lens Profile Creator actually expects camera orientation and location with respect to the chart changes from one image view to the next. It is recommended that one of the nine images is a frontal and approximately in-the-center shot of the chart, but in no way it has to be precisely controlled.

Q: *Can I just keep the camera in one position and move the chart instead?*

A: It's recommended that users move the camera instead of the chart so that the lighting remains constant on the chart, which will provide better vignette correction results when processed. When shooting the chart at very close distances, make sure that the camera/tripod setup does not block any lighting during shooting.

Q: *Do I have to have a perfectly even lighting setup?*

A: No. As long as the lighting setup is consistent between all shots, the Adobe® Lens Profile Creator can detect the pattern of chart lighting from the multiple shots and calculate the relative light falloff that occurs. An optimum exposure (one that does not clip any of the white highlights of the chart while still capturing the maximum range of possible tonal data) will also aid in generating an optimum vignette correction model. Having said all that, a more evenly illuminated lighting would only help to get a more consistent vignette estimation result.

Q: *What type of paper should I print the chart on?*

A: A matte, or at least semi-matte, heavyweight paper is recommended. Glossy is not recommended since specular highlights (light reflection off the chart) can interfere with grid detection. A heavyweight paper is recommended so that, when mounted, the printed chart will remain completely flat. The flatness of the chart is essential for accurate lens profiling, though the images themselves may have the chart shot at different angles.

Q: *Can I display the chart image on a flat-screen LCD TV monitor instead of printing it?*

A: This is a feasible method for shooting chart images for lens profiling, though the quality and potential caveats have not been tested in-house by Adobe. Some user has taken this route and reported good results with the geometric and vignette corrections. Care must be taken to make sure the chart squares display as perfectly square pixels, and that the display is not overexposed. Also, one needs to specify the correct square print dimension in the user interface of Adobe® Lens Profile Creator.

Q: *Where should I place my LCP file so that I can use it in ACR and the Photoshop Lens Correction plug in?*

A: You can place the lens profiles under a user specific or a shared all user location.
User profiles location:

- Mac OSX: /Users/(User Name)/Library/Application Support/Adobe/CameraRaw/LensProfiles/1.0
- Windows 7 or Vista: C:\User\(User Name)\AppData\Roaming\Adobe\CameraRaw\LensProfiles\1.0
- Windows XP: C:\Documents and Settings\(User Name)\Application Data\Adobe\CameraRaw\LensProfiles\1.0

Shared profiles location:

- Mac OSX: /Library/Application Support/Adobe/CameraRaw/LensProfiles/1.0
- Windows 7 or Vista: C:\ProgramData\Adobe\CameraRaw\LensProfiles\1.0

- Windows XP: C:\Documents and Settings\All Users\Application Data\Adobe\CameraRaw\LensProfiles\1.0

Q: *Do I have to shoot the chart against a blank background?*

A: No. The Adobe® Lens Profile Creator can still detect the chart when it's set in front of a busy background. Take care to avoid including any spectral highlights in the background that could confuse the Adobe® Lens Profile Creator's grid detection (shiny objects or anything particularly bright).

Q: *How can I create and use LCP files with older lenses that have no EXIF metadata, or with lenses that have simpler, less distinguishable metadata so that they can't be told apart from each other?*

A: In the Adobe® Lens Profile Creator, please specify a fully qualified camera and lens names (including make and model) so that a user can uniquely identifying the lens profile in the user interface.

Q: *What are the different colored grid points that show up when I run the Adobe® Lens Profile Creator on my images?*

A: Yellow grid points are the initial corners detected by the Adobe® Lens Profile Creator. The yellow zigzag dashed line shows the correct ordering of the detected corners. Red grid points indicate grid detection failures that it will remove the image from contributing to the computation of the lens profile. Looking at the red dots and finding where these red dots are missing in the checkerboard can give clues to why the failure occurred. Cyan grid points are drawn as overlays on top of the yellow grid points. The yellow point shows the original detected corner, and the cyan point shows the new location of the corner as predicted by the lens profile. The yellow points and the cyan points should be as close to each other as possible. The closer the points, the better fit of the estimated lens model to the actual data.

Q: *My images show red grid points and there is a yellow warning sign next to the image file name listing item after running them through the Adobe® Lens Profile Creator. What does this mean? How can I prevent this?*

A: Red grid points on the image indicate a grid detection failure. The Adobe® Lens Profile Creator will not include images that are determined to have a grid detection failure. The most common causes are that the user specified the incorrect checkerboard info in the Adobe® Lens Profile Creator calibration settings, or the presence of specular highlights on the chart, or the chart not being completely in frame, or chart squares being too small in the captured image. In the first case, check to make sure the checkerboard info in the Adobe® Lens Profile Creator is correctly specified. If the checkerboard info is incorrect, try rerunning the same images after correcting the checkerboard info.

Q: *What is the best methodology for determining the "smallest square" to measure in a group of images?*

A: Measuring the smallest checker square in a group of images is used by the Adobe® Lens Profile Creator to help correctly detect the grid. The measurement does not have to be completely accurate; an approximated value is good enough. Scan through your images to find a checker that appears to be the smallest due to the geometric distortion of the lens or the angle it was shot at, and then use the ruler tool to measure across its smallest dimension (length or width) and input the measured data.

Q: *When measuring the square pixel dimension, should the spread of the square due to chromatic aberration or geometric distortion be included in the measurement?*

A: This measurement is an approximation used by the Adobe® Lens Profile Creator to help correctly detect the grid, and does not have to be 100% accurate. Including or not including the spread from chromatic aberration should be fine, although measuring the smallest square should take into account squares that are smallest due to geometric distortion. These squares should be considered for measuring the smallest square. It's also recommended that no square in the image have a dimension shorter than 20 pixels.

Q: *Can the Adobe® Lens Profile Creator profile APS-C "digital" lenses used on a full-frame body?*

A: Yes. The full frame sensor is able to sample image data that is beyond the scope of the APS-C lenses, which is not a bad thing.

Q: *Can the Adobe® Lens Profile Creator profile full-frame lenses used on an APS-C sensor size camera body, and then apply the generated lens profile for lens correction to an image captured with a full-frame camera using the same lens?*

A: Not recommended, because the camera with the APS-C sized sensor (non full-frame sensor) can only sample a limited range of lens aberration data of the full-frame lenses. Applying the generated lens profile for lens correction to an image captured with a full-frame camera using the same lens amounts to extrapolation of lens aberration data to where it does not have any observation data, which may or may not work well.

Q: *The chromatic aberration correction results from my LCP file are not as good as I had hoped. Is there anything I can do to improve this?*

A: Focus distance also affects the chromatic aberration to a smaller degree. For best result, create a sub profile that matches the focus distance as well. In Adobe Photoshop CS5, the sub profiles of the current selected lens profile can be accessed in by right-clicking on the profile.

Some camera vendors enable (sometimes randomly) in-camera corrections that cannot be turned off. It is recommended to use the DNG images instead of Tiff or Jpeg images to create the profiles.

Q: *What if I only shoot images and profile for the minimum and maximum focal lengths of a zoom lens? Will the Adobe Photoshop CS5 still use the profile and make corrections for images shot in between these focal lengths?*

A: Yes. Adobe Photoshop CS5 will interpolate the lens profiles between the two focal lengths.

Q: *How should I meter and expose the calibration chart?*

A: Spot or center-weighted metering should work fine. The goal is to expose the chart to capture the maximum amount of tonal data possible without clipping the white areas of the chart. It's recommended that you keep objects brighter than the white of the chart out of the background so that you can view the white of the chart as your highlight area when looking at a histogram of your image.

Q: *When should lens correction be applied in my workflow?*

A: It is recommended that the lens correction be applied very early in your photographic workflow, before any additional scaling or cropping is applied to the image. The adoption of the non-destructive Adobe Camera Raw based workflow is highly recommended.

Q: *Can I still create a lens profile if the camera I use incorporates its own in-camera lens corrections that I can't turn off?*

A: If you wish to create lens profile for a camera that uses its own lens corrections, it is recommended that you shoot only raw images to prevent the in-camera lens corrections from being applied. Keep in mind that if you make and use a lens correction profile in this manner, the correction will only work for uncorrected images from the camera.

Q: *I want to profile for different focus distances, but my camera does not record this as EXIF metadata. Can I still profile for different focus distances?*

A: Yes. Adobe® Lens Profile Creator estimates the focus distance for each iteration regardless whether or not the focus distance is recorded in the EXIF metadata or not. If the focus distance is recorded in the EXIF metadata, Adobe Photoshop CS5 will try to automatically select the best sub profile with the closest focus distance