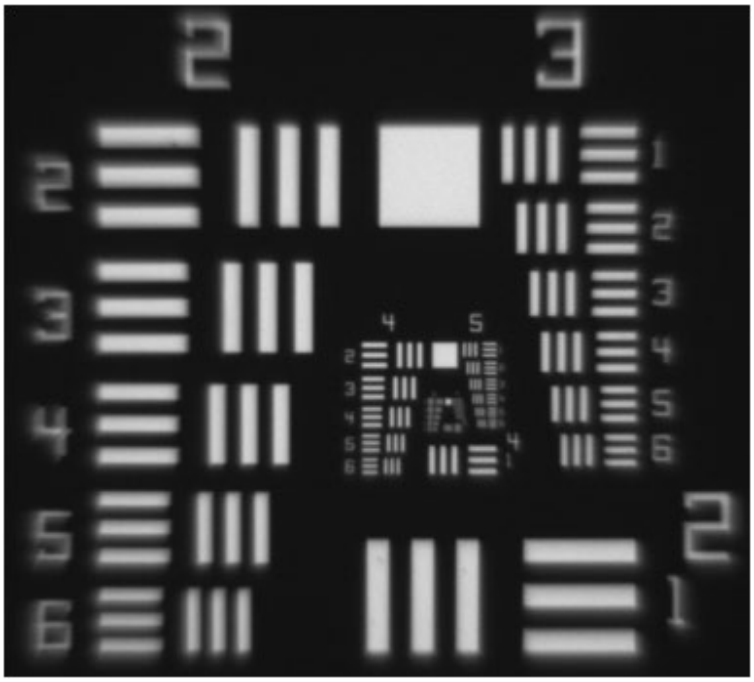
OPTI 415 Homework 4 Due: March 24, 2022

1. Suppose we have a wavefront error $W(\rho,\theta) = 0.001Z_2^0(\rho,\theta) - 0.001Z_4^0(\rho,\theta)$, where $\rho = r/r_{max}$ and $r_{max} = 3\ mm$. If the pupil shrinks to $r_{max} = 2\ mm$, what is the new wavefront error in terms of Zernike polynomials? Plot the old and new wavefronts. They should look identical to the old wavefront over the central 2.0 mm. HINT: After applying the definitions of the polynomials, convert to real coordinates and then normalize to the new pupil size.

2. Fit the points below to a 2nd order Zernike expansion (i.e. n ≤ 2) for a normalization radius of 3 mm. The raw data is available on the website for download.

r (mm)	theta(rad)	z(mm)
2.887169	0.28757508	0.135033
2.052795	6.17748179	0.078498
2.977826	5.59022254	0.164683
1.394372	0.75569144	0.024966
1.810666	5.53982243	0.060117
1.594199	1.34268698	0.029872
2.530637	1.49825415	0.078831
1.232245	0.59494106	0.021078
2.07852	0.22897919	0.071863
0.449652	5.43260759	0.003587
2.863492	4.72980717	0.104715
2.258365	0.77949345	0.064807
2.752189	5.09368332	0.115953
2.698072	5.25818296	0.120522
2.671377	5.6324715	0.133761
1.278568	1.16635971	0.018878
0.627787	5.67791786	0.00745
2.450552	0.08282896	0.105881
0.815722	1.37565042	0.007881
1.729898	0.17143128	0.051006



3. Assume that an imaging system with a magnification $m = -0.5$ is used to capture an image of a 1951 USAF target above (original on-line). What is the resolution limit of the system in cyc/mm?

4. You are testing an optical system and measure a wavefront given by the following Zernike expansion

$$W(\rho,\theta) = 1.5Z_1^{-1}(\rho,\theta) + 2.0Z_2^0(\rho,\theta) + 0.23Z_3^1(\rho,\theta) + 0.5Z_4^0(\rho,\theta)$$

where the expansion coefficients are in units of μm.

a) What are the peak-to-valley errors for the wavefront spherical approximation, the wavefront irregularity and the rotationally invariant wavefront?

b) Calculate the values for RMSt, RMSi and RMSa.

c) The ISO 10110 specification for the wavefront deformation of the system is

13/ 2(0.5) RMSa < 0.05; λ = 632.8 nm. Does the system meet the specification?