Reducing Images in IRAF

Brian Keeney

September 5, 2006

This document is a primer for reducing images using IRAF. It is meant as a reference guide and not an instruction manual. For more details on command usage and syntax, I recommend Josh Walawender's IRAF tutorial:

`http://solo.colorado.edu/~walawend/IRAFtutorial/`

This document and the IRAF tutorial are also linked from my ASTR 3520 webpage:

`http://casa.colorado.edu/~keeney/classes/astr3520/`

You might find the electronic version of this document useful because anytime that I mention an IRAF command below, I provide a hyperlink to the relevant information from the IRAF online help pages, which display the same information as the IRAF `help` task. If your PDF viewer does not open a browser to follow the hyperlinks, I can help you set the appropriate preferences.

Getting Started

If you have never used IRAF before, there are some setup steps that you will have to go through. These steps are described in the "Configuring and Starting IRAF" section of the IRAF tutorial, as well as in the "How to Setup IRAF" document posted under the Lab Handouts section of my class webpage.

The Lab Handouts section also contains some other useful documents. Data reduction with IRAF requires at least a passing familiarity with the UNIX operating system. If the first time that you have ever seen UNIX is when you logged into your cosmos account a couple of minutes ago (or you would like a refresher on command syntax), the document called "An Introduction to UNIX" should be helpful. "An Introduction to IRAF" discusses some IRAF basics that are covered more thoroughly in the "Interacting with the CL", "Ximtool and Displaying Images", and "Miscellaneous Tips for Working with the CL" sections of the IRAF tutorial. I have also posted the electronic version of this document in the Lab Handouts section.

Image Reduction

In this discussion I will assume that you have acquired a full set of science and calibration (bias, dark, flat) images in one or more filters. These reduction steps are also described in the "Basic Reductions for Imaging Data" section of the IRAF tutorial.

1. Make a copy of your data!
    - This is not strictly necessary, but is an excellent idea. I would recommend saving the copied data in a separate directory from the originals. This ensures that you have a pristine copy of your original data incase something disastrous happens with the reductions.
2. Combine the individual bias and/or dark exposures into an average image.
    - You can do this by brute force using `imarith` or all at once using `imcombine`.
    - Make sure you only combine dark frames of the same exposure time!
3. Subtract the average bias or dark frame from your science images and flat fields.
    - This is easy to do with `imarith`, especially if you use list files.
    - Make sure that the exposure time of the dark you are subtracting matches that of the science image or flat field!
4. Combine the individual flat fields into an average image.
    - This can again be done using either `imarith` or `imcombine`.
    - Make sure you only combine flats taken in the same filter!
5. Normalize the average flat field.
    - Find the most common value in the average flat field using `imstat`.
    - Divide the average flat field by this value using `imarith`.
6. Divide the science images by the normalized flat field.
    - This is also most easily done with `imarith` using list files.
    - Make sure that the science images and normalized flat field were taken in the same filter!

Congratulations! You now have a set of calibrated science images that have been corrected for the systematic effects of CCD read-noise, dark current, and pixel-to-pixel variations in sensitivity. However, if you have taken several images of the same object in a given filter, you still have to align and combine them to remove cosmic rays.

7. Align multiple exposures so they can be combined.
    - Measure star positions in each image using `imexam`.
    - Calculate a guess for the shifts and then use `imalign` to align the images.
    - You will probably want to align all images of a given object to the same reference frame, regardless of filter.
8. Combine the aligned exposures.
    - Use either `imarith` or `imcombine`.
    - Using `imcombine` with `combine=median` is best for cosmic ray rejection.
    - Only combine images taken in the same filter!

Image Analysis

Hopefully you will recognize the object in your science images (if not, let me know and I will help you). Once you have identified your object, you can find its celestial coordinates using Simbad:

`http://simbad.u-strasbg.fr/Simbad`

Then use those coordinates to retrieve a USNO finding chart for that region of the sky:

`http://www.nofs.navy.mil/data/FchPix/cfra.html`

The finding chart should allow you to identify several stars in your final image. Since you know the position and brightness of each USNO star, you should then be able to calculate the orientation, pixel scale, and approximate limiting magnitude of your image.