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Imaging Lab: f/#

Introduction

The purpose of this lab is to introduce the experimenter to f/#, and some of the effects that it can have on an imaging system. It is generally understood that changing the f/# of a vision system affects two things: overall light throughput and depth of field, and that these two quantities are opposing one another. However, this lab aims to address the effects that changing the f/# has on resolution. All pupil-dependent optical aberrations, such as astigmatism, are f/# dependent, and in most cases decrease with increasing f/#, which increases performance. However, while aberrations are diminished with the increase of the f/#, increasing f/# too much will actually decrease the resolution of a system. This decrease is caused by the diffraction limit, a fundamental physical limitation to the resolving power of a lens which is directly dependent on wavelength and f/#.

Parts List

Metaphase Fiber Optic LED Illuminator (86-437)
Fiber Optic Backlight (39-826)
12mm Focal Length High Resolution CFF Lens (63-777)
Camera Stand with 1/4”-20 Camera Mount
High resolution (5MP) camera, 2/3” Sensor
4” Star Target Array (58-835)

*These specific parts are recommended – user may need to swap products in or out for their specific needs

Procedure

1. Carefully thread the lens onto the camera, and ensure that the f/# is set to the lowest number possible (f/1.8).
2. Turn on the Metaphase Illuminator, and set the illumination to one of the white settings.
3. Adjust the working distance such that the front mechanical housing of the lens is roughly 250 mm from the target, and focus the lens using the focus adjustment knob on the bottom of the housing.
4. Using the camera software, zoom in so that you can easily view the five stars in the center of the array, and slightly adjust the focus if necessary.
5. Save an image of the target, and advance the f/# to the next click stop. Note the changes in image quality.
6. Repeat step 4, manually increasing the exposure time as needed, until each f/# is reached.

Conclusions

- Which f/# do you feel has the best balance between image quality and brightness of the image? How would your answer change if you had to consider depth of field more seriously?
- Where do you notice image quality start to degrade, on both the low and high ends of f/#?
- If the f/# of a system needs to be adjusted after installation, do you think it is best to set the “best focus position” of the lens at a high f/# or a low f/#? Why?