

Making NDVI Images using the Sony F717 “Nightshot” Digital Camera and IR Filters and Software Created for Interpreting Digital Images

Draft 1

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Digital Cameras

Digital cameras that have a CCD sensor (Charge Coupled Device) are sensitive to a broad range of the electromagnetic spectrum – from the ultraviolet to the near infrared (for more information of how digital cameras work, see <http://www.howstuffworks.com/digital-camera2.htm>). Scientists and artists take advantage of this sensitivity to make images of nature that appear to be from other worlds. A valuable Internet site that describes how to make such pictures and has many fascinating examples is http://www.naturfotograf.com/UV_IR_rev00.html. To be more efficient, IR or infrared will refer to only near infrared light, not thermal infrared (also commonly referred to as heat). Wavelengths of visible light range from 400 to 700 nm, yet the infrared ranges from 700 to 300,000 nm – a much greater range than what we sense with our eyes! A good discussion of infrared light is at <http://imagers.gsfc.nasa.gov/ems/infrared.html>.

Most digital cameras with a CCD have an IR-blocking filter placed in front of the sensor so only visible light is used to make the picture. The ultraviolet light is almost completely filtered out by the camera’s glass lens. Some Sony cameras have a way to remove the IR-blocking filter with the flip of a switch, so the camera may take pictures of both visible and IR light. This option is called “nightshot”. Using filters that block visible light yet are transparent to the near infrared, you can make high quality digital images using only near infrared light. Although other digital cameras may still take IR pictures using a visible light blocking filter, exposure times are often quite long–on the order of several seconds, which then requires very still wind conditions to take pictures of plants and landscapes outdoors). Also, the glass lenses are designed to focus visible light onto the CCD, not infrared. The focus of the camera needs to be adjusted to a shorter distance to make a crisp image with the longer wavelengths. Most digital cameras are not designed to do these easily, which often results in poor image quality.

Light Reflected from Plants

Plants absorb red and blue light for photosynthesis, yet reflect large amounts of green and infrared. The following gray-scale images illustrate the amount of red, green, blue, and infrared light various land covers reflect. The lighter the

gray, the greater amount of light being reflected. The darker the object, the greater amount being absorbed.

Color Image



Red Light in Shades of Gray



Green Light in Shades of Gray



Blue Light in Shades of Gray



Notice that plants absorb more red and blue light, which are used in photosynthesis, and reflect larger amounts of green light. Hence, more plants are green!

Three of the “Interpreting Digital Images” software programs could be used to create these images: *ColorPicture*, *ImageAnalysis* (which is being currently enhanced in the *MVHimage* version), and *SurfaceTypeRGB*. The latter two programs are designed for this effort: open the software, select an image, and then change the display to the proper enhancements and save this new image (don’t forget to rename the image from its original name). *ColorPicture* requires that you understand how to make a grayscale image (black and white).

For the purpose of the NASA-funded “Measuring Vegetation Health” project, we have been experimenting on collecting pairs of visible and infrared images of plants and landscapes, and combining the information within both images to visualize and analyze vegetation stress. The camera was placed on a tripod during a relatively sunny and calm wind day, and images were made with the visible light-blocking filter and in NightShot mode and without the filter and in regular visible light mode (internal IR-blocking filter was in front of the CCD sensor). The pairs of images were taken within seconds of each other so the sun angle and lighting conditions did not change appreciably. The corresponding IR image of the scene above follows:

Near Infrared Light in Shades of Gray



Notice that the vegetation reflects most of the incoming infrared light, yet the pavement behind the fountain absorbs much more. Water absorbs most of the incoming IR, but in this example, the mirror surface of the water is reflecting infrared that is reflected from the plants.

Vegetation Index

An additional software program, *SatelliteImageMaker*, was created so that these sets of grayscale images could be brought together to create one of the

standard color composites used for Landsat images: infrared being displayed as red, red light being displayed as green, and green light measurements displayed as blue on the computer screen. This color composite, which is completely false in color with respect to what humans see, is often referred to as NRG (near IR – Red – Green color scheme).



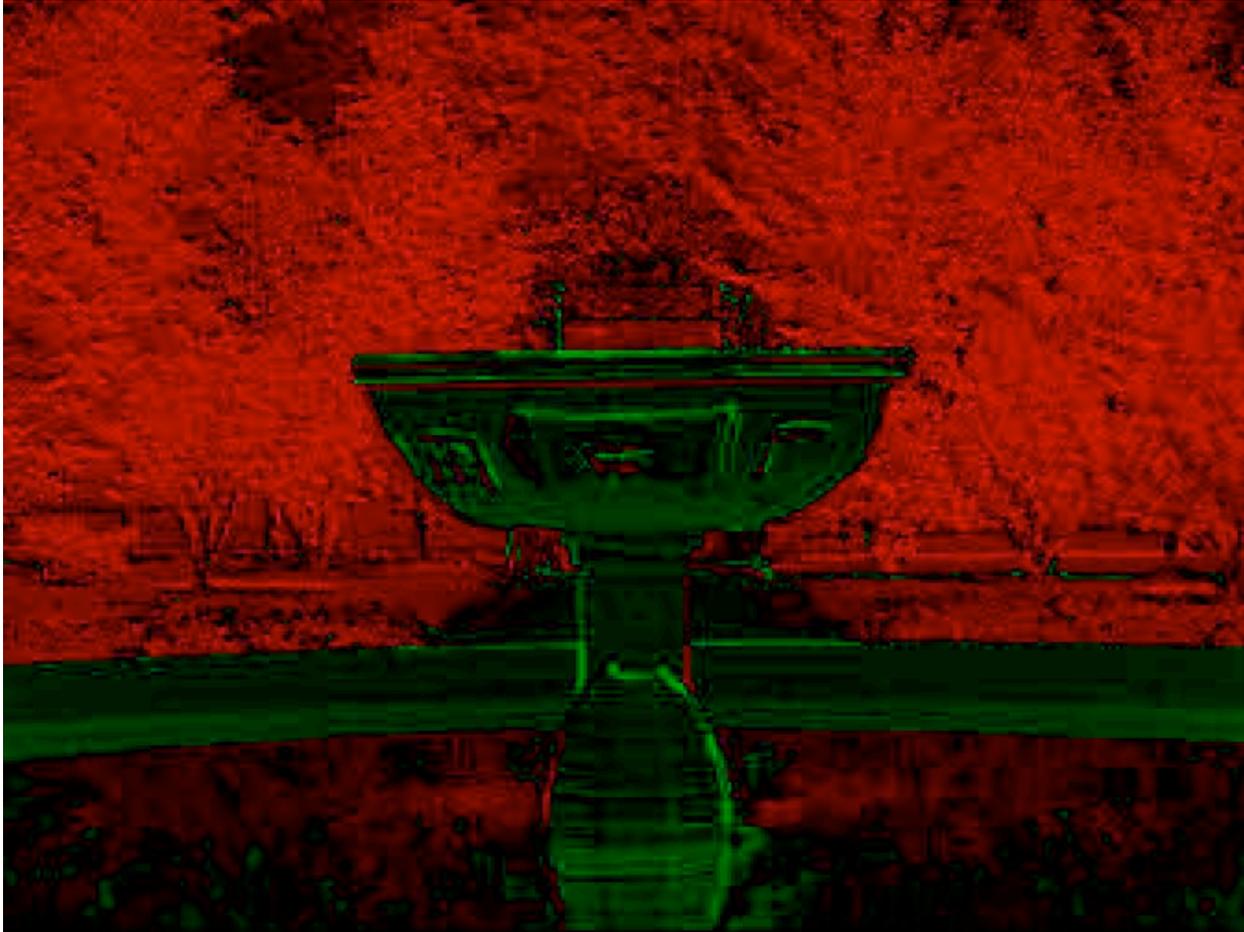
Healthy vegetation reflects more of the IR and absorbs large amounts of the red for photosynthesis, so in this color composite, plants appear bright red to pink. Notice that the originally red flowers appear to yellow in this composite – infrared (now displayed as red) and red light (now displayed as green) are both reflected and green (displayed as blue) was absorbed. Red and green light make yellow.

To make these images, open *SatelliteImageMaker*, and sequentially select which gray scale image you want to view in the image to be displayed:

IR grayscale image	->	Red layer of Displayed Image
Red grayscale image	->	Green layer of Displayed Image
Green grayscale image	->	Blue layer of Displayed Image

Vegetation Index

One of the standard vegetation indices is based on a comparison of the amount of infrared to red light being reflected: IR - Red.

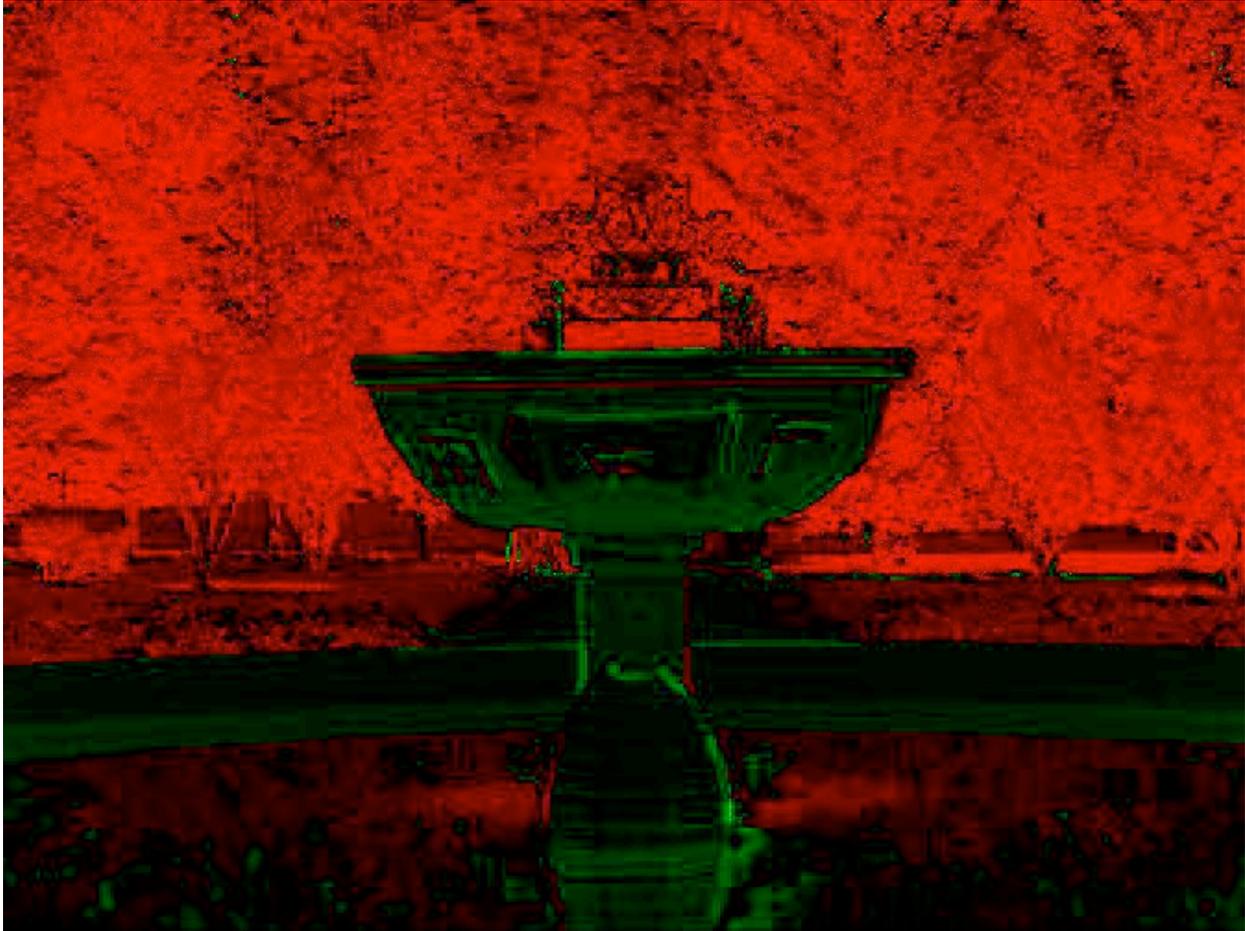


This image was created by comparing red (representing IR measurements) and green (representing red measurements) values at each pixel (a pixel is a picture element, or the smallest piece of the image with uniform color) in the NRG image. A pure red in the above image would be created if there were maximum intensity of IR light measured and no red light. If IR and red light were of equal intensities, regardless of their magnitudes, the color in the image would be displayed as black, and pure green would be created if all of the red light had been reflected and all of the infrared absorbed.

This image was created using the *SurfaceTypeRGB* software by selecting the NRG image created earlier with *SatelliteImageMaker* and displaying the Red versus Green of the image (remember, that the red of this image represents the IR and the green represents the red light measured in the original picture).

To compensate for shadowing and varying sun-surface-camera angles, the above vegetation index (IR-Red) is divided by (or normalized) by the sum of the

infrared and red light measurements. Therefore, a difference of 5 units will be much larger in a shaded area compared to the same 5-unit difference for a brightly lit object. This **Normalized Difference Vegetation Index (NDVI)** has been used to identify surface cover and indicate the health of plants from satellite data for decades.



Dense, healthy vegetation produces NDVI values near +1.0, which is shown as “pure” red. As NDVI values decrease from one, the intensity of red in the image also decreases proportionately. Bare soil and rock reflect similar levels of infrared and red light, so these surfaces produce NDVI values near 0, and are shown as black. Clouds, water, and snow reflect more visible light than infrared, which is the opposite of vegetation, and so produce NDVI values near -1.0, which are shown in increasing intensities of green. Comparing the two vegetation index images, notice that the effects of shadowing appears to be more limited in the NDVI image.

The NDVI image could be created using *ImageAnalysis*, *MVHimage*, and *SurfaceTypeRGB* programs by changing the display to the Red vs Green (normalized).