Photography for reproduction

by Dr. Chris Lantz

Many publishers have routinely relied on digital imaging for low resolution applications in newspaper production and desktop publishing for just over a decade. Cameras that capture just beyond television resolution images (640×480 pixels) are adequate for some of these applications and typically cost $300–$1,000 today. Low-resolution digital cameras are well suited to web sites, computer presentations, and output to laser printers because their resolution capacity matches the typical output resolution of low-cost monitors and printers. Higher resolution megapixel cameras have recently been introduced at slightly under $1,000 for the first time. These new low-cost cameras complement the increasingly common 1152×780 computer display resolution and desktop printer resolutions above 600 dots per inch (dpi). The future widespread adoption of the Federal Communications Commission approved HDTV (High Definition TeleVision) standard will likely spark a new round of low cost digital cameras to fill an even higher resolution standard in the near future. At the upper end of the digital camera market, commercial publishers have used high resolution digital cameras for catalogs and periodicals which depend on the rapid production of hundreds of images per issue. Currently, there are high resolution cameras in the $10,000–$20,000 price range that can approximate the resolution of ISO 400 speed 35mm transparency film. There are also cameras in the higher $25,000–$50,000 price range that can approach the resolution of conventional films such as ISO 25 speed 35mm transparency film. Some imaging technologies can now exceed the resolution of large format 4×5 or 8×10 inch film, but these currently are only cost effective for applications such as remote imaging via satellites.

Even though the quality of images that can be produced by digital cameras has increased dramatically in the past few years, they may not be appropriate for many uses. In this paper, the author compares the characteristics of film-based cameras to the characteristics of digital cameras and makes recommendations regarding the use of each type of camera in today's market.

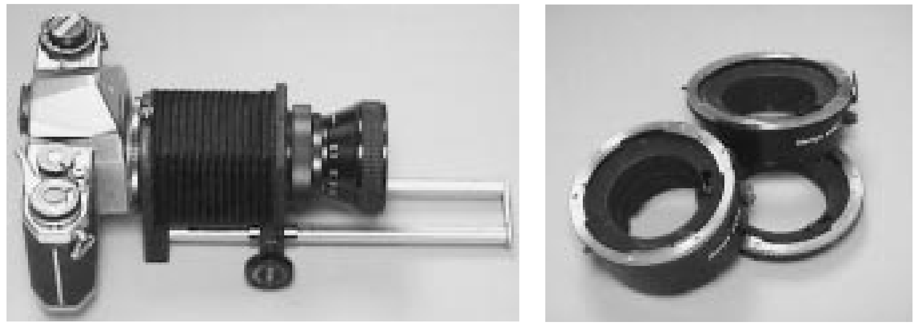

Figure 1: Bellows (left) and extension tubes (right) provide cameras an ability to image objects larger than life size on film. The greater the distance between lens and camera the closer focusing distances are possible.

Camera controls: digital versus analog

A disadvantage to many of the low- to mid-priced digital cameras on the market is they rarely have the manual exposure and focusing controls on which professional photographers depend. Some high-end digital cameras in the $8,000-$25,000 price range are actually film-based cameras that are converted to digital-based cameras by replacing the film back with a digital sensor back. These converted cameras are equipped with the manual controls of the standard 35mm camera from which they were created.

In the $500–$3,000 price range, digital cameras do not have the depth of field control afforded by f-stops, nor the motion-stopping control provided by a manual shutter speed. These are major limitations that prevent many professional photographers from switching to the digital format. Control over depth-of-field and motion stopping capability are essential creative tools of the professional photographer.

Another drawback of the low-cost digital cameras is that they do not have a removable lens mount. Hundreds of conventional 35mm SLR camera lenses and accessories are available. Without access to special lenses, photographers cannot use low-cost cameras to control the angle of view and perspective of objects in the scene. In addition, close-up or macro photography is not an option when using many low-cost cameras, because special equipment, such as extension tubes and bellows, is not available (Figure 1).

Other big disadvantages of the lenses on low-cost digital cameras are their relatively low quality and less-than-optimal light gathering ability. High-speed lenses transmit more light when needed in low lighting situations. Digital camera lenses are often quite slow, so harsh flash lighting is necessary. When compared to natural light, electronic flash lighting is unnatural by virtue of its angle and the high contrast of the shadows it casts. There are some techniques that can be used to soften flash lighting, such as bouncing it off a white card, but the small built-in flash lamps available on digital cameras lack both the power and angle adjustments to make such techniques possible (Figure 2).

Most of the lowest-cost digital cameras have fixed-focus or focus-free lenses. Fixed-focus means that the lens was fixed at one focus point at the factory and that any subject closer or further away from this point will be out of focus (Figure 3). The focus point is in the middle of the lens focus range. This provides a reasonable chance of getting a sharp picture, but the drawbacks of fixed focus are very apparent with close up photography.

Better digital cameras have true auto focus mechanisms which ensure sharp focus on subjects at various distances from

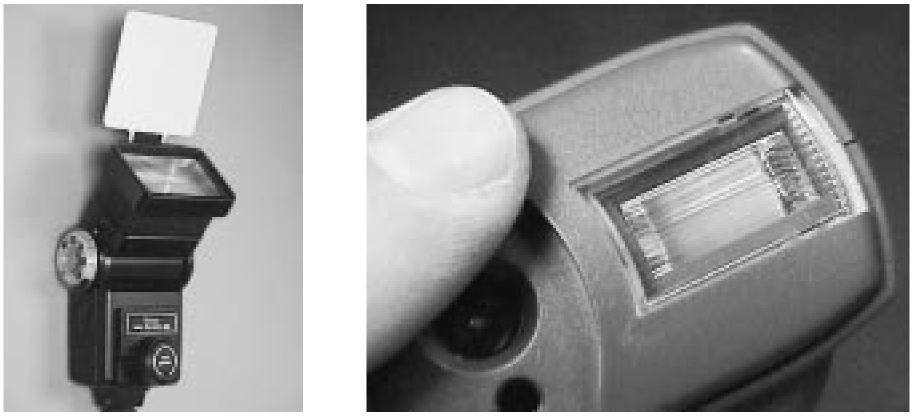

Figure 2: The flash built into digital cameras are not adequate in power nor have the angle adjustments to allow softer more natural reflected light as is provided in the bounce flash setup on the right.

the camera, so long as the subject is in the center of the viewfinder. Autofocus systems have a sensor that measures the distance to the subject and then changes the focus of the lens elements to compensate for different distances. Although this is much better than fixed focus, it still causes problems if the photographer wishes to place the subject of the photograph off-center. One approach to solve this problem is to use multiple focus sensors across the field of view and not just in the center. This improved focus system is available in conventional cameras but not for low-cost digital cameras.

Low-cost digital cameras often lack light metering features such as multi-cell metering and backlight control. In addition to calculating the focus from the center of the viewfinder, many cameras measure the amount of light in the scene from the center only. This can cause problems if the subject is dimmer or brighter than the background or if the subject is not centered in the viewfinder. Multi-cell metering collects light readings from various positions in the viewfinder and averages the readings. Multi-cell metering compensates for back-lit scenes that would turn out as silhouettes without this feature.

Finally, most entry-level cameras lack a manual exposure override. Manual exposure allows photographers to produce a dark or light picture on purpose or as a special effect. Even if the photographer is shooting a dark or light subject, the exposure system in an automatic camera is programmed to produce an 18% gray average density. If manual exposure controls were provided, the photographer could overexpose to compensate for a light subject or underexpose for a dark subject.

Despite the disadvantages of low-cost cameras, they still have many important advantages. A 640×480 image can be acceptable, even in high-resolution magazine publishing, if it is used at a fraction of its original size. Many lower-cost cameras are just starting to incorporate exposure value (EV) adjustments, which photographers can use to adjust to prevailing lighting conditions using a built-in LCD preview screen (Figure 4). As digital photography rapidly becomes more

Figure 3: The Quickcam is an example of a fixed focus digital camera (left). It is possible to change the fixed focus point but the camera needs to be disassembled in order to accomplish this, as is demonstrated on the right.

Figure 4: This digital camera has the ability to capture images on standard floppy disks (left). It also has a three inch LCD viewing screen. This screen is used as a viewfinder, to preview images, and also make exposure adjustments with a built-in EV exposure value control (right).

mainstream, many of the features that are presently lacking in low-cost cameras will be included. When this happens, many more applications will be opened up to digital imaging.

As recently as 1996, only a few low-cost digital cameras were available. By 1998, there were over 50 models. One new type of digital camera is the Digital Video Cassette (DVC) camera that can be used to capture both still pictures and video (Figure 5). DVC cameras have a new Firewire computer interface. Firewire allows the direct transfer of digital data from a DVC to a computer. In the past, when photos were needed from a video source, the computer required a specialized video capture board (Figure 6). DVC cameras allow the direct capture of individual video frames because data storage in the DVC and computer are both digital. No converting of analog to digital video is necessary.

Basic image structure: digital versus analog

In spite of these rapid developments, digital imaging technology has not overtaken traditional photography as the standard format for many commercial publishing applications. This is mainly due to the fact that conventional photographs are very high in resolution and low in cost. Kodachrome color slide film, invented in 1937, currently costs under $10 per roll, and, when scanned on a high quality drum scanner, can exceed the resolution of $25,000 digital imaging systems. An imaging system that costs $25,000 today will be much less expensive in the future. However, even the most optimistic do not predict that digital imaging systems will be able to financially compete with most film-based systems in the short term. Even if revolutionary imaging systems were developed in the short term, problems, such as projection and display of images, will still exist. Computer projection, LCD, and flat plasma panels are great recent strides that have been made in digital image display. However, these devices typically provide definition just slightly more than twice the resolution of the present-day National Television Standards Committee standard (NTSC). A

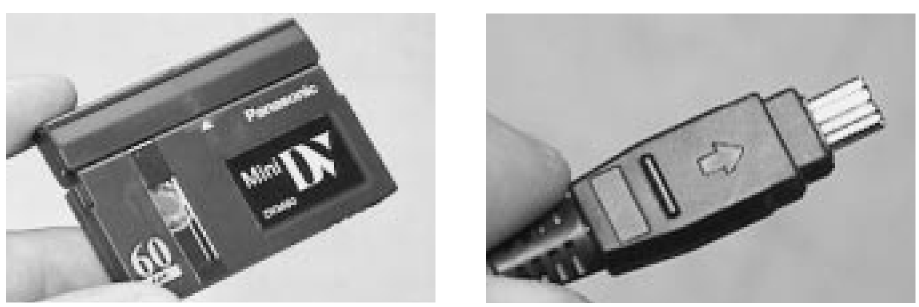

Figure 5: The digital video cassette (left) is a new video format that can interface directly with a computer with the firewire interface (right).

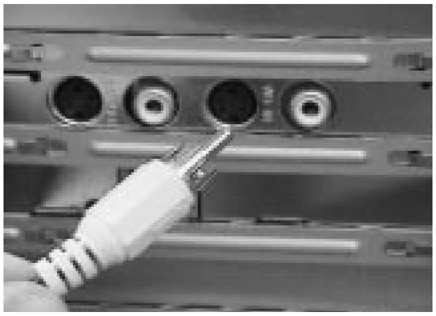

Figure 6: These are the video input/output ports of a video capture card on the back of a computer. A video capture or digitizing card takes input from a standard analog video source and converts it to digital data.

typical data projector in the $5,000–$10,000 price range can produce a maximum resolution of 832×624, and this is at least 100 times less resolution than conventional large-format film. A typical 35mm slide projector costs from $200–$500 and is smaller, lighter, less fragile, higher in resolution, and more reliable than a data projector for presentation of static images. Film recorders can record computer images on 35mm slides, and many presenters prefer using a low cost slide projector to present these slides as compared to the inconvenience of setting up a laptop and portable data projector.

Another advantage of film versus digital is that images archived on film are far more permanent than those recorded on electronic media. The projected life of some prints and transparencies is well over 100 years. In particular, black-and-white photos have very good archival characteristics because they are metallic silver; most deterioration of black-and-white plates is caused by tarnish and atmospheric conditions. Although some CD-ROM media could last just as long as black-and-white photos, it is unlikely that many CD-ROM drives will be around in 100 years. Film is still less expensive than magnetic or CD-ROM media to store high resolution images. For example, hospitals still store x-ray films because digital images cannot match the resolution of a large format x-ray without taking up an enormous amount of storage space. Many soft tissue details could be lost if x-ray images are scanned at a low-enough resolution for economical archival. Even those medical imaging processes that originate from digital data, such as CAT scans or NMR, are imaged on conventional photographic film, using a film recorder, for study and storage.

So, how can such an old chemical based imaging system such as photography, invented by a fortunate discovery in the mid 1800's and perfected in the early 1900's, beat out the current state-of-the-art digital imaging and projection systems in terms of resolution, price, and longevity? The main reason is the nature of the smallest picture element or pixel. In electronic images, these are manufactured in the form of

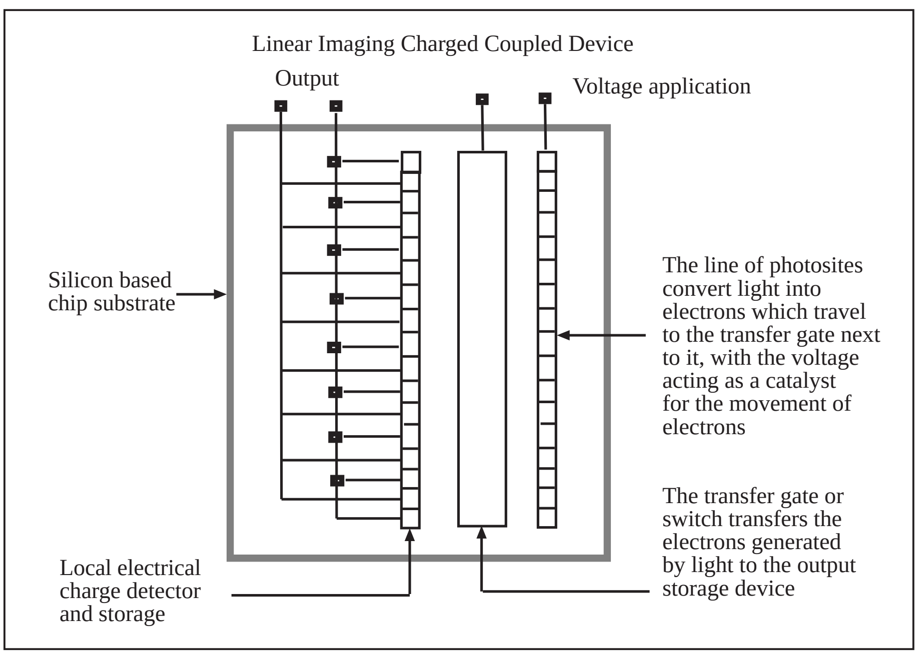

Figure 7: The basic structure and operation of a CCD or charged coupled device.

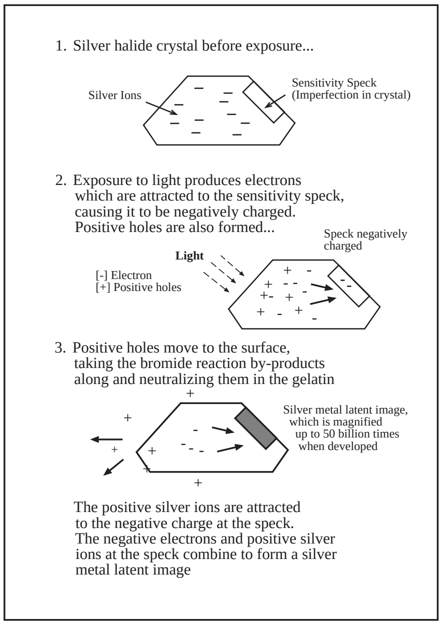

Figure 8: Latent image formation and development

a photosite on the surface of an imaging device, such as a charged coupled device (CCD) (Figure 7). The size of these photosites is limited to the capacity of the silicon wafer or chip substrate material on which they are manufactured. Currently, whole computers can be put on a portion of such a silicon wafer—these become a system's microprocessor. Unfortunately, current chip fabrication processes cannot place the required number of densely-packed photosites on a chip to match the resolution of conventional film. Film has a densely-packed structure of picture elements because these elements are not manufactured and are not directly limited to any physical manufacturing capability. Rather, film picture elements are created on an atomic level.

Photographic image formation

Light-sensitive photographic film is made from silver salt crystals, suspended in gelatin, that are coated onto a clear polyester film base. This coating is thinner than a human hair. Each of these sliver salt crystals is sensitive to light and are created by the mixing of silver nitrate and a halide such as bromide. A latent image is defined by just a few atoms of silver formed by exposure to light in an individual silver salt crystal. Latent images are developed in a chemical developer, which amplifies the atomic silver millions of times, into a visible picture element (Figure 8). A photographic image is made permanent, or fixed, by removing those silver salts which have not been exposed to light and do not contain a latent image. This leaves a permanent silver metal image.

The amplification of the atomic silver to a visible but extremely minute picture element in the developing process is comparable to converting the mass of a golf ball into the Empire State Building. Development is incredibly efficient and requires very little light to produce an image on film. Film's ability to magnify light in high-resolution distinguishes itself from high resolution digital imaging. Magnification of light is possible using digital imaging. However, this magnification currently leads to a comparatively large loss of resolution. More light is needed for higher resolution for both film- and digital-based imagery. An increase in light yields more resolution in film than it present-

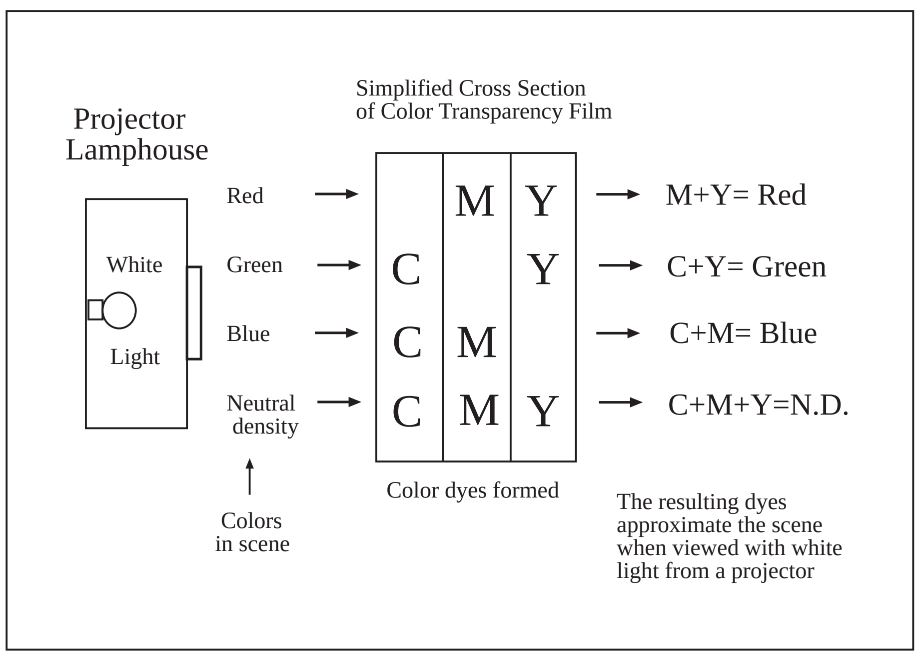

Figure 9: Color formation in photographic film

ly does in digital imaging. High-resolution film is less sensitive to light, and requires more exposure, because the light-sensitive crystals are smaller and have less surface area to collect light. More light is also needed for digital imaging so that all the photosites can be activated. When more photosites are activated, more picture elements are used to make up the image, and greater resolution is achieved. Current technology severely restricts how small and numerous these photosites can be when compared to high-resolution conventional film.

In color photography, the same light-sensitive silver halide principles are used to form a latent image, although the development of the visible silver image from the latent image is just a preliminary step. Color film contains silver salt layers that act as catalysts in the formation of cyan, magenta, and yellow (CMY) dyes in the final image. Bromide is released as a by-product when the silver is formed in these layers during development. This bromide by-product reacts with an oily substance, called a color coupler, in the film. There are couplers in the layers of the film that produce CMY images upon contact with the bromide. The silver formed in the production of the CMY dyes in color processing is bleached out in the later steps of development. Therefore, the final image contains only CMY dyes (Figure 9). Early color photography used the additive red, green, and blue (RGB) photographic process similar to the RGB glowing phosphors on a TV. Since RGB pigments could not be created on a minute chemical level, they could not produce as much resolution and this approach was abandoned with the exception of Polaroid instant photography.

Relationship between photographer and printer

Film-based photography is capable of producing images with a greater dynamic range and higher resolution than digital cameras. The main problem is that the detail and tonal range of film-based photographs are greater than the capabilities of printing presses. Digital images have less dynamic range than film-based photographs, so they are closer to the range that the press can reproduce. Many film-based photographers use the full range of tones available in film and are not aware of the tonal limits of the printing process. In many cases, the printer is able to compress tones in originals at a point where they are not easily detected, such as in dark shadow areas.

Many factors of the printing process can be standardized, although conventional photographs are almost never the same and variations are hard to anticipate. Because photographs are often inconsistent, a scanner operator must develop skills to interpret and correct for miscalculations and standard variations in originals. Standardization is likely to improve when more photographs are created digitally. Digital photographs are more consistent, so the quality control loop can be tightened between the photographer and the printer. Until this happens, inconsistency will prevail as a consequence of mixed imagery.

Many photographers are trained to produce display originals for gallery applications. Such originals usually utilize most, if not all, of the range of tones the imaging system can produce. It is a common practice in photography to make sample swatches of the highest and lowest densities the photographic material can produce and use these as aim points for placement of the highlight and shadow. This procedure ensures a wide dynamic range, which is appealing for display purposes, but is inappropriate for even the best printing conditions. Original prints made for display purposes can have a range higher than 100:1, while transparencies can range from 250:1–500:1 and above. In one example, the range from white paper to maximum ink density in one press impression can reach 20:1 and duotones on coated paper can reach 100:1. It is unfortunate that many photographers are not aware that tone reduction can reach up to 50%. Some photographers have the impression that a printed facsimile is possible and information such as "match original" may be the only input given by the photographer. Faced with this type of unrealistic instruction for a long range original, it is easy to see why printers may be skeptical of the value of communication: "Photographers are becoming careless and submit photographs with inferior quality that cause many problems in reproduction," or "it is realized that photographers will construe any effort to get them to reduce the lighting contrast of their originals as an attempt to stifle their creativity" (Bruno, 1989 p. 94).

The importance of graphic arts training for photographers depends upon the environment in which the photographer works. A freelance commercial photographer serves a variety of clients who may use different printing houses that produce at varying levels of quality. Even in situations where consistent corporate publication departments or art directors are involved, it would be desirable for the photographer to understand that consistency can greatly reduce work and aggravation for the printer. Experienced commercial photographers develop competencies that enable them to interpret which tones in a photograph are reproducible. Once the graphic arts is understood as a process of compromise, photographers can influence the reproduction of images by choosing tonal ranges that are reasonable.

Measured photography

Prepress scanning and image processing technology have made correcting original images far more flexible and rapid, but have not solved the basic problems of tonal incompatibility between photographs and printing processes. Standards, such as measured photography, have been proposed to assist photographers in conforming to reproduction parameters. Measured photography attempts to match the range of tones in original photographs to those that can be reproduced under local offset press conditions. Many digital photographers go a step further and are now in more direct control of reproduction because they submit images directly in the CMYK color space. Traditional photographers depend more heavily on the skill of others in the production team. For photographers who work directly with art directors, knowledge of tonal losses provides the ability to communicate which tones are most important to fit into the press window.

The implication of emphasizing the controls available to photographers is that quality control efforts can be focused on solving common problems in originals before they reach prepress. Eliminating or fixing a problem as early as possible in the reproduction chain costs much less than corrections made further down the reproduction chain. Measured photography is a method that photographers can use to conform the scene brightness range of their subjects to average press conditions (Sinar, 1987). Measured photography can convert the density range of ink on paper to an f-stop range that can be used by the photographer in setting up lighting in the studio or fill-in lights outdoors. The f-stop range is set by measuring the ratio between the key and fill light with a light meter. The key light is the brightest and defines the direction of the shadow in the scene. The fill light is dimmer and determines how much detail will be present in the shadow.

For excessive scene contrast in outdoor situations, use of an auxiliary light source will increase detail in the shadow areas. Auxiliary light sources can include a fill flash, reflector

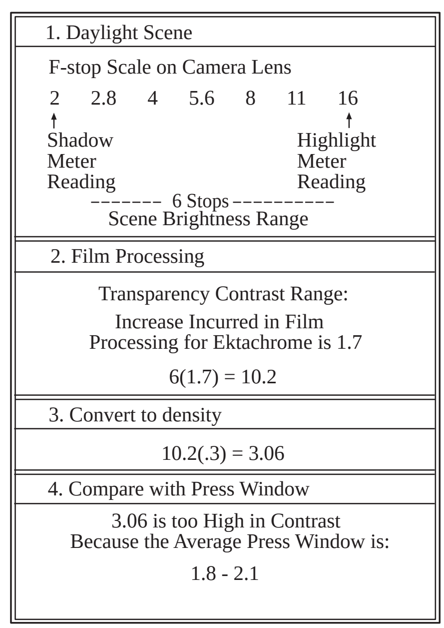

Figure 10: Example of how a daylight scene would not fit through a particular press window.

cards, and/or diffusion of the sunlight. Direct sunlight is convenient, but the ratio between light and dark is too great to be used without lighting modifiers. Photographers often measure ratios between light and dark or scene contrast on a light meter in f-stops such as f 2, 2.8, 4, 5.6, 8, 11, 16, and 22. Printers measure ratios between light and dark in photographs in density units. The scene brightness range of a typical daylight scene is commonly six f-stops, such as f-2 for the shadows and f-16 for the highlights. When a color transparency is processed, it gains additional contrast. In the case of Kodak Ektachrome film, the contrast increase is by a factor of 1.7, making the transparency contrast range a total of 10.2. Multiply the unmodified Ektachrome transparency contrast range by .3 to obtain density units. The result is 3.06, which is extreme contrast. In one example of local conditions, a particular press, ink, and paper combination can produce a density range from approximately 1.8–2.10 (4 f-stops) and 1.2 (3 f-stops) for uncoated paper (Figure 10). If photographers limit contrast to this range, there will be less difference between the original and the reproduction and a better chance for success. In this example, the photographer could be supplied with a range of f-stops in which to conform lighting methods. In the photographic studio, lighting is under total control, so the intensity of the fill light can be increased to lower the lighting ratio (Figure 11).

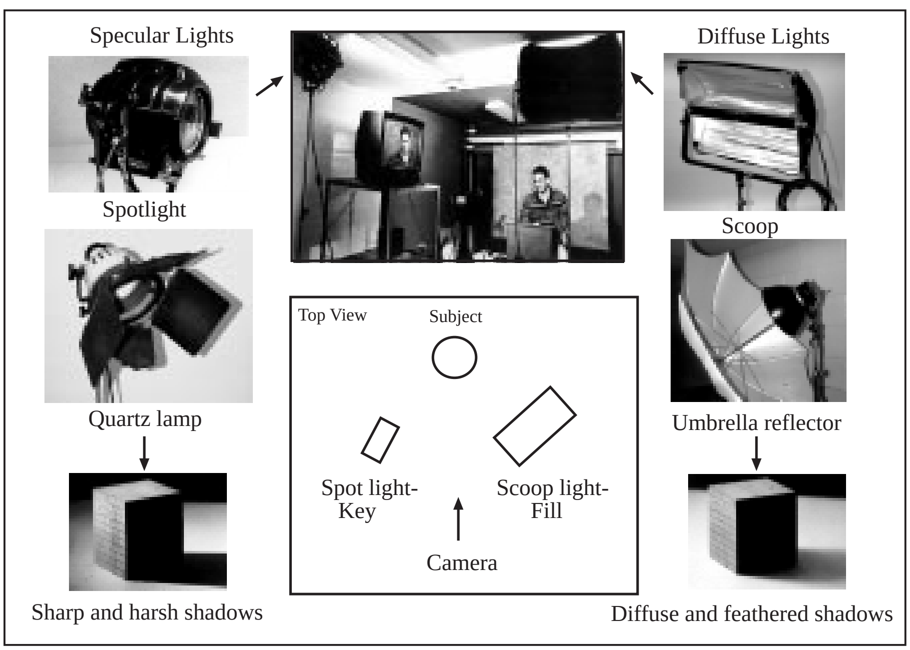

Figure 11: The key light defines the direction, shape and quality of the shadow. The fill light is dimmer, often more diffuse than the key and fills in the shadow cast by the key. The fill light intensity can be adjusted by moving the light back forth or adjustment of a light attenuator such as barn doors.

Figure 12: A simple hand held light meter can be used to measure the lighting ratio between highlight and shadow.

Measuring the ratio between the highlight and the shadow created by the key and fill lights is a common procedure already in use by photographers to set up lighting equipment. Although specialized equipment, such as the fibre optic meter made by Sinar, provides greater accuracy, the same procedures can be followed with an inexpensive hand-held light meter that almost any professional photographer already owns (Figure 12). Implementing the procedure can be as simple as metering the highlight and shadow and conforming this range to local press conditions.

One major limitation of measured photography is that results often lack the visual contrast of longer-range images. Altering local contrast (such as the inclusion of small reflections which do not contain detail), in conjunction with keeping total contrast within the press window, often offers a good compromise.

An ideal image would contain

only that range of tones that can be reproduced by the printing process without compression. Based on this ideal, the greater responsibility for tonal reproduction should reside with the originator of the image. In its present form, analog photography will not ever be able to precisely match reproduction requirements for this ideal. The exposure and development of a multilayer film does not offer the degree of precision and quality control that digital cameras have the potential to achieve. For this reason, tone control cannot rest solely in the hands of a photographer who uses conventional film. The scanner operator should be perform fine adjustment corrections that are not practical on the film exposure and development level.

The ideal of providing an image that precisely matches reproduction capabilities is drawing closer with the advent of low-cost and high-resolution digital cameras. When high-resolution digital cameras achieve wider adoption, measured photography standards could take on increased importance. An industry-standard tonal range, or local press conditions, could be programmed into the digital camera's microprocessor. When the lighting ratio, as detected by the CCD image in the camera, exceeds the programmed range, a gamut warning or code could be provided in the viewfinder.

It is important to realize that even with the wide range of corrections and special effects possible with digital imaging, it is only possible to realistically reproduce detail that was captured at the time of exposure. This is just as important with digital imaging as it is with conventional photography. If detail in the shadow is important and the photograph contains no detail in the shadow, as is typical in a sunlit scene, no amount of digital processing can bring out detail that does not exist. However, detail can be artificially added from another source. It may also be possible to electronically enhance detail from a deep shadow in an image, which may be useful as evidence or scientific documentation, but such an image would exhibit extremely poor image quality in a commercial publishing context.

Conclusion

Technology has a great ability to blend tasks and job categories. This has especially been the case in the printing and publishing industries over the past few years. Photography can be seen as the persistent missing link in the reproduction quality control loop because of an often artificial separation between the photographer and the printer. This artificial separation will be blurred as digital imaging becomes more wide spread and when most all images originate as digital data. The potential for a new level of standardization and consistency in prepress is important. However the standardization, has not arrived yet, in a complete sense, because of the cost and resolution factors explored earlier in this paper. In the mean time, the printer and the photographer do not have to wait for increased communication and standardization to happen as a natural consequence of the switch from film to digital. In the interim, local refinement of suggested standards, such as measured photography, can increase standardization.

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