Imaging Lab: Color

Introduction

Just about every variable in an optical system affects lens performance in one way or another. One of the major factors to determining lens performance that is often overlooked is the color of the illumination. In general, monochromatic illumination will provide a performance increase when compared to white light. However, the actual color can affect the overall performance. In many machine vision systems, red is the most commonly used color for illumination (due to cost issues and availability), despite the fact that it may not be optimal for the application. In this lab, the experimenter will investigate the effects that different colors can have on lens performance.

Parts List

Metaphase Fiber Optic LED Illuminator (86-437)
Fiber Optic Backlight (39-826)
12mm Compact Fixed Focal Length Lens (58-001)
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 aperture is set to f/11 or f/16.
2. Turn on the Metaphase Illuminator, and set the illumination to green.
3. Make sure that the exposure on the camera is set to auto, to compensate for changes in sensor response between colors.
4. 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.
5. Using the camera software, zoom in so that you can easily view the star in the center of the array, and slightly adjust the focus to ensure best image quality. [Note: to facilitate precise focusing, you may change the aperture to f/2.8 before adjusting the focus position; just make sure to change the aperture back to f/11 when finished!]
6. Change the color of the illumination to red, and note the image quality after refocusing. Save an image.
7. Switch the illumination color to blue, and again note the image quality. Save an image.

Conclusion

- At which color illumination does the lens achieve highest resolution? Why do you think this is? Keep in mind the equation of the minimum spot diameter, $D \approx 2.44\lambda(f/\#)$, where λ is the color of light (blue is smaller than red). What may be some disadvantages to picking this color for illumination? Set the camera exposure to manual and change the color of the illumination again for a hint.
- Based on what you learned in this lab, how do you think that the lens would perform under white light versus monochromatic illumination? Why?
- Do you think that the performance changes with color would be more or less apparent with a lower f/#? Keep in mind the equation that is mentioned in question 1.