An Image Processor for Students and Other Novices

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Each fall here at the Southwest Campus of Jefferson Community College (JCC-SW) I teach an Introductory Astronomy Laboratory (ASY 195) course. ASY 195 is highly observational in nature, and, like many 100-level college astronomy classes, is purely a "general education" course. The only prerequisite for the course is a grasp of basic algebra. Few students entering the course even know any "constellations" beyond the Big Dipper and Orion. Nonetheless, in the last month of the semester we study astrophotography basics, and the use of a CCD. The "gen-ed" nature of ASY 195 makes the CCD work the most challenging aspect of ASY 195.

Obtaining CCD images is not a problem in this class. JCC-SW has a dedicated CCD instrument, consisting of a Meade 10" LX-200 SCT mounted on a sturdy, mobile pier; an ST-6 CCD camera; and a support computer. With a little guidance most students can use this equipment to obtain CCD images, especially since work in astrophotography immediately precedes the CCD activities and introduces the students to concepts such as exposure times and the effects of bumping the telescope when the shutter is open.

The problem lies in helping the students to understand what CCD images are and how they are used by astronomers. In other words, the challenge in the CCD activities lies not in obtaining CCD images but in processing and analyzing those images. In the astrophotography activities processing is done by commercial labs, but students do learn that how astrophotos are processed has an impact on what they see -- usually when one group of students goes to the local drug store to get their photos processed and another goes to a good photography service store. So astrophotography builds a groundwork for students to understand what the processing of CCD images is all about.

That groundwork is very meager, however. Students have a lot of misconceptions about the astronomical images they see in the media. Some examples:

- Students tend to feel that false-color in some way represents the true appearance of the object that was imaged. Many do not fully grasp what "false-color" images represent.

- Students do not understand that images can be enhanced to bring out or suppress certain details in the image. They feel that the colorful, detailed images they see in the media represent “what’d you’d see if you were there”.

The challenge of the ASY 195 CCD activities is to get students to recognize that the images they obtain with the CCD camera are simply an array of numbers--data--that can be manipulated and represented in many different ways. Many representations have little to do with what the object that is being imaged actually "looks" like but nonetheless are useful.

To do this, I need image-processing software that meets a number of key criteria:

1. It must be simple and student-proof. This is the most important criterion. Time spent teaching students how to run software is time not spent learning about CCD imaging. ASY 195 needs software that students can simply “play with” and learn. It should not be possible for the students to “mess anything up” -- even random points and clicks should cause no ill effects. If introductory-level students feel they can mess something up they are far less likely to experiment and learn.

2. It must be able to display image data using a variety of representations (black-on-white, white-on-black, false-color, contour, etc.) and it must be able to switch between these representations easily. Being able to produce these representations, and being able to easily make comparisons between them, helps students to understand what this kind of information means and to realize that the astronomical images they see in the media are often not true-color representations. This is a useful understanding to have since students are exposed to false-color and contour representations of data in things such as maps and TV weather forecasts.

3. It needs to be able to do basic image-processing -- enough to help students understand that the astronomical images they see in the media are often enhanced to bring out or suppress certain details.

4. It must make it clear that a CCD image is numerical data, and that manipulation of a CCD image is manipulating those numbers.

These are all that is required. At the ASY 195 level there is no need to deal with flat fields and dark fields, nor do any quantitative analysis of the image. The work in ASY 195 centers on getting a CCD image and seeing what can be done with it. Results are strictly visual; targets are always bright. The two weeks we have to spend on CCD imaging need to be spent on image analysis that students can directly see and that will have an impact on them.

So far I have not found commercially available software that meets these criteria. Software developed specifically for CCD image processing is designed for people who are experienced, or plan to become experienced, with CCD imaging. This software is great for serious observers -- or even casual observers! But for ASY 195 purposes, such software takes too much time to learn and has too many capabilities. It fails #1 in a big way.

Image processing software developed for the public at large, such as LVIEW and Microsoft Imager have to be user-friendly to a broader, less dedicated audience. For that reason I tried them in hopes they'd better meet #1. However such software typically gives no insight into the numerical nature of an image. These programs can do some filtering and make some adjustments to contrast, etc., but they cannot easily produce the false-color and contour representations of an image often seen in astronomical images. They fail #2 and #4 in a big way.

My solution was to write my own software to better meet the needs of my class. I think the program -- "JCC-CCD" -- works pretty well, so I want to tell others about it, especially others who are trying to bring CCD's into introductory-level astronomy classes, and amateurs trying to get other amateurs interested in CCD imaging.

JCC-CCD is simple -- it has one screen on which all controls and tools are always visible. There are no options, no menu bars. It is written in Visual Basic so it is a Windows application. Furthermore it is mouse controllable. The user does not need the keyboard. There are no error messages. I made the program difficult to crash, but even if it does crash I prefer a crash to error messages. Crashes are easy to blame on the program -- students view error messages as assaults on their competence.

Keeping JCC-CCD to one screen, and keeping it simple and robust, meant making some choices (fig. 1). It saves nothing to disk -- if it cannot write to disk it cannot erase raw image files on the disk! It has only the most basic image-processing features -- a few simple filters, some brightness controls, a one-step zoom. It provides a read-out of the numerical data that comprises the CCD image. These limited capabilities are enough for a week or two of use (figures 2-4) in which students can gain understanding of what image processing is.

I tried JCC-CCD out on the ASY 195 class for the first time this past fall. I was delighted with the results! In the past, I would try to instruct students as to what they should be doing, what they should expect to see, and what it all meant. The students would nod, not really understand, and be intimidated by the software. This semester I just said ”do this to load the image; play with it; ask me if you have questions. You can’t hurt anything or lose anything.” The students quickly began playing with the images, asking questions, arguing with each other over what enhancements worked best, and producing better results in less time and with less stress than in previous years.

I hope that others who are trying to introduce people to CCD imaging--whether they are teaching a class or teaching less experienced members of their local astronomy club--will find this program useful. The program file and source code (Visual Basic 3.0) can be found on my web page at www.jcc.uky.edu/faculty/graney/jcc-ccd. My programming knowledge is limited, so I also hope others will play with the source code--and send me a copy of any improvements they make!

Figure 1
Caption: The main screen for JCC-CCD is divided into the following areas (counter-clockwise from top left): image file selection, image display and printing (to default printer) controls, basic filtering options, color scheme options, image brightness and contrast, numerical data display, and image display. The only other screen that appears is a zoom control, which pops up when the image itself is "right-clicked".

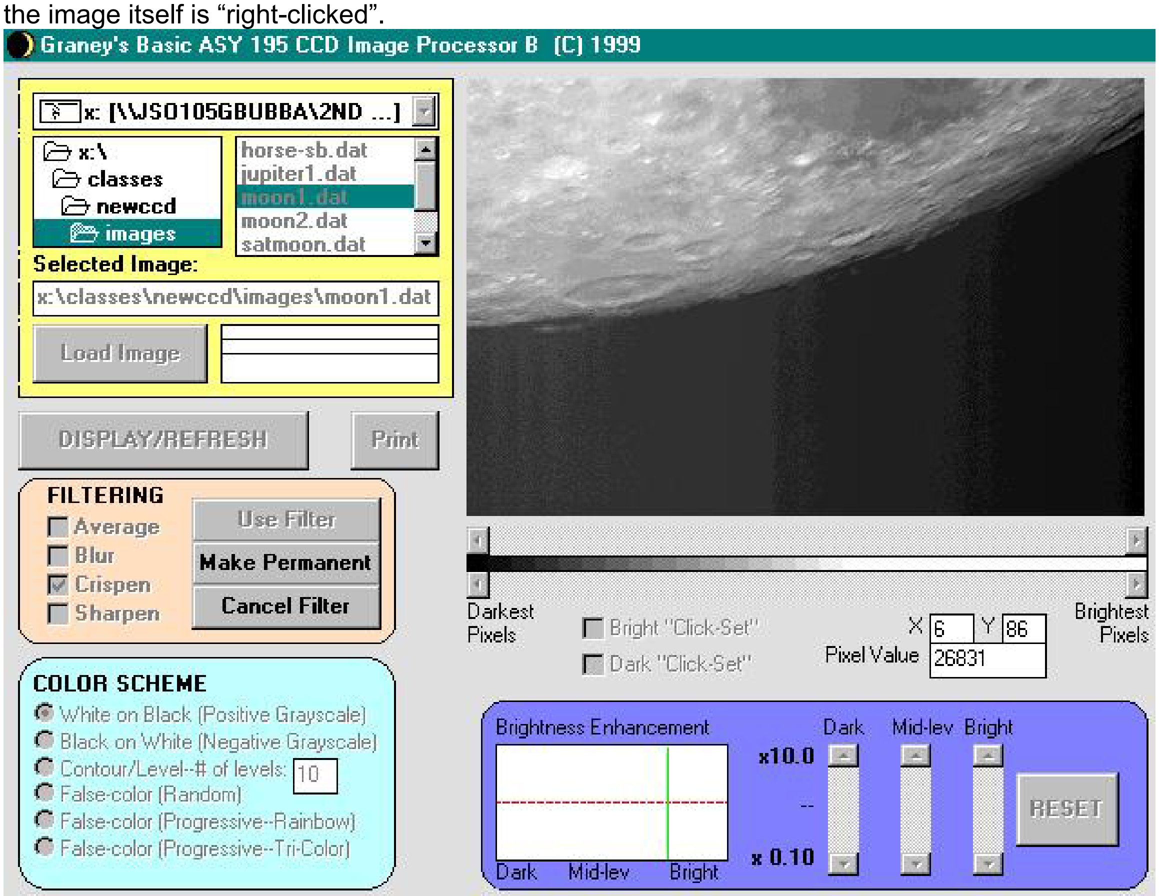
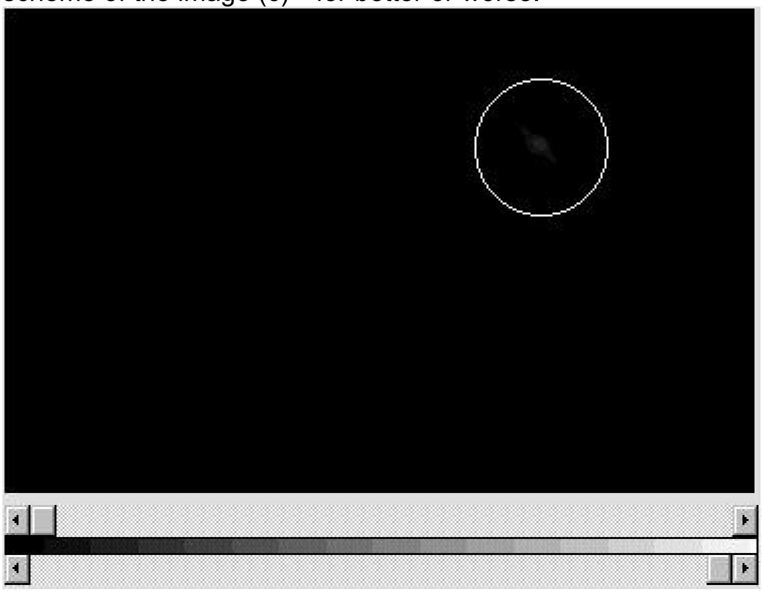
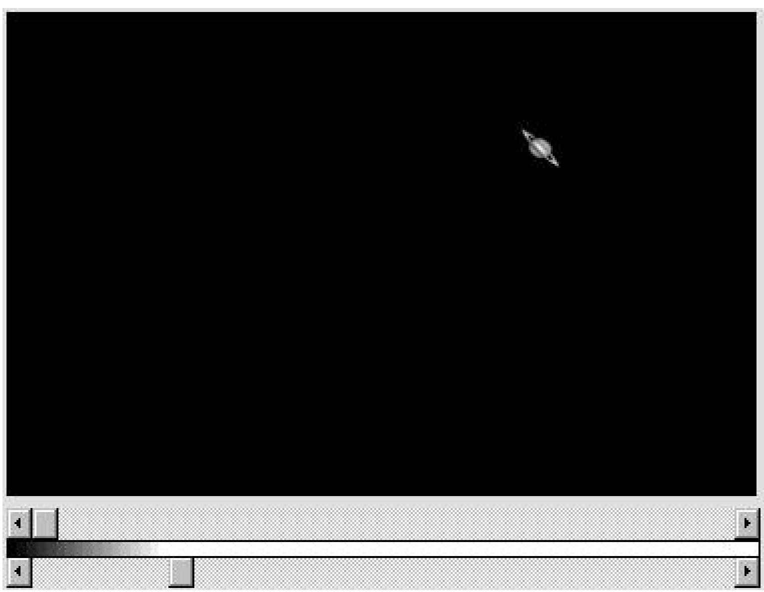


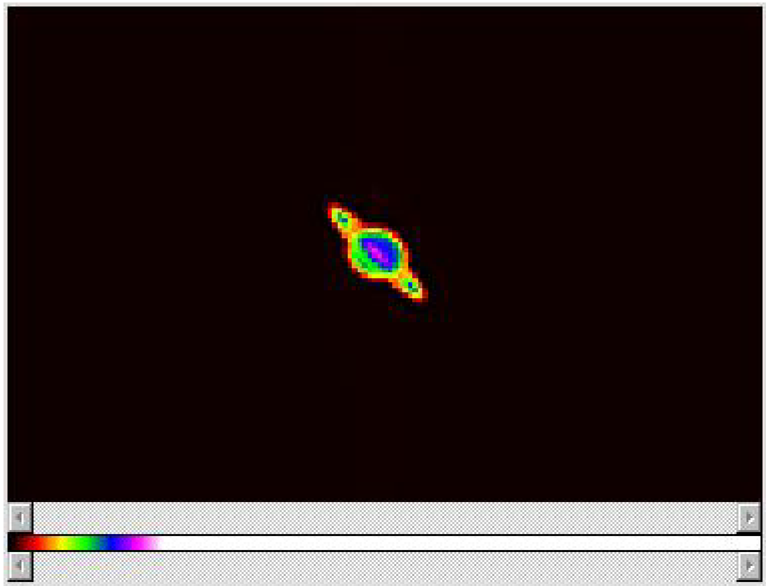
Figure 2
JCC-CCD allows students to take a raw image (a), and make changes to bring out detail that they can see was not obvious in the original image (b), and even zoom and vary the color display scheme of the image (c)—for better or worse.



(a)



(b)



(c)