Smartphone Image Analysis

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1 MEASURING THE FIELD OF VIEW

One of the most obvious differences between the camera in your smartphone and a CCD on a telescope is the field of view (FOV). Hold a penny at arm's length; this is approximately the FOV of a typical astronomical mosaic CCD (like the Large Format Camera on the Palomar 200-inch telescope). This makes it hard to take selfies! Let's measure the FOV that your camera can see.

- Snap a picture of the graph paper, making sure that the grid completely fills the image. Measure the distance (d) between your camera and the paper.
- Measure the size of the image captured. The grid line spacing is 1 mm, with bold lines every 1 cm.
- Use these two measurements to compute the angular size of the image captured. This is your field of view. As most sensors are rectangular, be sure to note whether you measured height or width. How does the FOV compare to the size of the full moon (1/2 degree)? How about the Hubble Space Telescope (3 arcmin)? The Large Synoptic Sky Survey (3.5 degrees)?

2 MEASURING THE PIXEL SCALE

The pixel scale of a detector is the angle captured by a single pixel. The pixel scale can be found directly from the FOV and the size of the detector in pixels. To find the number of pixels on your detector, you can either look up the total size in MP, or examine the EXIF information (easily done at http://regex.info/exif.cgi).
• Compute the pixel scale in arcsec/pixel.

• Compare the pixel scale to the theoretical angular resolution of the lens with optical light, using the Rayleigh criterion defined below. Given this, does the pixel scale make sense?

\[
\theta = 1.22 \frac{\lambda}{D}
\]

(2.1)

\(\theta\) is the angular resolution of a circular aperture in radians, \(\lambda\) is the wavelength of light, and \(D\) is the aperture of the lens (you can estimate this or find it in the EXIF information).

3 MEASURING THE DETECTOR SIZE

The detector size is one of the most important factors in comparing cameras. Your phone probably has a similar number of pixels as single astronomical CCDs, but the pixels are likely much smaller, resulting in a noisier image. To measure the size of your detector (\(d\)), use the field of view (\(\alpha\)) and focal length (\(F\)), following the below figure. In the case of your camera, the focus is likely set to infinity (smartphone cameras generally do not change focal length) so \(F = S_2\).

Figure 3.1: Measuring detector size from FOV and focal length.

• Compute the physical size of your detector in mm.

• Find the size of each pixel. Most astronomical CCDs have pixels 15-25 \(\mu m\) on a side. How does your detector compare? If we can make pixels this size, why do you think all astronomical CCDs use larger pixels?

4 EXTRA: DISTORTIONS AND ABBERRATION

The cheap plastic lenses in the camera of your smartphone produce a good deal of distortion and chromatic aberration, so much that image processing is baked into the camera module.
itself to correct much of this before it ever gets to you. Try to find some of these distortions. Using the grid imaged under bright light, you should be able to spot distortion towards the edges of the image. You may want to plot the image in python for closer inspection. CMOS detectors such as those in your smartphone are known to suffer less from bleeding of saturated sources. Try to make your camera bleed! You might use the Sun or a laser pointer to achieve this. While photographing these bright sources, note other features like chromatic aberration or internal reflections.