Basic Image Processing Steps

Getting a Useful Image off a Commercial DSLR Camera

In contrast to the images produced by commercial cameras, images intended for scientific analysis are created in a format that is designed to preserve the data faithfully as it was recorded, with no compression de-noising, or smoothing. All of those processes, while they contribute to aesthetically pleasing images, cause loss of information from the recorded image, which can lead to biased or erroneous conclusions. However, commercial cameras are very easy to use!

The cost of this fidelity is that scientifically useful images take up a lot of disk space and may look ugly. Typically they are also monochrome (grayscale/black & white) in many applications where it is desired to record pixel intensities and convert them to photon arrival rate per unit area. The specialised high-sensitivity cameras used to create such data may be custom built with their own control software that has a very steep learning curve.

In practice, we can get the best of both worlds if we are prepared to take a few steps with some freely-downloadable software. This guide explains how to take image data from a commercial DSLR camera in a scientifically useful form, without any programming experience. If you are comfortable using a programming language such as *python*, you will probably find these steps to be unnecessary, as you have many more tools at your disposal. The following is aimed at science students who are just starting out and who want the tools to go from point A to point B to analyse data for a specific experiment, without building software tools on their own.

The most important underlying facts can be stated at the outset:

0. Image data is a raster (or array) of pixel values. Every pixel is defined by its position and the pixel value at that position. For example, a 2-dimensional image that is 256 pixels wide and 256 pixels high contains pixels that have indexes running from (1, 1) → (256, 256)[1].

Each pixel will have a value. The range of values depends on the software that produced the image. Usually the maximum value is some power of 2. (some common choices include positive integers from 0 to $2^8 - 1$ (255), real numbers from $-(2^{16} - 1)$ to $+(2^{16} - 1)$, etc).

The raster is just a list of pixels and their values. The values can represent any physical quantity and can be operated on mathematically just like any other matrix or vector. Image data is usually saved in a binary format to be efficient with computer memory. Image processing software, given correct information about the way the pixels are encoded, is capable of performing sophisticated operations on the image data. The assumption here is that you will want to dump the raster into a list of text pixels so you can put them in a format to be plotted using a simple tool like a spreadsheet.

1. **Ensure the camera is saving images in RAW format.** The default for most cameras is to use ".jpg" or ".jpeg" compression, which throws away some information in the interests of manageable file sizes. Saving in RAW format preserves all of the information, but camera manufacturers typically don't give away their "secret recipe" for how the raster is encoded in RAW format.
2. **Get the RAW format data into an open-source, easily manipulated format.** There are many ways to do this. If you are a keen photographer, you may be familiar with the ($paid) software *Adobe Lightroom*. There is a freely available, open source equivalent called **darktable** that does nearly all of the same things, and for our purposes, it is more than enough to do the job:

   I. **darktable**. Because the RAW formats are proprietary, your computer probably can't manipulate them on its own, out of the box. If you don't want to buy a subscription to Adobe Lightroom, the free equivalent is downloadable from **https://www.darktable.org**.

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[1] or from (0,0) → (255, 255)

Darktable is non-destructive, that is, it won't destroy your original image unless you deliberately overwrite the file. Darktable is available for Mac, Linux, and Windows systems. **If you can't download this or are having trouble with the install, see a staff member for assistance. In the worst case, we can convert your images for you for further analysis** (but recognise that you may be required to analyse image data again in the future).

Once you've got darktable installed, open the image and export it into a different format using the export menu option. For "file format", choose "PPM" (unless you are confident you can work with other formats). "ppm" stands for portable pixel map; see **http://www.physics.emory.edu/faculty/weeks/graphics/mkppm.html** for a quickstart guide.

II. GIMP. Sometimes, darktable doesn't seem to work on some computers. In this case you might be able to get it as an extension to a program called GIMP. GIMP is to *Adobe Photoshop* what darktable is to *Adobe Lightroom*. GIMP can be super useful in a number of contexts, but it can sometimes be used to convert file formats if you can't get darktable working as a standalone program. If this is the case, open your .PEF image in GIMP then go to File > Export or press ctrl+shift+E. This will allow you to save the image in a different format. Do so by typing "FileName.ppm". Then, a new window will pop up where you can select to save the image in this format.

3. **Dump the pixel raster into a text file**. GIMP can do many things, but it can't do this. A piece of software that can is called Fiji. Fiji is an image processing package that facilitates scientific image analysis, built on top of a display package called ImageJ. The packages are well-documented and easy to use, and there are many tutorials online. Fiji can be downloaded from **https://imagej.net/software/fiji**

Opening the newly formatted image in fiji will allow you to make a selection of the spectra. Making a plot of the selected image will allow you to get the data for pixel intensity. To do this open the image and use the selection tool on the data then go Analyze > Plot Profile. In the plot window you are able to click the data button and save the necessary data as a .csv file.

Note: When selecting the strip of the picture make sure that the selection covers all the pixels in the horizontal range. At the top of the open picture you can see the dimensions of the selection. Make sure that the width is the same as that of the original picture. The original dimensions are displayed in the main fiji window.

IMPORTANT: The DSLR camera contains sensors with three different colour sensitivity ranges (red, green, and blue), which the camera software mixes to produce the colour photos. For science data we want only raw numbers. When the image is displayed in Fiji, it will have a legend at the top that looks like: "3/3 (blue); 3894x2614 pixels; 16-bit; 58 MB". The very first bit of information is the channel you are looking at. You may need to play around with the image to get all of the relevant data out for analysis. *In particular, trying to analyse things in the blue/violet part of the spectrum using the red channel will give notably poor results.*

4. Scientific image data is often created in a format called FITS (Flexible Image Transport System). If you're interested in FITS image analysis tools, GIMP can export images to FITS format. See a staff member (particularly one with astronomy experience) for more information.

Document created by Andrew Cole

GIMP and Fiji Instructions by Averil Dare, 2019.