

AP 187 GROUP ACTIVITY 10 – MEASURING MODULATION TRANSFER FUNCTION

INTRODUCTION

The modulation transfer function (MTF) of an imaging system is a measure of the response of system to signals of varying spatial frequency. It is used to measure the resolution of your imaging device, which is how well an imaging device can measure fine detail. The MTF is dependent both on the lens design and the sensor array. If the zoom or focus changes so will the MTF. The finer the size of the CCD or CMOS pixels, the higher the MTF. However even if you have a good lens but a coarse CCD, or a poorly designed lens on a 24megapixel CCD you can still get poor resolution. In designing cameras for a satellite MTF measurement is one of the important tests done. In this activity we use the slanted edge technique to measure the MTFs of different cameras.

MATERIALS

Light box (any light source will do), print-out of a slanted edge with scale bar (ideally on highest print quality photopaper or high gsm paper), camera under test (your PiCam or smartphone) with tripod or stand.

PROCEDURE

1. Setup your camera on a stand and place the slanted edge image at a fixed distance away from it. Use the light box to illuminate the slanted edge image. Make sure that the plane of the camera sensor and slanted edge image are parallel to one another.
2. Capture an image of the slanted edge. You may use your PiCam and your groupmate's smart phones or DSLR's.
3. Open the slanted edge image using your scientific software. Get the intensity profiles of a line crossing the edge (LE).
4. Get the derivative of this line ($d(LE)/dx$) and then get the Fourier transform of this derivative, that is, get $FFT[d(LE)/dx]$.
5. Get the modulus of the FFT of the derivative $abs(FFT[d(LE)/dx])$ and keep only the positive half. Make sure the scale of the Fourier Transform plot is properly calibrated using the scale bar from your image. The spatial frequency units should be in cycles / mm or line pair (lp)/mm.
6. Repeat Steps 3 to 5 for several lines across the edge and get their average.
7. Normalize the average of the MTF to 1.0. Where the MTF is at 0.5 is the resolution of your camera in lp/mm. The higher the lp/mm the more your camera can resolve fine detail.