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This issue is about the difference between film cameras and digital cameras.

The Guild's digital camera on the right (Olympus E-20) with its add on macro extender lens far right, and one of the Guild's film cameras on the left (Olympus OM-2)

So, what is the difference between film cameras and digital cameras?

Why should I use one vs the other?

By Jerry Work

This is a question which is asked a lot. Most people have some experience with film cameras, and to a growing extent with digital cameras as well. But, few really understand fully how very much different they are and why that matters in terms of representing art or craft items to a prospect, show or gallery.

The similarities - first the film camera

Let's first start with how they are similar. All film cameras have a lens for focusing the light reflected off of a subject onto the film plane. The lens usually has an adjustable diaphragm which controls how much light can come through the lens within a given period of time. Increase the diameter of that diaphragm and you increase the open area which increases the amount of light that can pass through and on to the film plane in a given period of time.

In terms of the physical quantity of light that is passed, lenses of different focal lengths require different sized open areas to pass a given amount of light.

To establish a standard way of expressing the physical amount of light allowed to pass through different lenses, the focal length is divided by the open area of the diaphragm to create a ratio, or function, called an "**F stop**". A given F stop will pass the same physical quantity of light on to the film plane no matter what the focal length of the lens or the diameter of the diaphragm.

To make this F stop ratio more meaningful, the lens is usually marked with a sequence of numbers representing twice as much or half as much light from number to number. That progression arithmetically is (from most light passed to least) 1, 1.8, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32, etc. So an F stop of 4 will pass twice as much light on to the film plane as an F stop of 5.6. Similarly, an F stop of 4 will pass only half as much light on to the film plane as an F stop of 2.8.

The progression of half as much to twice as much light looks funny, but remember, it is the ratio of the focal length divided by the open area of the diaphragm so the smaller the open area the larger the ratio.

The diaphragm is often referred to as "**the aperture**" so the ratio of F stops is also often called "the aperture" at which the lens is set. Moving from a larger to a smaller open area (from a little to a bigger F stop) is called "**stopping down the lens**".

The photos show the Guild's 50mm macro lens at F22 (top) and at F3.5 (bottom). This is a lens that fits the Guild's Olympus OM-2 film camera which allows you to focus with the aperture wide open (the most light coming into the viewfinder) and then stops the lens down to the taking aperture just before the shutter releases.

To make these shots I had to manually close the aperture for the top photo with my finger moving a lever that normally engages the mechanism for stopping down the lens inside the camera.

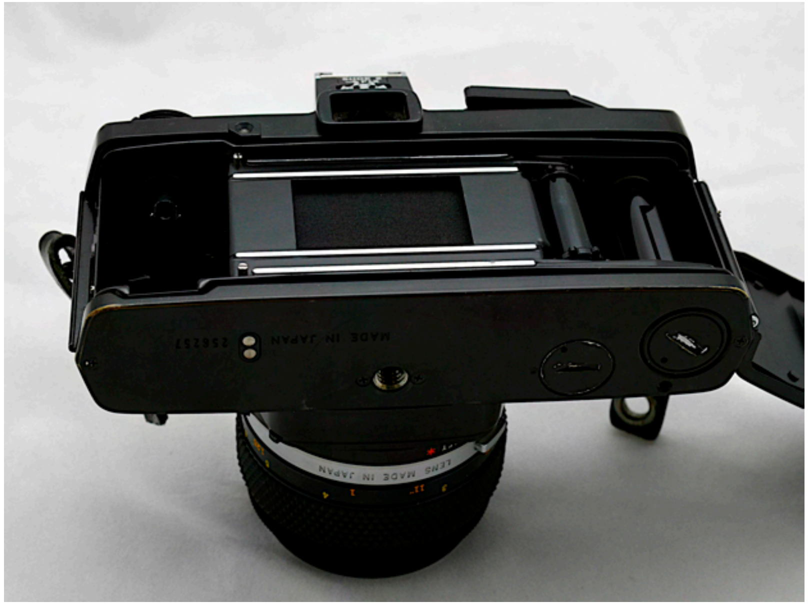
Most film cameras also have a **shutter**, a mechanical device, which limits the amount of time light can pass through the diaphragm, or aperture of the lens.

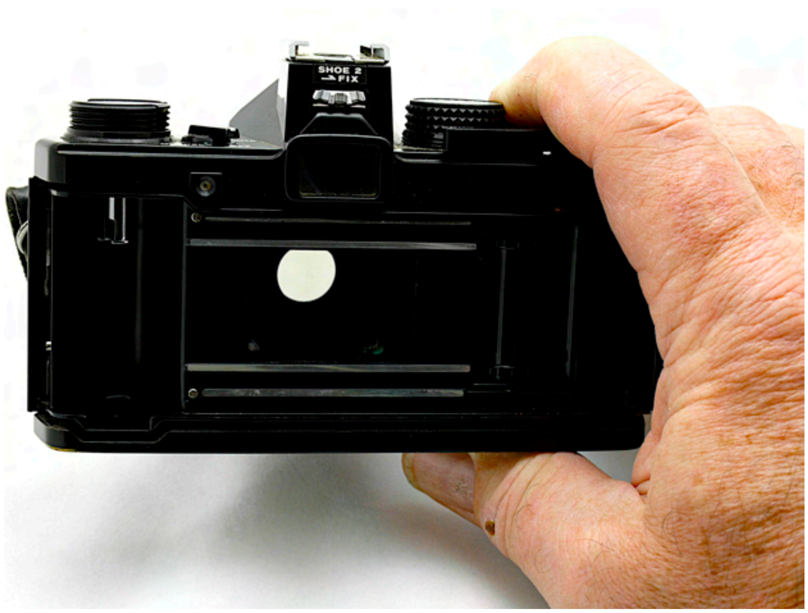
This is also most often expressed as a series of numbers representing approximately twice as much or half as much time as the number before or after it. The sequence is simply the amount of time in seconds or fractions of a second that the shutter is open allowing light to pass through the lens and on to the film plane.

The sequence is usually something like 1/1000, 1/500, 1/250, 1/125, 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, 1, 2 ,4 and 8 seconds. Obviously, a shutter open for 1/250th of a second will let in twice as much light as a shutter that is only open for 1/500th of a second, etc.

Film cameras also provide a means of holding a film media flat and exactly at the point of focus of the lens, called the "**film plane**". The photos at the top of the next page show the Guild's Olympus OM-2 with its back open. In the top photo the shutter is closed while in the lower photo the shutter open so you can see the light coming through the lens that will be focused onto the film plane.

The silver lines hold the front of the film flat while a spring





loaded plate on the inside of the back forces the film flat from the rear.

The film media is made up of a flexible plastic film onto which has been deposited ground up crystals of a light sensitive compound commonly made from particles of silver. Since it is light sensitive it must be kept in darkness all the time except at the moment when the shutter opens to take a picture.

The film loads into a light proof canister which fits into the chamber on the left side of the camera. The first part of the film pulls out from the canister and engages in a winder on the right. Once the back is closed, unexposed film can be wound to position and an unexposed segment right at the film plane is ready to receive light from the subject once the shutter opens.

Each crystal will change state chemically when exposed to light and then chemically altered in a process called "**developing**" the film. The more light that strikes a crystal before development the more opaque the crystal becomes. The less light, the less opaque the crystal becomes once developed.

After the film is exposed to the development chemicals the result is called "**a negative**" since it is a reverse representation of the image captured. What was light in the scene is dark on the negative and what was dark in the scene is light on the negative.

Focusing a bright light that passes through the negative onto a paper that is also coated with a light sensitive material reverses the process and produces what is called a "**positive**" image that looks just like the original scene.

These positives are most commonly called a "**print**".

Smaller crystals of silver require a greater quantity of light to become opaque while larger crystals can become similarly opaque with a smaller amount of light. More smaller crystals can fit on a film of a given size than large crystals. So, the more light sensitive the film (larger crystals) the **grainer** the film because there are fewer crystals to record the scene.

To allow the photographer to adjust the diaphragm and shutter speed to allow the correct amount of light to fall on the film to result in a negative that captures both very bright parts of the scene and very dark parts of the scene, the actual light sensitivity of the film must be known. Manufacturers of film long ago formed standard ways of expressing the light sensitivity of different films.

In the US this is called the American Standards Association (**ASA**) scale. In Europe it is called the International Standards Organization (**ISO**) scale. While the scales are different, they both share the trait that a film with a rating twice as high will be twice as light sensitive so will only need half as much light to fall on it to properly record the bright and dark parts of a scene. Nearly all digital cameras, including the Guild's, now use the ISO scale.

There is one more characteristic of light that has to be considered when capturing a scene on color film and that is the actual **color temperature of the light** reflecting off of the subject.

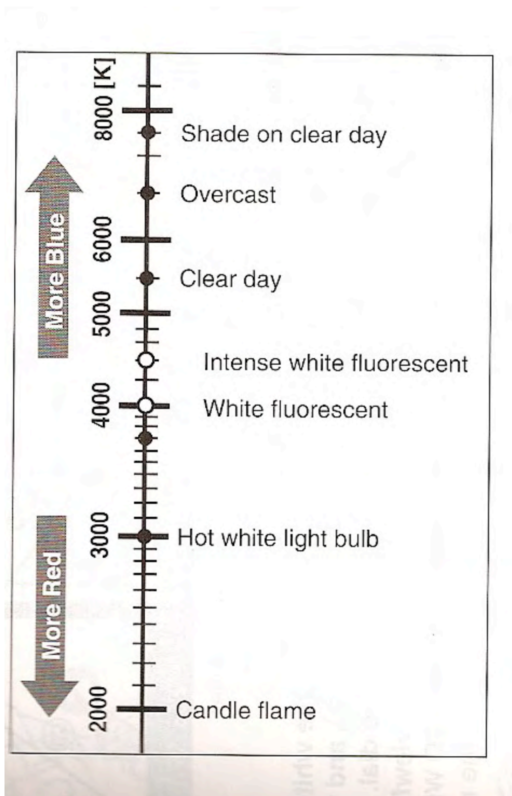
Sunlight on a clear day appears quite blue to our eye while a candle flame appears quite yellow to our eye. A Brit by the name of Lord Kelvin developed a scale for expressing how our eyes perceive different colors of light. This scale is called the Kelvin **Color Temperature** scale (shown left).

The yellower light from a tungsten light bulb (called hot white light bulb in the chart above) has a color temperature around 3000 degrees Kelvin while the bright sun on a clear day has a color temperature around 5500 to 6000 degrees Kelvin. The flash on the Guild's studio strobe lights and most cameras is set to produce light at 5000 to 5500 degrees Kelvin. The Olympus E-20 digital camera has a built in flash with a color temperature of 6500 degrees Kelvin.

A florescent light fixture can be made to produce nearly any color of light, with most in the 4000 degree range where the light tends to look quite green to our eye. Photographic "cool light" florescent bulbs have a color temperature around 5000 degrees Kelvin.

All this matters so our eye will see white without a blue or yellow (or other) color cast. Setting the proper color temperature in a digital camera is called setting the "**white balance**".

Film is manufactured to properly record only a certain color of light being reflected off of the subject, hence the notion of "daylight" film which is "white balanced" to properly record scenes illuminated by the sun on a clear day. If you took a picture with that film indoors at night illuminated by a tungsten light bulb the picture would have a strong yellow cast to our eye.



So called "indoor" or "tungsten" film properly records scenes lit by artificial light emitting colors in the 2500 to 3500 degrees Kelvin range. Use that film in the daylight and the resulting image would have a strong blue cast.

With a film camera the only way to change the white balance is to load a different kind of film into the camera.

The similarities - now the digital camera

Digital cameras also have a lens to focus light, as well as a diaphragm and shutter to control the amount of light that can pass through the lens. Instead of a film to capture the scene, digital cameras utilize an electronic device called a "**photo sensor**".

Photo sensors are made up of a large number of individual cells, each of which is capable of recording the relative brightness of light falling on that one cell. Where the crystals of the silver solution change continuously as a function of the amount of light falling on them, each photo sensor cell normally only records 256 levels of light intensity, about the number of discrete light levels the human eye is capable of detecting.

What about capturing images in full color, rather than just the amount of light falling on a single crystal of photo sensor cell?

In the case of film, there are three layers of the silver crystals each covered by a colored filter which only allows either red, blue or green light to fall on that layer. So, one layer records the relative intensity of red light falling on a given spot on the film plane, while another crystal layer records the amount of blue light at that location in the image and still a third crystal layer records the amount of green light at that point.

This is quite similar to how the human eye works. The eye has a lens to focus reflected light from an image through a diaphragm and onto a series of photo sensors at the back of the eye. Some of those see only red light, some only blue light and the rest only green light.

An odd fact of our genetics is that the human eye has twice as many green receptors as either blue or red receptors. As a result, most films also have twice as many crystals in the green layer as in the other two.

The photo sensor in the digital camera works in quite the same way. There are photo sensors to record the amount of red light, blue light and green light falling on a given cell. While this is accomplished in a variety of ways, for our purposes it is only important to understand that at each point light falls on the photo sensor the amount of red light is captured on a scale from zero to 255. Similarly the amount of blue and green light is captured on a scale from zero to 255.

When you mix the 256 possible intensities of the red, blue and green light together you get more than **sixteen million possible colors at each point on the photo sensor.**

Now we will get a bit techie for a moment. In the binary number world used by most computers where there are only zeros and ones (represented on integrated circuits by either the presence or absence of minute voltage signals) it takes a total of eight binary digits to represent the numbers from zero to 255. Since we need three such sets of numbers for the three different colors recorded, it takes 24 binary digits to represent those more than 16 million color combinations.

That is where the notion of "**8 bit color depth or 24 bit color depth**" comes from. 24 binary "bits" are required to record 8 bits of intensity information for each of three colors for each light recording area on the photo sensor.

Photo sensors come in several different physical sizes from very small to quite large. For each different physical sensor size there can be various number of photo sensor cells. These cells are usually referred to as "**picture elements**", or **pixels** for short.

So, in describing a photo sensor one usually states its physical size, the material from which it is made, and how many pixels are on the surface. If you place 1,000 cells across and 1,000 cells up and down on a sensor it would be called a one million cell sensor. That usually gets shortened to one **megapixel**.

In the marketing hype surrounding digital cameras the number of pixels on the sensor is usually about the only thing mentioned, even though ***that is one of the least important considerations*** in determining the quality of images the camera is capable of rendering.

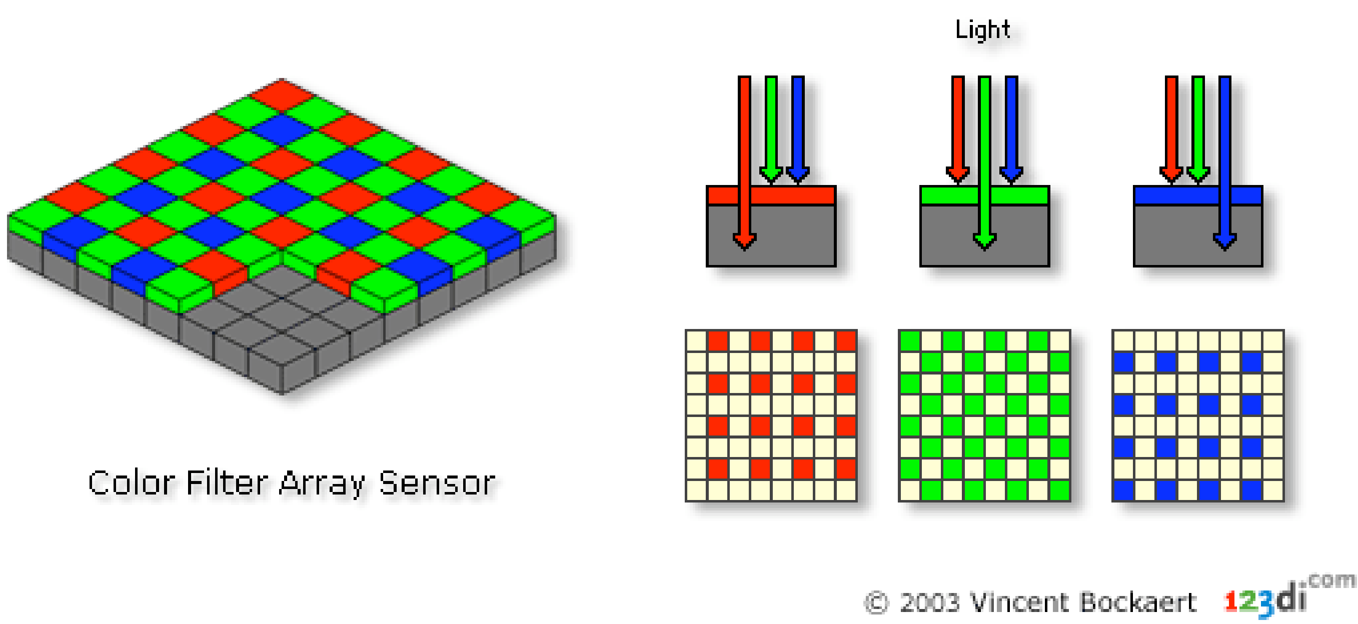
As of the time of this writing most professional and prosumer cameras employ a sensor that has between 8 and 12 million pixels.

The Guild's Olympus E-20 has a CCD sensor with 4,950,000 pixels.

What happens after the light falls on the photo sensor or film?

Before we go any further, let's go back to the issue of what happens once the light has fallen on the crystals (in film) or the photo sensor cells (in digital).

We know that the film has to be developed by exposing it to certain chemicals. Once developed it becomes a negative from which prints can be made.



In a digital camera the intensity of red, blue and green light falling on each cell in the photo sensor is stored on what is called a "**non-volatile random access memory card**". Non-volatile means the recorded information is preserved even when no electric power is available to the card. Random access means the card can be read by a computer from any spot on the card to any other spot on the card, it does not nave to be read in sequence from start to finish the way a strip of magnetic recording tape would be read.

The light intensity information is stored as a series of binary numbers representing every one of the cells on the sensor. Obviously, the more pixels on the sensor, the more storage space on the card is required to store that one image, and hence the fewer images that a memory card of a given size can hold. The larger the image the longer it will take to write the information onto the memory card, or to subsequently read it off of the card.

Physically, for the digital camera to be able to record, format and store this sequence of numbers it must have the on-board intelligence, **a computer**, to do so.

So, in addition to the difference between a film camera using photo sensitive film to store the image while a digital camera uses a electronic photo sensor and a memory card to store its images, **the digital camera also contains a computer and software** to instruct the computer what to do and when to do it.

And, from here the differences between film and digital cameras becomes even greater to the point that they no longer resemble one another in any way other than physical appearance.

Before proceeding further, it is important to understand that unlike film, a digital camera's photo sensor can be adjusted on the fly to become more or less light sensitive over quite a range.

However, as you adjust the light sensor to become more light sensitive, it will also become more susceptible to electronic noise. This characteristic is described by what is called the "**signal to noise" ratio.** The signal is the information about the actual amount of light of a given color falling on the sensor. The noise is the unwanted extraneous information that serves to deteriorate the accuracy of the signal information.

And, here is where the reality of digital camera performance collides with the marketing hype about how many megapixels the camera can record.

A sensor with fewer pixels and a high signal to noise ratio will produce better images than one with more pixels but relatively more noise.

In general, the physically smaller each cell is in the photo sensor the lower the signal to noise ratio (i.e.: more noise for a given signal strength, a bad thing). So, a physically smaller sensor with the same number of cells as a physically larger sensor will have smaller individual cells and likely more noise in the captured image information.

As the manufacturers strive to satisfy the marketing hype surrounding more and more megapixels on their sensors, they often wind up making poorer, rather than better sensors by cramming so many pixels on a sensor of a given size that each cell gets too small and captures too much noise along with the intended image information.

The sweet spot given todays state of technology for professional and pro-sumer grade digital cameras tends to be sensors that are physically between half the size of a 35mm film frame up to about the physical size of a 35mm film frame with somewhere around 8 to 12 million sensors on them.

Most all of the sensors used by digital camera makers are produced by three or four electronic giants. Sony makes most of the current crop of 10 million cell sensors used by many manufacturers including Nikon, Pentax, Samsung, their own Sony brands, and several others. These are about three fourths the physical size of a 35mm film frame.

Canon makes their own sensors in several different sizes up to and including a 35mm film frame with up to 12 megapixels. Panasonic makes the sensors half the physical size of a 35mm film frame (called four thirds size for a bunch of arcane reasons) that is used by Leica, Olympus, Panasonic and others. Kodak makes a wide range of sensors of different sizes and densities from very small to very large.

In general, the larger the physical size of the sensor the more expensive and power hungry the sensor is requiring a larger and heavier the camera, battery and lens.

So there is a definite downside to simply ever bigger sensors.

What determines the quality of the image captured by a digital camera?

Earlier I said the number of pixels on the surface of the sensor was one of the least important elements to the quality of the resulting image. We just talked about the importance of low noise (high signal to noise ratio), but an even more important element is **the quality of the lens** itself.

The lens must be able to focus light very precisely, especially since the majority of digital cameras use a sensor that is smaller than a 35mm film frame. Since they have to focus light on a smaller area, **the precision of the focus, the control over lens induced glare and the absence of lens aberrations become the critical factors.**

That is one reason that you see highly respected 35mm lens maker names on the lenses on most prosumer and professional cameras. **The lens quality makes more difference from my experience than any other single factor.**

There simply is no way to correct for a lessor quality lens, while we will see in a moment that, since there is a computer inside the digital camera, it is possible for the camera itself to compensate more easily for sensors with lower signal to noise ratios.

The computer and software inside the digital camera is also critical to the quality of the image

Whew! We have covered a lot of ground in a short time. But, there is still more to come for you to fully understand what is going on between the time you push the shutter release and the time a great print emerges from a photo printer.

The first thing one needs to do when using a digital camera is to tell the computer inside the camera what you want it to use for ISO setting, white balance setting, and several other important parameters. In addition to providing a means for you to set these parameters yourself, often the camera comes with the ability for the camera to set these itself on the fly off of the light it sees coming from the photo sensor - usually called the "automatic" or "**auto**" settings.

Since there is a computer inside the digital camera, it is possible to have it manipulate the image by altering the sequence of numbers in a whole variety of ways. We are certainly not going to cover them all here, but we will discuss a few so you get more comfortable with what "**image manipulation**" or "image adjustment really means.

One of the ways to have the on-board computer manipulate the image for our benefit would be to have the computer reduce the size of the file that we need to store all the light intensity information captured by the photo sensor in the first place.

Lots of smart people have developed a range of algorithms to do just that. By analyzing the pattern of adjacent light points it is possible to shrink the file size for storage purposes and then have another computer recalculate all the original light intensity information at a later time. This is called "**image compression**".

We don't need to dwell on how this is done, only recognize that it can easily be done given the processing power inside most digital cameras and most desk top or lap top computers.

The most common means of compression was developed by a group of professional photographers, academics and computer professionals who came together under the name "**Joint Photographic Experts Group**", most often shortened to **JPEG** or even to **JPG**.

They established a protocol, specific information contained within the stored image file, that tells the computer reading the file how the compression was accomplished and what needs to be done to properly decompress the file back to near the original image information.

Most all digital cameras have the option of storing the image information in JPEG format. One of the attributes of that format is the ability to define how much or how little compression to do. More compression can deteriorate the quality of the image at larger print sizes while the benefit is a much smaller physical file size. Small amounts of JPEG compression do little to erode the quality of the image at any but the very largest print sizes.

Most professional and prosumer digital cameras also offer the option of storing the captured image in what is called **RAW file format**. This is, as the name implies, the actual image color/intensity information obtained right off of the sensor itself with little or no in-camera computer processing.

RAW format files must be read by special software on a computer that can recognize the particulars of each manufacturer's RAW file format. No two manufacturers use the same or even a standard version of a RAW format even thou one has been developed by Adobe, Inc. If you intend to store files in the RAW format of the camera you are using, make sure you also have that specific RAW format file reading capability on your computer that will receive those files.

Adobe Photoshop and Photoshop Elements software installed on the Guild's Mac and

Windows computers are capable of reading most of the more common RAW file formats, including the RAW format output option on the Guild's Olympus E-20..

Less frequent, but still available on some digital cameras such as the Guild's E-20 is the ability to store image files in **Tagged Image File Format**, which is usually shortened to the acronym **TIFF**. This is a defined, standard, uncompressed file format that preserves most of the original quality of the captured image. It is not used very much any more because the better JPEG algorithms have become so good that the degree of image quality degradation is so small compared the radical reduction in stored file size to make it the preferred format for most uses.

As we said earlier, the computing power inside most modern professional and prosumer digital cameras is quite extraordinary. But, it is not as extensive as the processing power inside desk top computers so most of the time it is best to use a desk top computer to do the image manipulation.

By analyzing the pattern of recorded color/intensity points in the captured image the in camera computer software or the image adjustment software in the desk top computers, manipulate the image to correct for many things such as ***under or over exposure, improperly set white balance, improperly set ISO ratings, to increase or decrease color saturation, contrast, tint, and many other image parameters*** which we will cover later.

How do you move the images stored on the camera memory card to a computer?

As we discussed earlier, digital camera store the image information on one of several different types of random access non-volatile memory cards. The Guild's Olympus E-20 uses either one called a "SmartMedia" card (which is not very common) or a "CompactFlash" card which is far more common. The two kinds of cards are shown in the picture below.

The SmartMedia card is the black card with the gold area while the CompactFlash card is below it with the number 256 on it. 256 refers to the capacity of the card in megabytes.

If you set the E-20 camera to capture images in RAW or TIFF formats that card can hold about 25 images. If you capture at Super High Quality 9 (a JPEG file format with little compression) you can store about 65 images, at High Quality (JPEG with medium compression) 160 and at Standard Quality (JPEG with very high compression) about 800 images.

Once stored on the memory card there are two ways to move the image data onto a desk top or lap top computer.

The first and easiest way is to remove the memory card from the camera and place it into a card reader that is attached to the computer. The photo below shows two common kinds of memory card readers. The lower left is a PCMCIA card reader and you can see the CompactFlash card has been removed from the camera and inserted into that reader.

Many lap top computers have a PCMCIA slot built in so you would just insert the reader with the card in it into that slot on the lap top and the lap top would see it like any other storage device attached to it. It will look to the computer like a disk drive.

From the file management function on the lap top you would drag and drop the image files from that card an onto the hard drive of the computer in whatever folder you wished.

In the photo above a second kind of card reader is shown just above the PCMCIA reader. This one attaches to the desk top of lap top computer via a USB cable. Insert the card into the appropriate slot on the reader (this reader can read six different kinds of memory cards), plug the USB cable into the computer and drag and drop the files onto the hard drive.

You can delete the files off of the card while it is in the computer to make room for new image files or you can insert the card back into the camera and delete the files there. Just be sure to use the computer function "empty trash" before you remove the card so the files will actually be removed from the card. Before you empty the trash, the files are merely marked for removal, they are not actually removed until you do empty the trash.

On a Mac computer be sure you use the computer function to dismount and eject the card before removing it from either reader or before removing the reader from the computer. This will make sure the card format is maintained and ready to be used again by the camera.

If something unexpected does happen and the card is no longer readable by the camera, perform an in-camera function called "format" to make the card readable again.

The second way to move the image data from the camera to a desk top or lap top computer is to directly connect the USB cable (shown in the photo left on the previous page) to the camera and to the computer.

Any time the top dial on the camera is turned to the double ended arrow symbol the computer will see the card inside the camera and you can drag and drop files as discussed earlier.

Note in the photo left on the previous page the black cord with the yellow plug and just above where the USB cable is connected to the camera the yellow connector. This cord and connector are used to connect the camera directly to a television, recorder or other device with a standard RCA video in plug.

How are captured images represented on computer screens and digital printers?

For this session there is one more topic that we need to understand. That is the notion of how digitally captured images are represented on computer screens and by digital printers. After all, our whole purpose in taking quality photographs of our work is to represent ourselves to prospects, shows and galleries who are too far away to see our work in person. They will most likely use either a computer screen or a digital print to view our work.

We already know that the image is captured by the digital camera by a sensor with a certain number of cells or pixels horizontally and vertically. A computer screen and digital printer also display images by a defined number of pixels horizontally and vertically.

Commonly computer screens display images with somewhere between 70 and 90 pixels per lineal inch horizontally and vertically. Let's use 72 pixels per inch, often called, just to confuse you further, dots per inch or DPI. PPI (pixels per inch) and DPI mean the same thing.

An image that was captured with, say 1440 pixels horizontally, displayed full size at 72 DPI will render that image as being 20 inches wide (1440 divided by 72 equals 20). If the computer monitor is less than 1440 pixels wide you will need to scroll from side to side to see the whole image. If the image was captured at 2880 pixels wide, full size it would be rendered as being 40 inches wide, and so on. The same is true for the vertical dimension.

Digital printers can usually be set for how many DPI to use to render the image. Most are capable of 300 DPI or more. So, that same image captured with 1440 pixels wide rendered by a printer set to 300 DPI would render the image only 4.8" wide (1440 divided by 300 equals 4.8). If you told the printer to use 200 DPI instead then the rendered image would be 7.2" wide. If you elect 100 DPI the resulting image would be 14.4" wide.

The more dots per inch the smoother the image appears to our eye. Fewer dots show the same scene, but look grainy to our eye.

Given the calculating power of most computers it is easy for the computer to do such things as alter the presented image to be a certain physical size, or to fit the printed page or to fit to the physical size of the screen, or to be some multiple of its real size, and so forth. Hence, the very many "**view**" options that are presented in most image manipulation, display or printing programs.

If you ask the computer to render the image at a size larger than it physically is, the computer software will analyze adjacent points and calculate the most reasonable intermediate points it thinks necessary to make the image look right to our eye (called "**properly rendering**" the image).

If you ask the computer to render the image at a size smaller than it physically is, the computer software will selectively throw away points to satisfy the selected image size.

Bottom line - using the Guild's computers and software (or your own) you enjoy a bewildering array of ways to alter (manipulate) the image information captured by the digital camera.

Doing so thoughtfully and appropriately can produce radically better quality photographic representations of your work than you ever thought possible. Doing so in less thoughtfully or in less appropriate ways can result in a botched image that looks artificial and overly manipulated.

In another session we will explore the many ways to alter for the better your captured images.

How digital and film cameras are coming back together after all these years

When film cameras first became commercially available they were equipped with fixed focal length lenses that were permanently mounted to the camera body.

Over time manufactures figured out how to design and build lenses with more than one focal length, called "**zoom**" lenses. Some were of high quality and performed well while others were of dubious value.

Similarly, manufacturers also found ways to make the lens removable leading to the growth of what are called "**interchangeable**" lens cameras.

Film camera makers also over time added means to automatically set the proper exposure by having the camera change either the aperture and/or the shutter speed in response to the amount of light available.

Later still they found ways to automate the process of focusing the lens by placing battery operated motors and controllers inside the camera body and/or the lens itself.

By the latter part of the 1900s such advanced film cameras were available from many different manufacturers. Price, feature and lens quality factors drove many out of business or into partnerships or mergers with stronger competitors.

As digital cameras evolved they first were offered by both the surviving traditional camera makers and by large electronic device manufacturers. The traditional camera makers often struggled with the issues of the in-camera computers and photo sensors. The traditional electronic device manufacturers struggled with issues of lens quality, form factor and ergonomics.

More recently these two formerly competitor groups have combined their strengths through joint ventures and acquisitions.

Now it is common for the largely SE Asian electronics manufacturers to make the components to designs presented by the quality, largely European, traditional camera firms.

German Leica lens designs made in Panasonic factories staffed by Leica inspectors now adorn both Panasonic and Leica branded camera. Kodak uses lenses either made by or designed by the German Schneider Krenoff firm for their upper end offerings. Sony purchased the assets of the Konica Minolta company and quality Minolta lenses are now common on Sony branded cameras. Zeiss lenses are showing up on several different digital cameral brands. Olympus, Canon and Nikon all now offer digital cameras that can accept their previous film camera lenses with the appropriate lens adapter. Similar joint ventures abound.

Originally, like their film counterparts, digital camera makers offered cameras with a (usually zoom) lens permanently attached to the camera body. More recently there is a trend towards using interchangeable lenses on bodies that more and more resemble film camera bodies. Optical view finders are either replacing or complimenting electronic view finders. Manual control over shutter speed, aperture and lens focus is now common on professional and prosumer interchangeable lens cameras.

And, in an ironic twist, while improvements in digital camera quality has largely driven film cameras from common use, the lenses originally made for the high end film cameras are now finding their way back to the most current digital cameras. Lens mounts are now available to allow selected high quality film camera lenses to be mounted on equally high quality digital camera bodies.

Such lens mount "adapters" as they are called usually do not allow the lens to auto focus or to automatically select aperture, but they are so good relative to the (often) price driven cheap "kit" lenses that come on even very expensive digital cameras that users are foregoing those features to achieve higher and higher quality image outcomes, manually.

Another result of this trend is more and more the expensive professional and prosumer cameras are being offered as a body only, without lens with the understanding that the discriminating buyer will procure their own high quality lens rather than enduring the disappointment of the cheap "kit" lens offered.

***To end this session, lets summarize what we have learned*.**

1) photo receptors record the amount of red, blue and green light falling on each of the discrete points which the camera is capable of recording.

2) in film cameras these photo receptors are crystals of a silver compound. In digital cameras these are electronic light sensitive cells that record light intensity on a scale of zero to 255 for the red, blue and green components of the image.

3) In film cameras the photo receptor is fixed by the manufacturer of the film. It will record properly only certain color temperatures of light, and only light intensities that fall within a fixed range.

4) In digital cameras the photo receptor simply records what it sees and the in-camera computer (or an external computer) with the right software can manipulate what the sensor recorded to render a useful image over a very broad range of conditions.

5) Digital and film based cameras both use a lens to focus the light reflected off of the image onto the photo receptor.

6) Both use a diaphragm and a shutter to control the absolute quantity of light falling on the photo receptor.

7) The quality of the lens is the most important element in terms of eventual image quality whether digital or film based camera.

8) For digital cameras the number of pixels on the photo cell is far less important than the signal to noise ratio of the photo sensor. The physically smaller each cell is, generally the lower the signal to noise ratio so cramming more cells on a sensor of a given physical size will usually degrade, rather than enhance, the resulting image.

9) For film cameras the finer (smaller) the crystals, the more of them there are within a given physical film plane size and the higher the apparent resolution. But, the smaller they are the more light they need to be exposed to in order to properly record both the bright and the dark parts of the image.

10) The apparent resolution of a rendered digital image is far more a function of the device being used to render the image than it is a function of how many cells were used to capture the image in the first place. The in-camera or the external computer with the proper software can calculate intermediate pixels needed if the recorded image size is too small, or can selectively throw out pixels if the recorded image is too small.

The next page is an appendix which shows and talks a bit about the components required to use the Guild's Olympus E-20 digital camera.

These are the components of the Guild's Olympus E-20 computer that you will need to take quality photos of your work. The camera, of course, which is shown upper right. To the right of the camera is a lens shade you should use when shooting outdoors. Below the lens shade is a remote control with which you can trigger the camera from a distance. Read the manual to find out how to set up the camera for remote use.

Above left are the three kinds of ways you can power the camera. Unlike many contemporary digital cameras this one DOES NOT have rechargeable batteries. You must either plug it into a 120V A/C wall outlet with the cord and plug shown upper right, or use replaceable CR-V3 lithium battery packs which you can buy at any Radio Shack or other such store, or you can use standard AA size throw away batteries. Check the manual for full details.

You will need one of the two types of memory cards this camera utilizes. Be sure to tell the camera which card you want it to use to store images. Check the manual to determine how to do this.

Far left on the bottom is a close focus lens which you can screw onto the front of the camera lens to allow full 1:1 macro images. That means the image you see through the view finder will be the same size as you see with your eyes. This is very handy for photographing very small objects or where you want to show a lot of detail.