

# Geometric Distortions in a Canon EF 50mm f/2.5 Macro Lens

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## Abstract

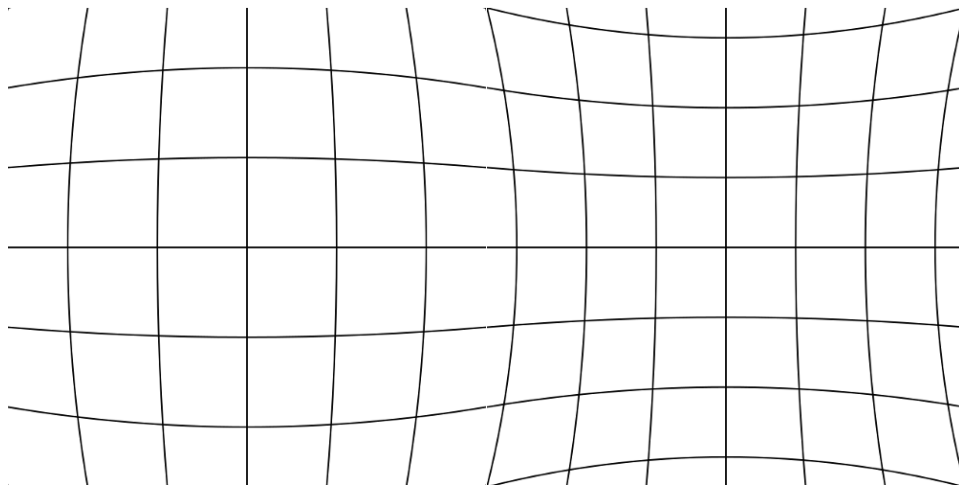
In order to test for geometric distortions produced by a Canon EF 50mm f/2.5 macro lens, a photo was captured, in lab conditions, of a square grid. A digital grid was superimposed on this image. Any discrepancies between these two grids would indicate aberrations. It was found that the geometric distortions of the lens were negligible as was expected from a quality, prime lens such as this one.

## Introduction

Geometric distortions are a type of optical aberrations that afflicts lenses of all forms to varying degrees. These distortion present problems, especially when used in scientific applications, as they alter the physical reality the user has been tasked with capturing and, if not corrected, can prove to be a source of both scientific error and personal frustration. This procedure sought to analyze the geometric distortion of a Canon EF 50mm f/2.5 macro lens mounted on a Canon 5D MkII used in spectral imaging procedures at the Munsell Color Science Laboratory.

## Background

Geometric distortions can be divided up into two general categories: barrel and pincushion. Barrel distortion is when the magnification decreases as the distance from the optical axis increases. This results in an effect where the center of the



**Figure 1:** Illustrations of how barrel (left) and pincushion (right) alter a square grid. <sup>[1]</sup>

image appears to bulge out of the plane. Pincushion distortion, on the other hand, is where the magnification increases as a function of the optical axis resulting in an appearance where everything is drawn into the center of the plane.

## Procedure

A Canon 50mm f/2.5 macro lens was mounted on a Canon 5D MkII and elevated above a grid with a 140 patch Gretag Macbeth Digital Color Checker in the center of the frame. The color checker served as a secondary, courser grid on which any distortions could be observed as color accuracy was not of interest in this particular procedure. The imaging system was elevated to a height where the grid filled the field of view and a sharp focus could be achieved. At this height, the camera was leveled both vertically and horizontally to bring the detector both parallel and square with the target.

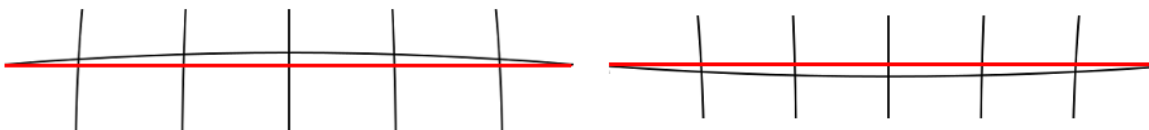
A RAW image was captured through the EOS Remote Shooting software provided by Canon upon purchase of the 5D MkII. The image was exposed to a point where all the lines of the grid were easily visible. In this instance, the settings were f/8.0, 1/125 seconds, and ISO 6400. Other settings are certainly applicable, but the aperture should be kept smaller rather than larger in order to avoid an accidental soft focus.

The captured image was imported into the image manipulation freeware GIMP for analysis.

## Analysis

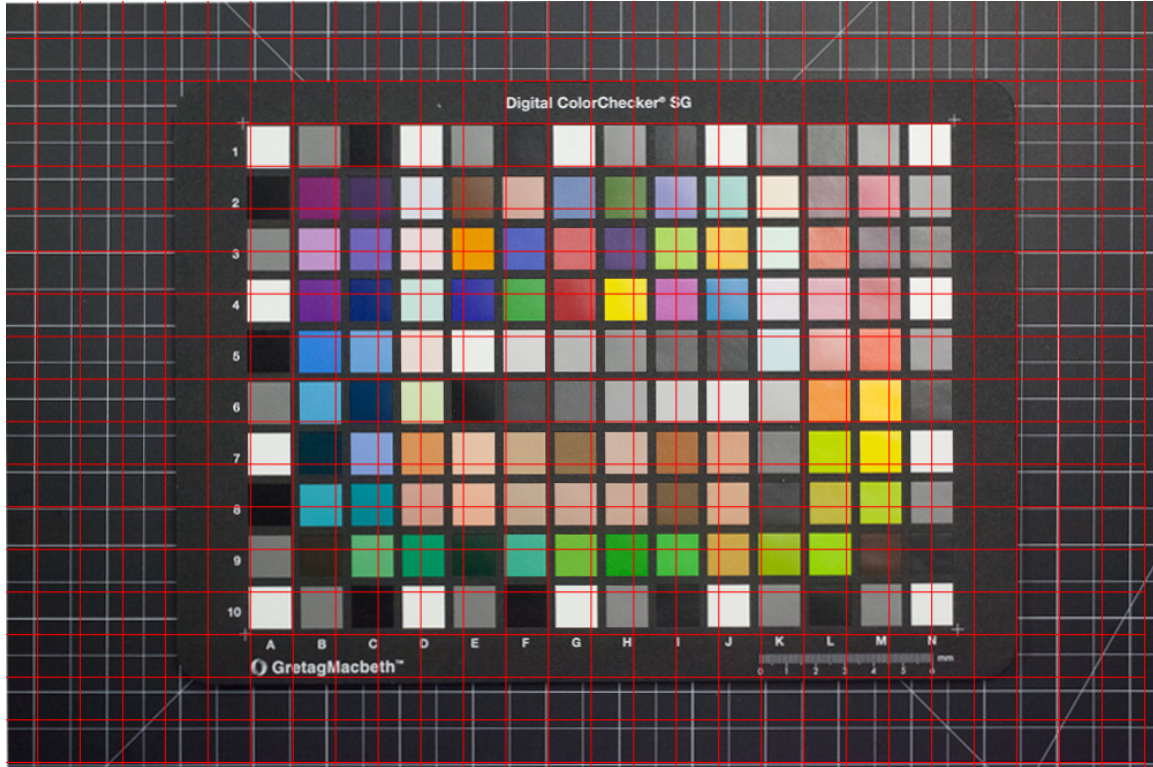
Before any distortion analysis was done, it was noticed that the image was not exactly square with the grid, which arose from an imperfect horizontal leveling of the imaging system. A grid was superimposed upon the image and the centermost physical grid lines, the ones with the least distortion, were lined up with the superimposed lines. The image had to be rotated 0.20 degrees counterclockwise in order to be square in the frame.

The grid used to square the image was kept in place in order to evaluate the amount of geometric distortion in the image. When a square grid is superimposed on an image of a square grid, all grid lines should run parallel across the entire image, both vertically and horizontally. If the captured image suffers from barrel distortion, the captured grid lines will bulge out from the superimposed grid lines and away from the optical axis. If the captured image suffers from pincushion distortion, the captured grid lines will be sucked in from the superimposed grid lines and towards the optical axis as illustrated in Figure 2.



**Figure 2:** Examples of what a line from the upper half of a distorted grid (black) would look like with a superimposed straight grid (red) for both barrel (left) and pincushion (right) distortions.

When the digital grid was superimposed on top of the captured grid, there were no deviations between the two lines over one pixel. With deviations as minor as these, the geometric aberrations can be considered negligible and the image treated as square. All the grid lines closest to the edge of the image were tested and found to have equally negligible deviations. As geometric distortions worst close to the edge of the image, the inner grid lines were assumed to be straight after the linearity of the outer grid lines were confirmed. These findings agree well with independent reviews of this same lens done by independent photographers [2] [3].



**Figure 3:** Captured grid (white) with the digital grid (red) superimposed.

## Conclusion

This procedure analyzed the geometric distortions of a Canon EF 50mm f/2.5 macro lens mounted on a Canon 5D MkII used in spectral imaging procedures at the Munsell Color Science Laboratory. The lens was found to produce negligible geometric distortions which make it reliable and suitable for scientific purposes.

## References

- [1] "Distortion (optics)." Wikipedia, 1 Jan. 2014. Web. 1 Aug. 2014.  
<[http://en.wikipedia.org/wiki/Distortion\\_\(optics\)](http://en.wikipedia.org/wiki/Distortion_(optics))>.
- [2] Rockwell, Ken. "Canon 50mm Macro." *Canon 50mm Macro*. Web. 5 Sept. 2014.  
<<http://www.kenrockwell.com/canon/lenses/50mm-macro.htm#distortion>>.
- [3] "Canon EF 50mm F/2.5 Macro - Review / Test Report - Analysis." *Canon EF 50mm F/2.5 Macro - Review / Test Report - Analysis*. Web. 5 Sept. 2014.  
<<http://www.photozone.de/reviews/161-canon-ef-50mm-f25-macro-test-report--review?start=1>>.