EE/Ae 157a
MIDTERM/FINAL

Due Date: EOD November 22, 2019

Open book, but no collaboration
No explicit time limit. It should not take more than ~ 3-4 hours to finish this assignment.

Problem 1 (20 points)

A telescope is orbiting Mars at 300 km altitude. The telescope lens diameter is 40 cm, the focal length is 120 cm, and the focal plane is 4 cm wide. The pixels in the detector are 10 microns on a side. Calculate the swath width, size of the pixels on the ground, and the number of pixels across the swath assuming a pushbroom design. Also, calculate the maximum integration time per pixel, and the resulting data volume per day if we acquire 20 images that are 50 km long in the along-track direction.

The instrument is now changed into a spectrometer. The incoming light is dispersed using a grating such that the different colors are separated spatially in a direction orthogonal to the pushbroom line array. Assume that the wavelength region 0.4 microns to 2.4 microns is dispersed over 640 microns in the focal plane. Now assume that we stack 64 line arrays next to each other to cover the dispersed spectrum. Calculate the bandpass of each channel, the dwell time per spectral channel and the resulting data volume if we acquire the same number of images as before.

Problem 2 (20 points)

Consider a planet with radius 1900 km, located at a distance of 1.4×10^9 km from the Sun and 1.25×10^9 km from the Earth. The average surface temperature of the planet is 70 K. The surface reflectivity is 0.3 across the visible and infrared spectrum. Plot the received energy by a 1 m^2 aperture telescope in Earth orbit as a function of wavelength between 0.1 and 100 microns. Assume that the Sun is a blackbody with a temperature of 6000 K and a radius of 7×10^5 km. Now let us assume an area of size 100 km x 100 km at the equator consists of an active volcanic caldera with a temperature of 700 K. Can the earth orbiting telescope uniquely detect the presence of the caldera? Can it measure its size and temperature? Explain. (Hint: The planet is rotating while the telescope observes it.)

Problem 3. (10 points)

A five band camera is used to image a scene with a heterogeneous distribution of minerals. From our knowledge of the area being imaged, we expect three minerals with the following spectra to be present in the image:

S1 = [.9 .1 .9 .9 .9]
S2 = [.9 .9 .1 .9 .9]
S3 = [.9 .9 .9 .1 .9]

The following four spectra are extracted from our image:

SM1 = [0.95 0.58 0.60 0.99 0.98]
SM2 = [1.23 0.77 0.94 0.85 1.26]
SM3 = [1.25 1.02 0.45 0.98 1.11]
SM4 = [1.15 1.09 0.45 0.96 1.17]

Calculate the relative abundance of each of the three minerals in these spectra.