Lab 9: Image Quality

Laboratory Report

Fundamentals of Imaging Science

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Introduction

For this lab, we learn how the modulation transfer function can be used to describe image quality. The graph used to represent this function is a contrast of modulation and spatial frequency. Spatial frequency is the spatial analog to the temporal frequency. As the spatial frequency increases, there will be a point where image quality begins to decrease. This happens due to the target contrast decreasing. An example of this is a real-world scenario in which perfectly white and perfectly black are placed next to each other with perfectly sharp edges. With our eyes, regardless of how close we get, we will always see only black and only white. However, if we were to capture an image and zoom appropriately, we will notice that there is some gray coloring coming from the edges of the black and white objects.

Methods

To begin, the spatial frequency was calculated by simply dividing the target cycles by the target size. Next, the given image was opened in Fiji and changed into an 8-bit grayscale image. Next, the image was rotated to align vertically. On the image, there are four sets of #3 vertical black bars (Highlighted by Figure 1). For each of these vertical bars, a rectangle was placed around the bars. Each rectangle was declared accordingly. With each rectangle created, a plot profile was created to view the gray values of the image. These can be viewed in Figure 2.1 - 2.4. Within each of these plot profiles, there is what closely resembles a square wave. The lowest points represent the black bars of the image and the highest points represent the white spaces between each bar. Knowing this, the average value was taken of each of the high and low points to create an average of each. From there, the values' difference was calculated for the contrast value, then was divided by 255 to attain the normalized contrast. This process was repeated for all 4 targets.

Results

Table 1: Measurements and variables related to the Modulation Transfer Function

Target Position	Target size (mm)	Target cycles (cycles)	Spatial Frequency (cycles / mm)	Contrast White - Black	Normalized Contrast
#3 Left (R1)	20.5	2.5	0.12195	186.38547	0.7309
#3 Right (R2)	10.3	2.5	0.24272	163.13083	0.6397
#3 Mid Left (R3)	5.3	2.5	0.47170	133.30375	0.5228
#3 Mid Right (R4)	2.5	2.5	1	57.333330	0.2248

Figure 1: All Black bars highlighted with a red rectangle

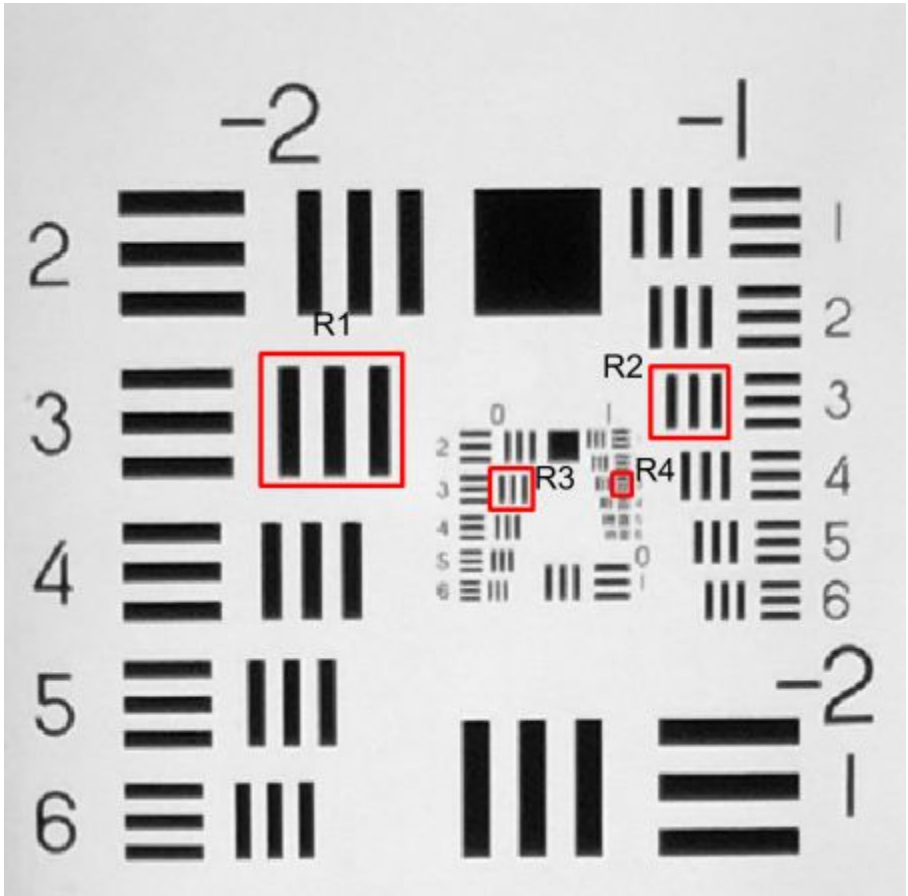
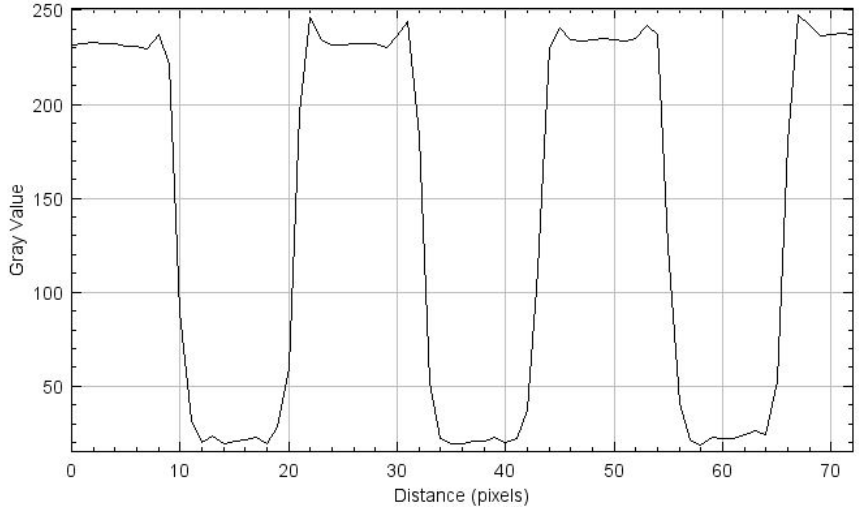


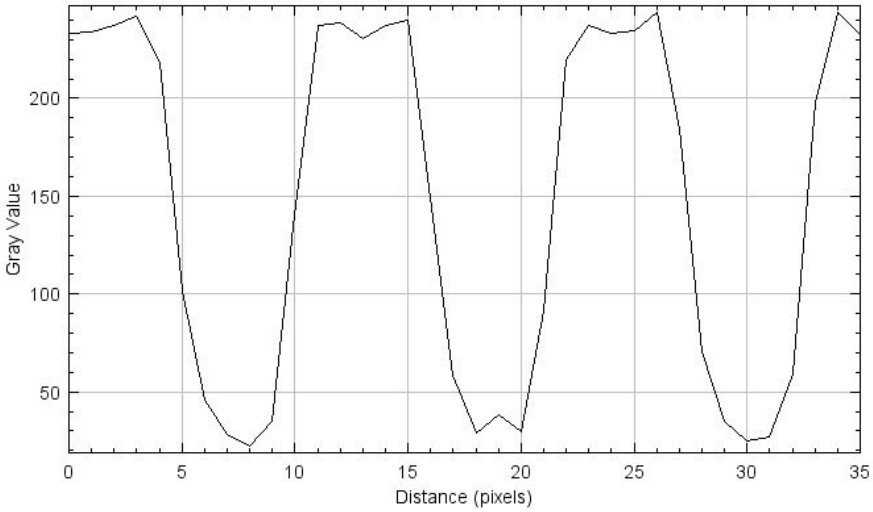
Figure 2.1: Plot Profile for R1



Average black bar value: 23.53633

Average white bar value: 209.9218

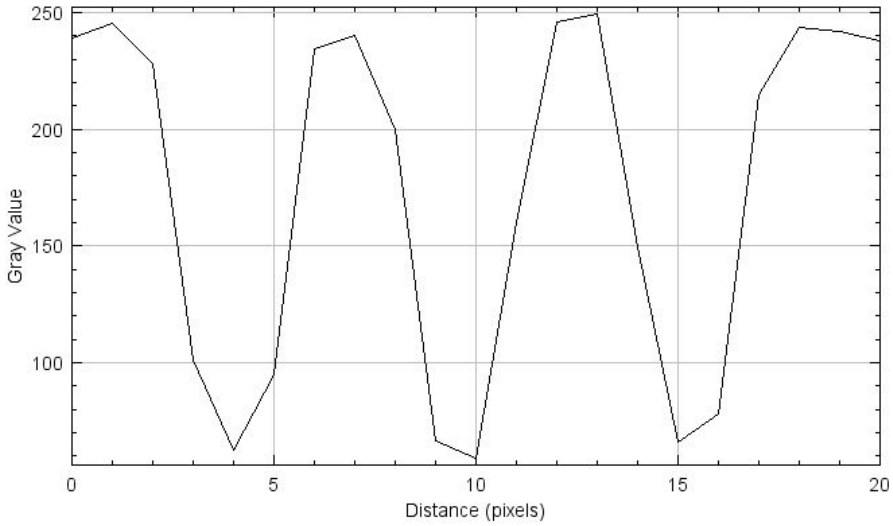
Figure 2.2: Plot Profile for R2



Average black bar value: 35.98717

Average white bar value: 199.118

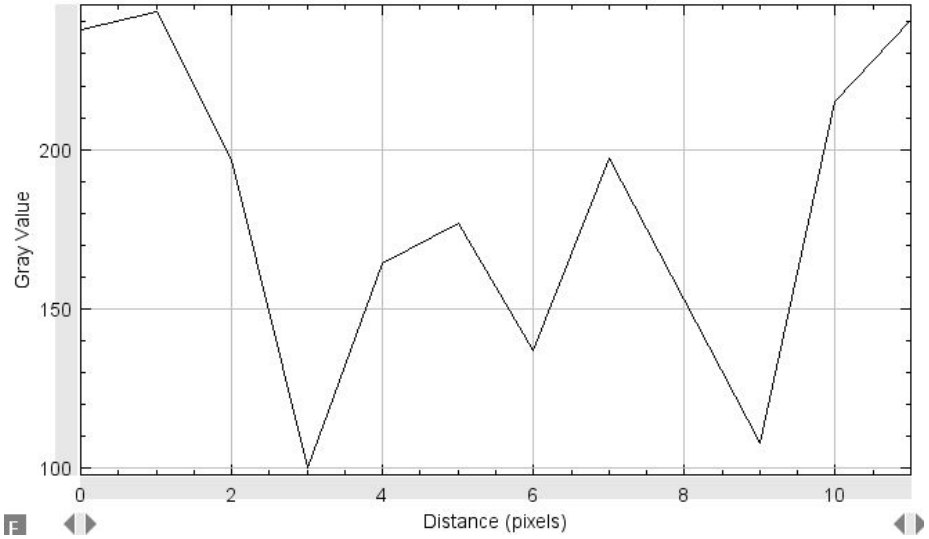
Figure 2.3: Plot Profile for R3



Average black bar value: 63.46425

Average white bar value: 196.768

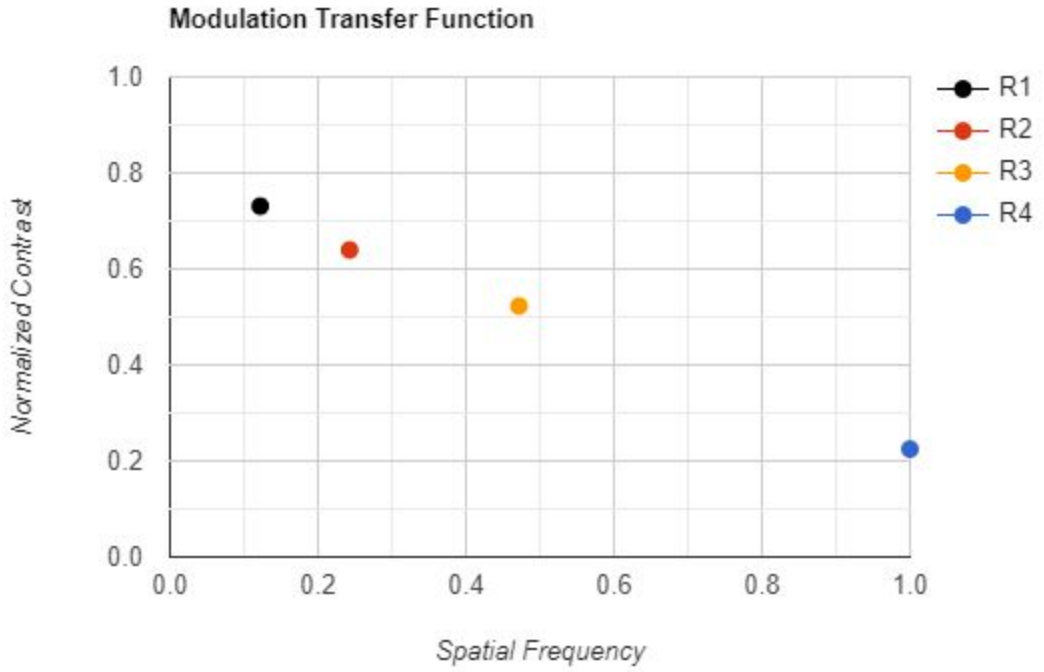
Figure 2.4: Plot Profile for R4



Average black bar value: 114.9167

Average white bar value: 172.75

Figure 3: Scatterplot for the Modulation Transfer Function



Discussion

The MTF plot says that as the spatial frequency increases, the normalized contrast decreases. This is exactly what was said in the introduction section. Although to our eyes, we can perceive the smallest target as relatively discernable between black and white, the camera saw this as a mostly gray area. However, since the contrast is above 10%(~22.5%), that means that the camera has correctly captured the pattern. The resolution limit of the camera is also better than average because of the same reason.