Image and Visual Representation Lab
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AAM: AN ASSESSMENT METRIC OF AXIAL CHROMATIC ABERRATION

We propose a novel metric, Axial Aberration Magnitude or AAM, that assesses the degree of axial chromatic aberration of a given lens. Our metric is generalizable to multispectral acquisition systems and is very simple and does not require expensive hardware to compute. We present the entire procedure and algorithm for computing the AAM metric, and evaluate it for two spectral systems and two consumer lenses. The end use is for the evaluation of the performance of lenses in correcting axial chromatic aberration.

Chromatic Aberration

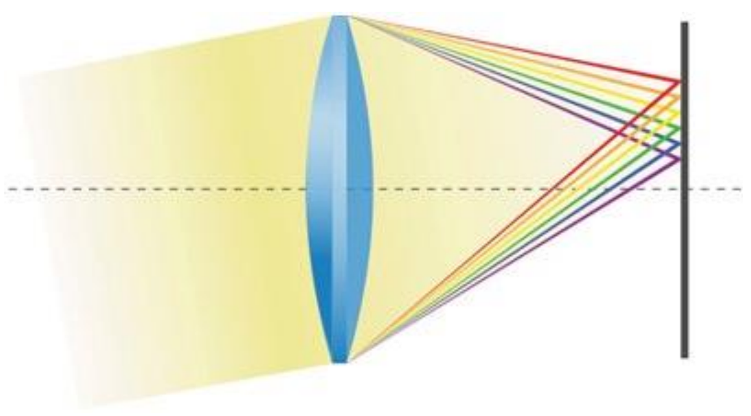
Chromatic aberration is present in all camera systems to different extents. Chromatic aberrations are caused by dispersion, as the refractive index of a lens is non-linearly wavelength dependent. Every acquired wavelength λ has a different refractive index *n(λ)* and is thus deviated by a different angle. The result is that every wavelength has its own focal length *f(λ)* and power *P(λ)* given by the lens makers' formula:

$$P(\lambda) = \frac{1}{f(\lambda)} = (n(\lambda) - 1)\left(\frac{1}{\epsilon_1} - \frac{1}{\epsilon_2}\right)$$

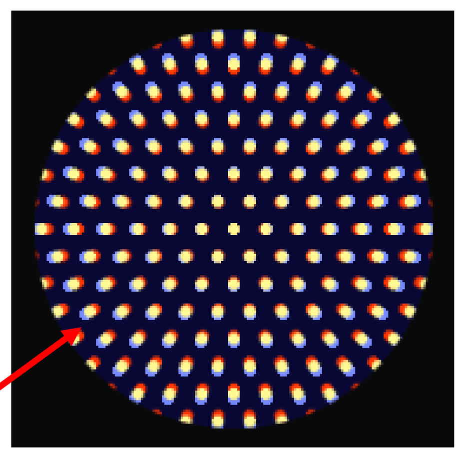
Lateral Chromatic Aberration

A physical illustration of **lateral** chromatic aberration is given on the left. The right image is the capture of point light sources illustrating the visual effect of this aberration on images.

Physically



Visually

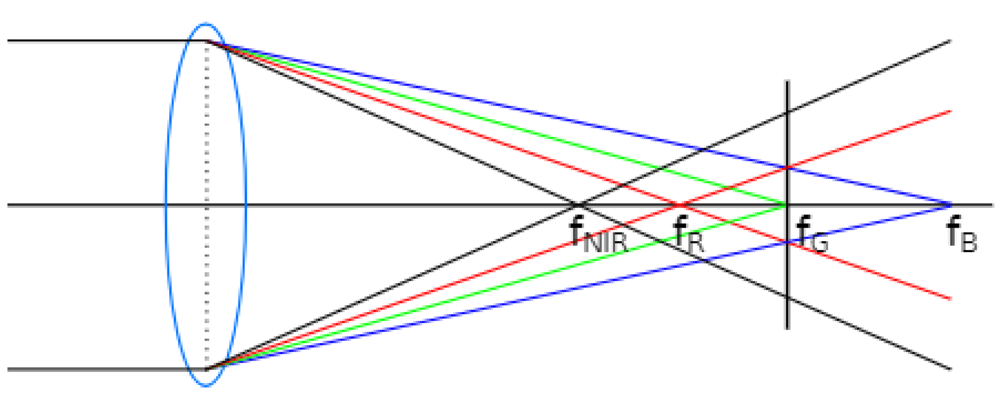


Color fringing, present mostly on image borders

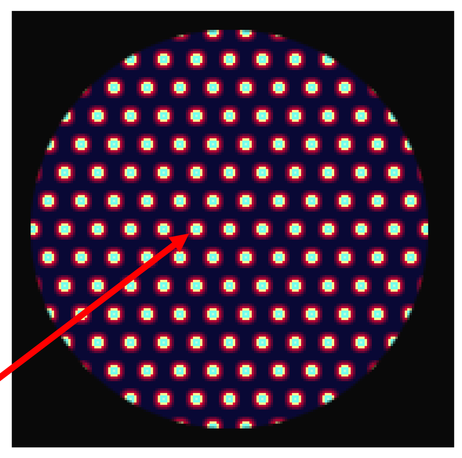
Axial/Longitudinal Chromatic Aberration

A physical illustration of **axial** chromatic aberration is given on the left. The right image is the capture of point light sources illustrating the visual effect of this aberration on images.

Physically



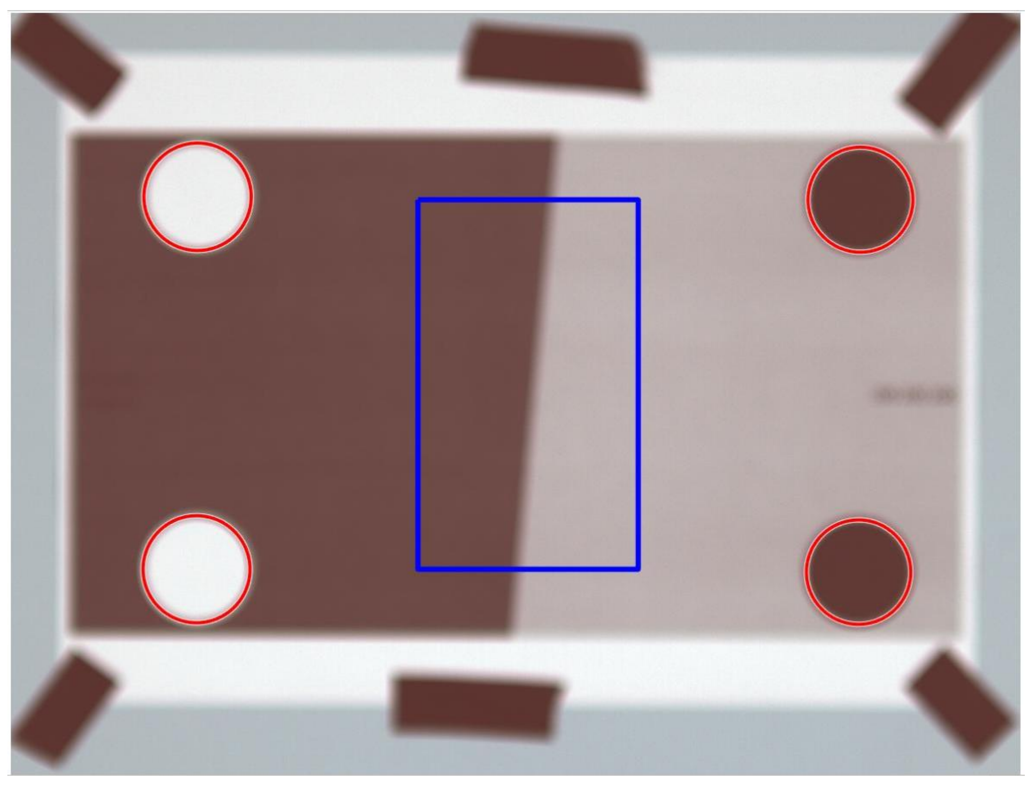
Visually



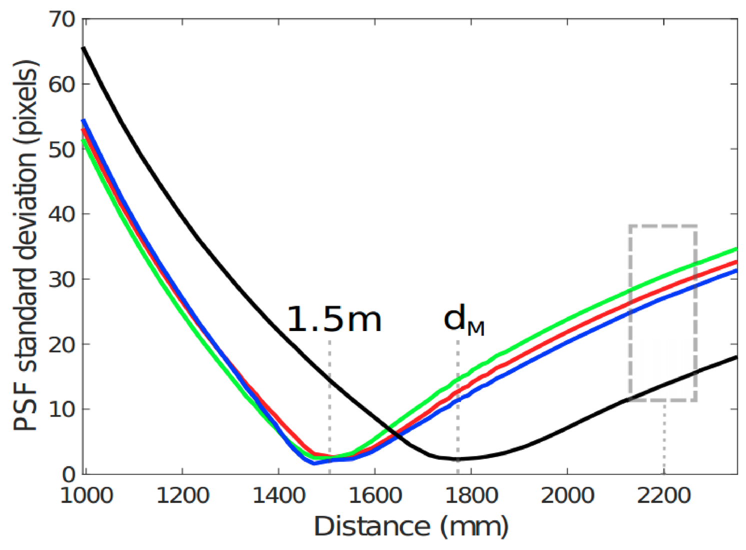
Color fringing, present all over the image

AAM

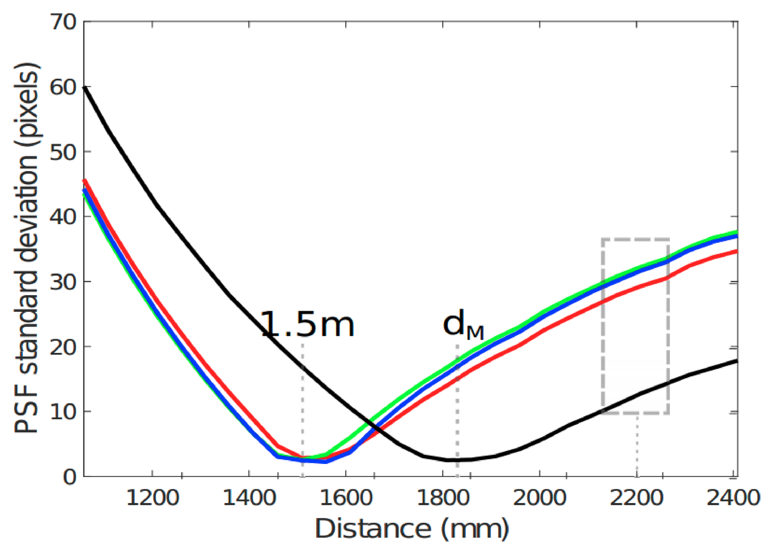
PSF estimation based on the ISO 12233 slanted edge method



EF 50mm f/2.5 PSF plot



EF 50mm f/1.8 I PSF plot



The curves are in black for near-infrared, and red/green/blue for RGB

Normalized:

$$\bar{\delta}_\alpha(\Lambda_i, \Lambda_j) = \frac{1}{b_{ij} - a_{ij}} \int_{a_{ij}}^{b_{ij}} [r_i(x) - r_j(x)]^2 dx$$

Multi-Spectral:

$$AAM_\alpha(\Lambda_1, ..., \Lambda_N) = \log_{10}\left(\frac{1}{|\mathcal{M}|} \sum_{i,j \in M} \bar{\delta}_\alpha(\Lambda_i, \Lambda_j)\right)$$

Polynomial-Fit:

$$= \log_{10}\left(\sum_{i,j \in M} \frac{1}{|\mathcal{M}|}\left(\sum_{w=1}^{11} \frac{d_{ij_{w-1}}(b_{ij}^w - a_{ij}^w)}{w(b_{ij} - a_{ij})}\right)\right)$$

(a,b) define the depth range of interest
x represents depth, and x⁰ the PSF minima
α is a free parameter for range tuning
Λ stands for a spectral channel's PSF

$$\begin{cases} a_{ij} = (1-\alpha) * min(x_i^0, x_j^0) \\ b_{ij} = (1+\alpha) * max(x_i^0, x_j^0) \end{cases}$$

Consumer Lenses Tests

AAM is evaluated for 3 different depth ranges of interest. The two lenses are those of the PSF plots shown above.

Table 1. $AAM_\alpha(R, G, B)$ values as a function of α for two lenses, using an f-stop of 2.5.

α	0.2	0.35	0.5
Canon EF 50mm f/2.5	0.87	1.66	2.34
Canon EF 50mm f/1.8 I	2.97	3.55	4.09

Table 2. $AAM_\alpha(R, G, B, NIR)$ values as a function of α for two lenses, using an f-stop of 2.5.

α	0.2	0.35	0.5
Canon EF 50mm f/2.5	5.59	6.21	6.78
Canon EF 50mm f/1.8 I	5.83	6.44	7.00