Digital Infrared Photography

By Vega Buchbinder

The advent of digital cameras has made infrared photography relatively easily accessible. No longer does one need to handle and process infrared film in the dark under stringent conditions. In the days of film photography Kodak's film HIE High Speed Infrared Film was the première infrared film, noted for its extensive range. Kodak has stopped making this film in 2007. Today, with a digital camera, an infrared filter, and a tripod, anyone can explore the near infrared spectrum photographically with ease and repeatable results.

Using digital infrared (IR) photography one can produce fascinating images that can look surreal, or of an alternate reality. In addition one can use many variations in image rendering, ranging from black and white, to false colors, in order to create artistic images.

What is infrared photography?

What makes digital infrared photography possible is that the silicon sensors used in digital cameras can "see" into the infrared range of the electromagnetic spectrum. From short wavelengths to longer wavelengths, the electromagnetic spectrum is made of gamma rays, X-rays, ultraviolet rays, visible light, infrared rays, radar, FM radio, TV, and AM radio.

The human eye is sensitive to wavelengths from approximately 400 to 700 nanometers (nm), which is the wavelength range for visible light. The CCD and CMOS sensors in digital cameras can easily "see" further into the infrared region to about 1050 nm, which makes IR photography with a digital camera possible today. Note that this part of the IR range is called the near infrared. Thermal infrared rays are much longer, and are not detectible by the CCD or CMOS sensors in our digital cameras.

What equipment do I need?

If you want to photograph infrared radiation, you will need to make the following equipment decisions:

- Type of camera:
  - DSLR or point & shoot
  - Convert or don't convert the camera
- An IR passing filter strength (either on the sensor for converted cameras, or in front of the lens for unconverted cameras)
- Lenses

The choice of camera type, and whether to have it converted, will reflect on the adjustments you need to make in order to take IR pictures. Below is a summary of the ramifications of your choice:

Digital Cameras for IR

Unconverted	**Converted**
• Need IR passing filter on lens • Image is red • Long exposures (in seconds or more) • Images may have more noise • Older cameras better	• IR cut off filter removed • IR passing filter placed on sensor • Image may have false colors • Can hand-hold camera
Non-DSLR	**DSLR**
• Uses the image sensor for AE, AF, and AWB • AE and AF should work fine • AWB ? • LCD viewfinder shows actual image	• Have a separate sensor for AE, AF, and AWB • Need to adjust AE and AF • Can create a custom white balance • LCD viewfinder shows a jpeg version of the actual image

In order take an IR picture, one has to 1) block the visible light that is reaching the camera sensor, and 2) allow IR light to reach the sensor.

There are two ways to do this: 1) remove the IR blocking filter from the sensor, and replace it with an IR passing, visible light blocking, filter or 2) put a IR passing, visible light blocking, filter on the front of the lens. This basically translates into whether or not you get the camera converted. The bottom line is that you need an IR passing, visible light blocking filter either on the lens or on the sensor. Where you put it makes a difference on how you take pictures.

Since the sensors in digital cameras are sensitive to the near infrared wavelengths, camera manufacturers have placed an infrared blocking filter on the sensor because with most lenses, infrared radiation will focus differently than visible light. Lens manufacturers design lenses to

focus visible light to one point (the film plane or sensor), but do not try to focus the invisible IR. An IR cut off filter is used to eliminate the IR wavelengths in order to create a sharp image.

You can have a camera converted for only IR use by having the IR blocking filter removed. The conversion process involves replacing the original filter glass with glass that blocks visible light, but passes infrared light. If the camera is a DSLR, the focus is also adjusted.

Any digital camera with a CCD or CMOS sensor can be used to take IR images, but some are better than others as unconverted cameras. If you are not going to have your camera converted, the older cameras are better because the IR blocking filter is not as effective in older cameras as it is in newer cameras. You can test your camera by shining a TV remote into your camera in a dark room and taking a picture. If you see a large spot, your camera can be used for IR photography.

IR passing filters are dark red to opaque. If you do not convert your camera, then you need to

- First make sure your camera can take filters (if non-DSLR)
- Then place the camera on a tripod
- With the filter off, compose and focus
- Place the filter on the lens
- Take many shots, bracketing widely until correct exposure attained.

Your exposures will be long because the filters are dark. As a result if you are into pictorial photography you will find that tree leaves may be blurred. Also, long exposures mean more noise.

If you convert your camera, you can use the camera as if it were a regular camera you walk around with. No need to have a tripod (unless you want it). Exposure times are fast enough that you can hand hold the camera. The image on the LCD shows a jpeg version of your picture. You can check exposure, focus, false colors, etc. and make appropriate corrections quickly.

If the camera you use is not a DLSR (i.e. compacts and EVFs), the focus, metering, and electronic viewfinder are all done using the main image sensor. AE is more accurate in non-DSLRs (because it's not contaminated with visible light when the IR filter is on the lens). If you cannot set a custom white balance, use tungsten as an approximation.

DSLRs have a separate sensor (instead of the main image sensor) for AE, AF, and AWB. For DSLRs, the AE and AF sensors receive *both* visible and infrared light, hence corrections must be made. These corrections are discussed in the next section.

After a decision has been made about the type of camera, and whether to convert it, the next choice is the filter. Whether you will put the filter on the sensor (converted camera) or on the lens (unconverted camera) the IR images you get will be affected by the wavelength passing characteristics of the filter.

The decision to be made is how much of the visible spectrum do you want. If you want a moderate amount of the false color, go with the Hoya R72 or its equivalent. If you want more color, go with a filter that has a 50% transmission closer to 665 nm. If you want purely IR, and hence only black and white images, then go with the B+W 093 or its equivalents.

Remember IR has no color. Your image may display false colors, but these colors are the product of the camera's hardware and firmware. To get the false colors, you need portion of the visible red spectrum (~ 720nm). If you use an opaque filter or have your camera modified to IR only wavelengths (beyond ~ 750 nm) you may not get the false colors.

Two commonly used IR passing filters:

- **The Hoya R72 (B+W 092; Wratten 89B)**
    - ❖ Is dark purple, almost black, in color
    - ❖ Passes some visible red light
    - ❖ 50% cut-off at 720 nm
- **The B+W 093 (Wratten 87C)**
    - ❖ Totally opaque
    - ❖ Cuts out all visible light
    - ❖ Get stronger IR effect
    - ❖ 50% cut-off at 850 nm

For non-converted cameras, use the Hoya R72 since a B+W 093 filter in the camera may cut off too much of IR radiation passing to the sensor.

Filter Type	**Range**	**Effect**
"Enhanced Color"	665 to 1300 nm	• Includes more visible light, which results in a greater range of color • Image has a lower contrast • Harder to get a crisp B&W image
Standard Infrared	720 to 1300 nm	• Includes some color information • Normal B&W image with good contrast
Deep Infrared	830 to 1300 nm	• Blocks all color information • Produces high contrast B&W images

The above are LifePixel's conversion choices. MaxMax has similar conversions. If you use an external filter on the lens, you can choose a filter from among many that will have the wavelength properties to meet your needs.

Another factor to consider is lens hot spots. Lenses are designed for visible light, not IR light. Some lenses have "hot spots" which are brighter areas in the center of the frame. Lens hot spots

are internal reflections within the optical pathway. The coatings on lenses create hot spots and flare more easily in IR and are more prominent on bright sunny days. Use the lens hood, and try opening up the aperture to minimize the hot spots.

How do I photograph?

When you are out and about trying to take IR pictures, these are some issues you should keep in mind until they become second nature to you:

- Custom white balance
- Focus (for DSLRs)
- Exposure (mainly for DSLRs)
- Expose to the right

Check your camera to see if you can create a custom white balance preset for IR. If you don't set the white balance you will get a red image. Since foliage reflects IR light, making it the brightest, whitest part of your photo, you'll need to "calibrate" your camera to let it know that visible light green is equal to infrared white. To create a preset custom white balance shoot grass full frame in full sunlight (around -1 EV to -2 EV) and use that image to set the white balance.

Even though the sensor has been converted to pass only IR, the autofocus system still uses visible light in DSLRs. IR does not focus on the same plane as visible light. Back focusing is an issue. Back focus is when the camera actually focuses on something behind the intended subject. Older lenses have a red dot to indicate where to focus IR. This location may be different for the wide angle and telephoto ends of a zoom lens.

Use a greater depth of field to counteract focus issues. Use f/8 or smaller aperture to minimize focus issues but don't stop down too far. Diffraction is twice as bad with IR waves as it is with visible light. Focus bracket, especially in diffuse light, and for close subjects.

The meter sees visible light, not IR. DSLRs do not use the image sensor for light metering, hence bracket, bracket, bracket. Anywhere from +1.0 EV to -1.0 EV from the camera's meter reading gives good results. After a while you can "feel" when to go over or under 0 ev.

Expose to the right is a technique to obtain as much information as possible from the raw data without clipping the highlights. The goal is to maximize the signal to noise ratio and minimize the posterization and noise that can occur in the darker regions of the image. Digital cameras record data in a linear fashion. Each f/ stop records half of the light of the previous one, and therefore half the remaining data space available. As a result, the shadows are more compressed. In light of this, the goal is to get the histogram as close as possible to the right hand side without causing the over exposure indicator to flash.

What do I photograph?

These are the traditional infrared subjects:

- Foliage in sunlight appears white
  - Willow trees give the best white tone
  - Deciduous trees are white also
  - Conifers give the darkest tone
- Clouds are clearly defined
- Blue sky appears black
- Water can appear black
- Buildings, roads, and other man-made structures often appear black unless they are in direct sunlight.

Don't limit yourself to these subjects. Many "ordinary" scenes are very surprising in infrared. Photograph cloudy days, rain, snow, reflections, man made places and things, people, etc. You may find an image you love.

Sunlight, tungsten lamps, and electronic flash are good sources of IR radiation, so try them out.

When can I photograph?

Most people take IR pictures in the middle of the day. Some say just after the morning golden hours for color to before noon, and again from 2:00pm to before the start of golden hours for color. I have photographed at all times of the day with good results.

IR is highest in summer, is approximately one stop less in winter, and is halfway between in spring and fall. Don't put the camera away because it is winter. You will be amazed at what you find in winter. Clouds that you can barely see are pronounced even in winter.

Moisture in the air affects clarity. Low relative humidity is best for a clearer image. Atmospheric water vapor absorbs, or "soaks-up" infrared radiation, so your image may be soft on very humid days.

Over 5000 feet altitude, you gain one stop of IR exposure due to the thinner atmosphere.

How do I process my image files?

How you process your raw images (you do shoot in raw, right?) depends upon your goals. If you want only black and white images, then opening your images in Adobe Camera Raw will work for you.

If you want to preserve the false colors, you must use a raw converter other than Adobe Camera Raw. ACR cannot handle the custom white balance of your raw images; it will give you red

images. No matter how you set the temperature/tint sliders, you will lose the brick and cyan look of your images and just have red.

If you are a Nikon person, use Capture NX2 or ViewNX to open your files and then save them as tifs to be sent to Photoshop. That will preserve the false colors. If you are a Canon person, use Digital Photo Professional (DPP). There are several other raw converters available, such as Bibble, Capture One DSLR, DCRaw, GIMP, etc. If you use one of these other converters, just be sure they don't convert your file to 8 bit.

If you like the false colors, but want the sky to be blue and the rest to be brick, then swap the red and blue channels in Photoshop to make the sky look like the more natural blue color. Go to Layer -> New Adjustment Layer -> Channel Mixer. Then in the red channel, set red to 0 and blue to 100. Go to the blue channel and set blue to 0 and red to 100. You will then have a blue sky.

Now, for black and white. There are many ways to convert your images to black and white. Some are destructive, others are not. Some are luminosity based, others are color altering. Grayscale and Desaturate are the most common methods used, but they are not the best. They do not offer you any control over how the conversion takes place. I think Gradient Map, Channel Mixer, B and W Adjustment Layer, and Lab Lightness work better. In addition, the nik software Silver Efex Pro is a superb black and white converter.

Where can I find additional information?

Infrared Camera Conversions

There are several companies offering conversion services. The following are the most prominent companies.

Life Pixel: http://www.lifepixel.com/
LDP LLC: http://www.maxmax.com/
Precision Camera: http://www.precisioncamera.com/infrared-conversion-services.html
Spencer's Camera and Photo: http://www.spencerscamera.com/

Internet Sites

Infrared Photography with a Digital Camera:
http://www.wrotniak.net/photo/infrared/index.html

Introduction to Digital Infrared Photography: http://diglloyd.com/articles/Infrared/infrared-main.html

Apogee Photo Magazine, *Digital Infrared Photography Made Easy:*
http://www.apogeephoto.com/may2003/odell52003.shtml

A Gentle Introduction to Digital Infrared Photography:
http://www.infraredphoto.eu/Site/Welcome.html

Books

Harnischmacher, Cyrill; *Digital Infrared Photography*; Rocky Nook, Inc, Santa Barbara, CA; 2008

Farace, Joe; *Complete Guide to Digital Infrared Photography*; Lark Books, A division of Sterling Publishing Co., Inc., New York; 2007

Sandidge, Deborah; *Digital Infrared Photography Photo Workshop*; Wiley Publishing, Inc., Indianapolis, Indiana; 2009