

IMAGE PROCESSING EXPERIMENTS FOR THE CLASSROOM

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Exploring the Solar System is a science enrichment program taught at LPI for gifted fifth-grade students [1]. As part of this semester-long course, we teach a series of three computer labs on digital image processing. Images of the planets obtained by various NASA spacecraft have had a key role in the overall exploration of the Solar System. The purpose of these labs is to teach the students the basic nature of digital images and how computer processing of images can aid in the interpretation of images. The labs described here represent our experience developed from teaching this course on 16 occasions since 1992.

These labs are appropriate for upper elementary and middle school students. With suitable choices of imagery, the labs could focus on the Solar System, geography, earth science, environmental science, or astronomy. The activities described here can be performed on personal computers. We use Paint Shop Pro for these labs, but the instructions given here can be modified for use with other image processing software.

Each of the computer labs is about 45 minutes in length and begins with a formal instruction segment and ends with a less structured exploration segment. For simplicity, we focus on black and white images during the first lab and for part of the second lab. The remainder of the second lab and part of the third lab is devoted to studying color images. We also devote a portion of the third lab session to 3-D stereo imagery.

Black and White Images

We begin with an image of a familiar object, usually an image of one of the instructors. Using the Magnifying Tool, have the students blow the image up to high magnification. They will see that images are

composed of individual rectangular blocks, known as picture elements, or pixels for short.

Return the image to its normal size. Activate the Color Palette Tool and the Eyedropper Tool. Have the students place the mouse on a dark region of the image and note the intensity level (for black and white images, the R, G, and B values shown in the Color Palette window are identical and indicate the brightness level). This should be a low number. Now move the mouse to a bright region of the image. What happens to the intensity value? What do the students think will happen in an intermediate gray region? This relationship between brightness and numerical values is known as the gray scale. In the common GIF image format, brightness levels range from 0 (black) to 255 (white).

Because computer images are essentially arrays of numbers, they can be modified using mathematical operations. We introduce the students to two basic types of image modifications. The first and easiest type is brightness and contrast enhancement. Activate the Histogram window. Upper elementary students are familiar with histograms in the form of bar charts. The histogram is a very useful tool for understanding the brightness and contrast of an image. In the Colors pull-down menu, there is an entry for Adjust Brightness and Contrast (there are also a lot of other Adjust options, which can be ignored for the purpose of an introductory lab). Have the students explore the effects of changing Brightness and Contrast separately. How does each affect the image? Do the changes in the image's intensity histogram reflect the changes in the image? As a challenge, provide the students with an image that has been deliberately darkened and see if they can recover an improved version of the image.

Digital filters are a second type of useful image processing tool. These filters can

systematically alter an image. In the Effects pull-down menu, explore how the various types of edge enhancement and sharpening filters modify an image. In this context, “edge” means any boundary between distinct brightness structures in an image. Can the students think of any reason why such filters might be useful to geologists (e.g., enhancing the visibility of faults or channel systems in an image)? Allow the students some time to experiment on their own with the effects of these filters.

Color Images

For labs using color images, you will want to use 24 bit color images (JPG or TIF formats). Such images build color from three color channels: red, green, and blue (RGB). Place the program in Eyedropper mode. Scroll the mouse across the image and notice how the R, G, and B intensity values change in regions of different colors. In the Colors pull-down menu there are entries for Split Channels and Combine Channels. Splitting separates the color image into its three component channels. For an introductory lab, stick with the RGB option. If you are careful about adjusting the sizes of the images, you can display all four images (color plus the 3 RGB channels) on the monitor at once. Does the appearance of the image in the various channels make sense? For example, why does the polar cap of Mars appear bright in all color bands? In images of the surface of Mars, why do red dust and gray basalt have different appearances in the various color bands? What does Jupiter’s Great Red Spot look like in the various color channels?

You can use the Combine Channel function to reassemble the various color bands. End the lab in a memorable way by combining the images in an unusual color sequence. For example, can your students make Jupiter have a “Great Green Spot”? Can they turn Mars into the “Purple Planet”? In some versions of Paint Shop, you will have to turn off the “Sync Blue and Green to Red” option in the Combine Channel function’s dialog box.

Stereo Images

We devote a portion of the final lab session to “three dimensional” stereo images. Such images can be very useful in visualizing the nature of planetary surfaces. We often organize this in a compare and contrast format. For example, we contrast the appearances of the volcanos Mount Saint Helens on Earth and Olympus Mons on Mars. The different appearances of these volcanos reflects differences in the types of magma that formed each structure. Similarly, we compare the appearances of the surface of the Moon as seen on Apollo with the surface of Mars as imaged by Mars Pathfinder. We use the Neotek viewing system for viewing these images, although a similar activity could be performed using the common red-blue stereo glasses.

Image Sources

Images for these labs can be downloaded from a variety of sources, depending on the focus of your course. A basic selection of images for these labs is available from LPI [2]. Additional planetary images are available from the Planetary Photojournal [3]. Geography and environmental science courses could use images of the Earth from space [4]. Astronomy courses can use Hubble Space Telescope images [5]. Three-dimensional stereo images of the planets are available from LPI [6]. In all cases, set the copy protection on the images to Read Only prior to the start of the lab session.

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References: [1] Kiefer et al., this volume.
[2] <ftp://www.lpi.usra.edu/pub/outgoing/ImageLab/>
[3] <http://photojournal.jpl.nasa.gov/>
[4] <http://earth.jsc.nasa.gov/>
[5] <http://www.stsci.edu/pubinfo/Pictures.html>
[6] http://www.lpi.usra.edu/research/stereo_atlas/SS3D.HTM