QuickTime Virtual Reality – how to make panoramic images

by Brian P. Lawler

I have long been a fan of panoramic photography, and in the last 20 years have collected a few antique panoramic images and even taken a few with specially-built rolling-film slit-scan cameras.

Apple Computer has now satisfied my thirst for making panoramic images with its QTVR software. QTVR stands for *Quick Time Virtual Reality.*

The software has several functions: to "stitch" a

Software for QTVR

When making QTVR panoramics, you need special software.

The leader of the pack is Apple Computer's *QuickTime VR Authoring Studio.*

In researching this paper, I found and purchased three additional Macintosh products for making panoramas. One is called *Spin,* published by

A snippet from a panoramic image of my city. This was taken as 20 images on a point-and-shoot Nikon camera (with focus locked at infinity). The focal length of the lens is 28mm., and the field of view as calculated by Apple's QTVR software is about 70°.

series of panoramic still photos together, to "dice" the images into tiles appropriate for viewing, and finally, to build the complete interactive and navigable panoramic image.

The wonderful thing about the final QTVR images is the viewer software. When you use it, it's as if you were *inside* a photographic cylinder at the viewpoint of the lens as you look around the image.

There are two big classes of QTVR images: panoramic images and *object images.* A panoramic is made by rotating the camera through a series of steps to take a complete (or incomplete) panoramic image. An *object image* is taken of an object rotated in front of a stationary camera. The result is an image which is viewed on the computer screen as if you were moving *around* the object.

This essay concentrates on the panoramic image, but much of the information here applies to object images as well. At some point I'll expand this paper to include a discussion of objects.

Picture Works in Dublin, California. At US$99, it's reasonably priced, but I found its interface a bit hard to work out. I was unsuccessful in my first try to make a panorama with this software, and even after I succeeded, I came to the conclusion that the software is nice, but it takes too much operator intervention to make a successful panoramic. I was also unimpressed with the amount of blurring between frames created by Spin. It was too obvious to me where one frame ended and another began because of the blurs.

The second is called *Nodester* (rhymes with roadster) and it is so easy to use it's great. In one try, with no instruction manual, I succeeded in making my panorama. A demonstration version of Nodester is available from Roundabout Logic at 407-327-4500. The purchase price of the software is US$169.00.

You can download Nodester and make it work in a very short time. The results are great.
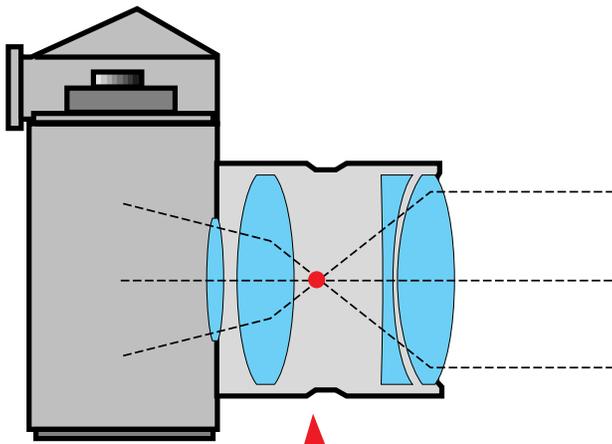
**Nodal Point of lens
and point-of-rotation of panoramic image**

The third product is called *PhotoVista* from Live Picture. At under $75, it's a great deal, and its interface is very nice. For those using the Windows operating system, both *Spin* and *PhotoVista* are also available for Windows.

Cameras, tripods and accessories

To make a QTVR panoramic image, you need a camera – and almost any camera will work. Moderately wide angle lenses are best, and good sharp lenses are reasonably important.

Apple's manual recommends very wide angle lenses (a 15mm Nikkor is shown in their manual). It's my experience also that panoramic images taken close to the subject with moderately wide angle lenses are much better than long (or even normal) focal length lenses.

So far, my most pleasing panoramic prints have come from images made with a 28mm lens. The aspect ratio of a 360° print from this lens is 5.7:1; the aspect ratio of a 15mm lens is much shorter, about 3.1:1. There is a huge – and visible – amount of distortion in such an image.

You'll also need a tripod. A sturdy one with a rotating head is required. I use a medium-quality (<$100) tripod for my panoramas; it works fine.
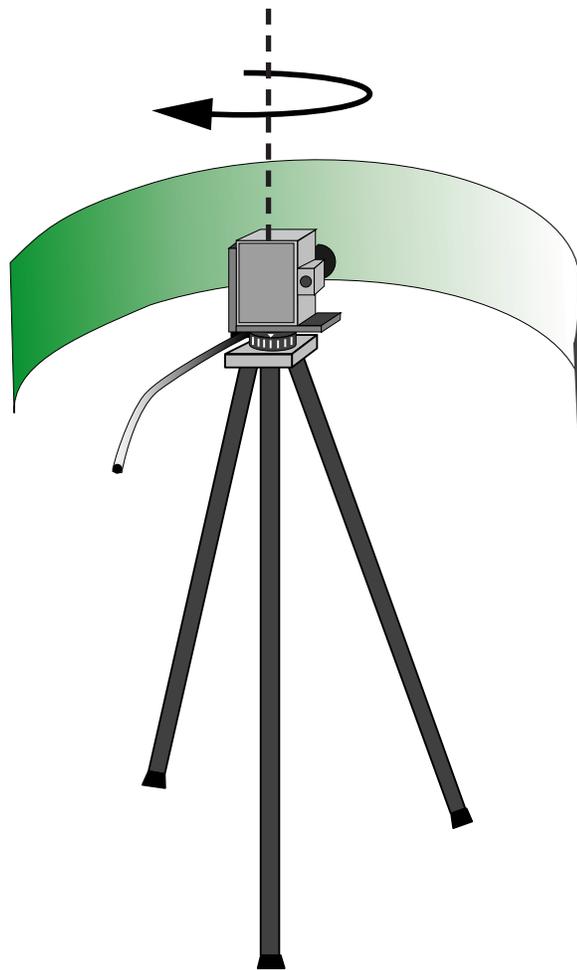
With the tripod and its rotating index head, the camera is panned through a series of frames to take the entire panorama.

The next part can be tricky: an indexing camera/tripod mount. For my panoramas I have used a wooden bracket that I made in my workshop (see the drawing on page 5 for details). For my first experiments, I attached this to my tripod and then held my camera to the mount with a sturdy elastic band! It worked fine. Recent advances include a nylon machine screw to attach the camera to the mount.

The important point is that the rotation of the
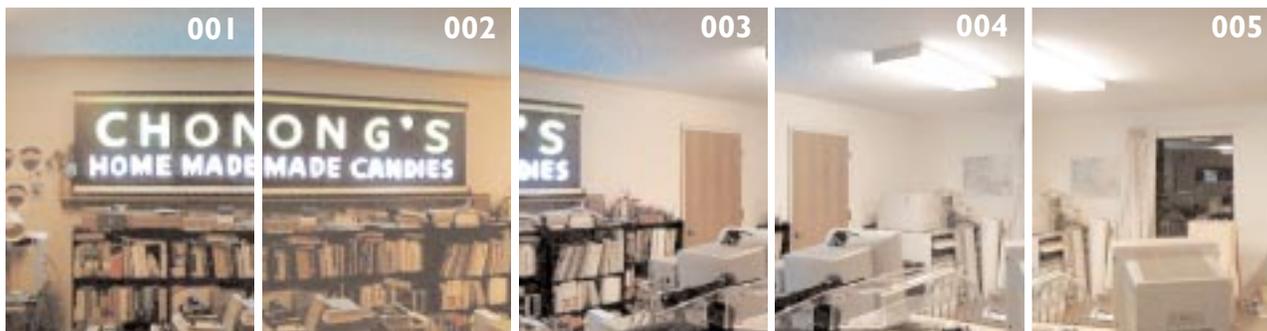
The successive images (five of 20 total) taken for the panoramic image are shot in a clockwise direction. Notice that there is considerable overlap of images, and some variation in exposure. In out-of-doors scenes, the lighting is an even more critical issue. There are a number of thoughts on the issue, but the best is to avoid the direct sun if possible. This can be done by placing the camera where it will be shielded from the sun by an object. Another is to shoot in the dusk or dawn hours where there is no direct sunlight. A third is to shoot during mid-day where the sun is high overhead and will not shine directly into the camera.

camera should be around the lens' *nodal point.* It's much easier with full-size lenses to find the nodal point, but on the small camera I was using, I just guessed the nodal point to be approximately half way into the camera, and it has worked beautifully.

I have now made numerous wooden panoramic bases, and find them to be excellent alternatives to

to get it perfect (but *perfect* isn't absolutely necessary – *close* counts here!).

Rotational indexing

On some commercial panoramic indexing heads there are click-stops for each photo. On Kaidan's heads, for example, aluminum discs can be inserted into the mount for ball-detent positioning.

This is a 140° section of my Taj Mahal panoramic. This image was made with a Nikon 35mm point-and-shoot camera and 16 individual images. The quality of photos from this camera is excellent, and the image profits from the use of film (as opposed to digital imaging). Scanning was done on a Scitex SmartScan by the Apple Publishing Technology Centre in New Delhi.

the nice, but more expensive aluminum variety on the market. I bought a spirit level at the hardware store for $3.50 (in the hand tools section), and I put that on the wooden base to set level when making my set-ups. A ball mount would be much easier.

Finding the nodal point

I have recently learned a clever way to find the nodal point for any camera and lens. You set the camera on its panoramic mount on a tripod, and focus the lens to infinity. Place a broomstick in front of the camera at a distance of roughly one meter.

Rotate the camera on the tripod head. If the broomstick shifts left-to-right relative to the background as you rotate, the nodal point is not correct.

Slide the camera on its mount forward or backward and repeat the process until the broomstick stands virtually still relative to the background while the camera turns left and right. Tiny forward or backward movements are necessary

This indexing strip was created in Adobe Illustrator, then printed on a color printer. I use double-sided tape to affix it to the rotational base of my tripod. This strip has 16 indices, yours may require more or less (see the table at right to determine the correct number). On one I made, I put both 18 and 16 indices so I could shoot with both 28 and 35mm lenses. When you buy a commercial mount you avoid all this measurement and construction, but I think it's fun.

My tripod mount features a *paper* indexing marker which is positioned visually for each frame. I make these indices with Adobe Illustrator and a plastic caliper. Measure the diameter of the rotational element of your tripod with the caliper, then calculate the circumference (πD) and draw an indexing strip for your tripod (see illustration below). Print the illustration on any printer, then attach it to the tripod with very high-tech double-sided Scotch tape (accuracy counts!).

Panoramic step-and-repeat

When taking a series of panoramic images for QTVR, you must step the rotation so that the

Focal Length	FOV Horiz.	FOV Vert.	Pan Steps
15mm	110°	72°	10
18mm	100°	66°	12
20mm	94°	62°	12
24mm	84°	55°	16
28mm	74°	49°	16
35mm	62°	41°	18
50mm	46°	30°	24

resulting images overlap by a considerable amount. Apple's documentation recommends an overlap of between 20 and 40 percent.

With this overlap, the QTVR stitching software can find enough common points in the images that it makes the process of combining the images into a single panoramic frame simpler.

Calculating the overlap and the number of steps with the digital camera is an interesting process. I succeeded by trial-and-error since I didn't know the focal length of my first camera's lens.

This is a part of a panoramic image taken on the surface of Mars in 1997. The rover *Sojourner* can be seen in the foreground, and the rock called *Yogi* is in the upper-right. NASA and JPL have used Apple's QTVR extensively in the Mars exploration photo imagery.

After gathering more information from lens manufacturers, I developed the table shown on Page 3. With this table you can look up the focal length of your lens, see the angles of Field-Of-View (FOV), and the number of steps necessary for a panoramic image. Each of these assumes a 35mm camera, mounted in a *vertical* position on the tripod.

Since the image must be shot in an even number of steps, whatever the field of view, it must be evenly divisible into the 360° rotation of the camera.

Once you have determined the number of steps to make your panoramas, you can take the photos and make a test panoramic image.

Which film to use for panoramas

My best experiences have been with color negative film because of its great exposure latitude. Kodak's ISO 200 Gold color negative is my favorite film because it allows for good depth-of-field and is good for most early morning and full sunlight shots. It is also virtually grain-free at the sizes at which I use it.

All negative films allow for greater exposure variations without overexposure, and as a result are superior to transparency films for panoramas. In bright sunlight, the range of exposure from the side to the sun can be greater than 4 stops, and most negative films can tolerate this.

Shots made directly into the sun will be overexposed or nearly overexposed, but this is acceptable. Transparency films, by contrast, cannot handle this exposure variation without overexposure.

Exposure considerations

One of the more challenging issues when making full 360° panoramic images is that of setting exposure. When you have control over exposure it's important to give all the frames exactly the same exposure.

Most point-and-shoot and digital cameras take over exposure control and won't give it back. When shooting with these cameras, there are a number of techniques for "controlling" exposure. One is to shield the camera from direct sunlight with an object in the panorama (I have often used a tree for this purpose). Another technique is to shoot just before the sun comes up, or just after it goes down.

Midday shots are also successful when the sun is so high that it does not appear directly in the scene, but this is hard to control.

When you can, set your exposure with the camera set at a 90-degree angle relative to the sun (see diagram on the next page). Set the exposure at this setting for the entire panorama, and take all your shots with this same exposure.

### Which resolution to use when stitching

When your images come back from the lab on Photo CD disc, you have five choices of resolution. I find that the Base and Base∗4 resolutions are most appropriate for QTVR panoramas.

Since I print most of my panoramas in addition to making the interactive version, I am interested in obtaining significant resolution in the finished files. Using Base∗4 images results in a file just over 35MB when I shoot 16 frames with a 28mm lens. This size is excellent for printing on my Epson 3000 ink-jet printer all the way up to 44 inches in length. It will reproduce at about 27 inches in length on an offset press with a screen frequency of 150 lpi.

If your intentions are less grand, you can use the Base-size files which will stitch into a finished panorama of just over eight megabytes. These are useful for printing at smaller sizes and still result in excellent image quality. I have printed them at 44 inches on the Epson, but I can see a visible quality loss compared to the higher-resolution Base∗4 images. I have tried making a panorama with Base∗16 files, but it takes a tremendously long time, and the results are not visibly better on my printer.

Stitching with QuickTime VR software

QuickTime VR Authoring Studio comes as a collection of panoramic and object movie making
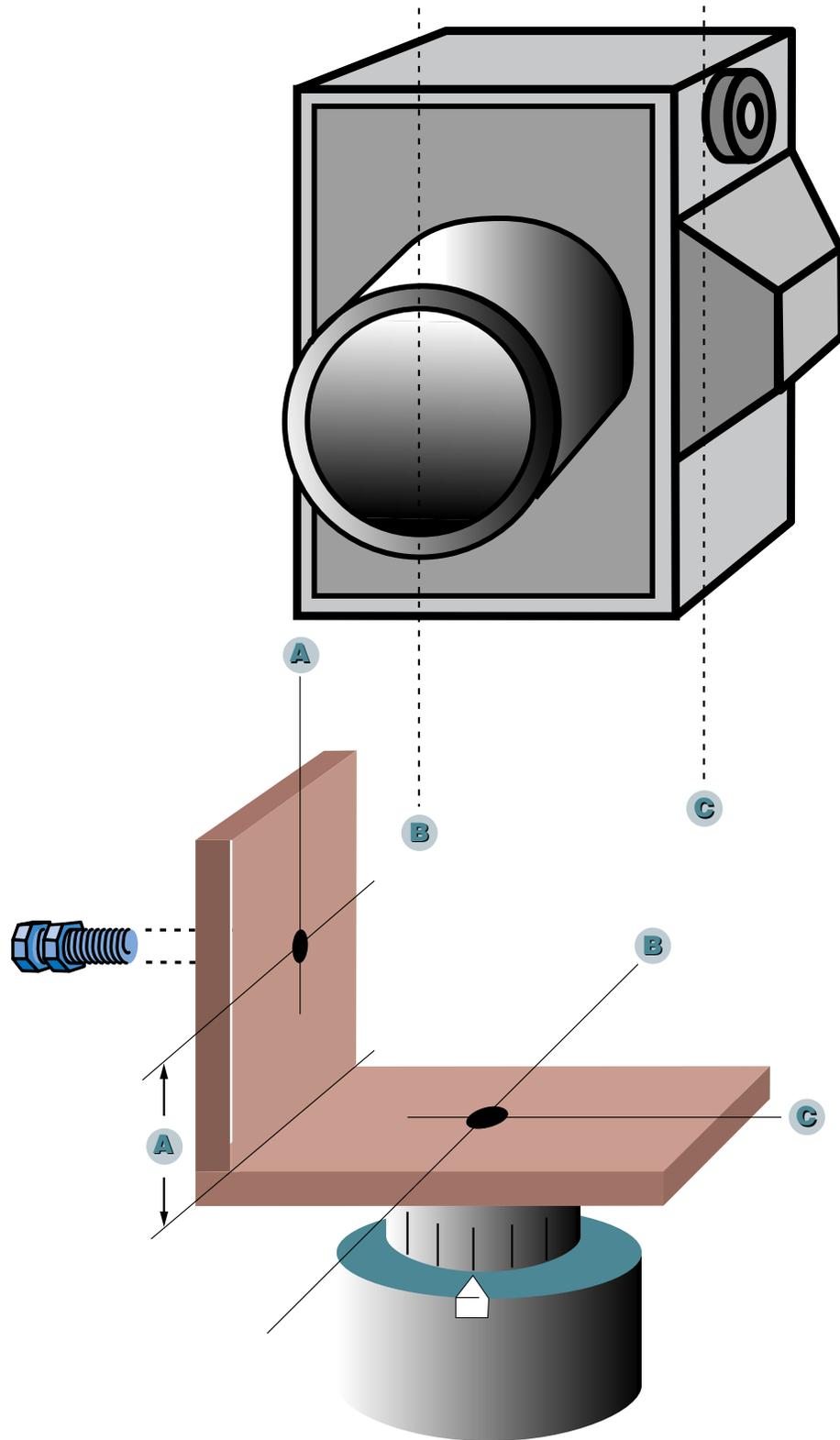
Build-your-own QTVR panoramic mount. My wooden panoramic mounts consist of two pieces of wood screwed together at a 90° angle. The measurements marked A are the distance from the edge and the front of the camera for the tripod screw in the camera base. B is the center point of the lens which will indicate the horizontal line of the nodal point position. C indicates the vertical dimension of the nodal point. It is determined by a process described on the next page (see *More on finding the nodal point*). The camera is held to the base by a ¼-20 machine screw with an extra nut for tightening.

The rotational indicator is made by measuring the circumference of the tripod base and splitting that distance into 12, 16, 18, or 20 increments (see the chart on page 3 for details). The pointer is a piece of white drafting tape cut to a point. If your tripod has no rotational base, you can make one by cutting two additional base parts and allowing one to rotate on the other; this can be a bit more complicated, but it's not too difficult.
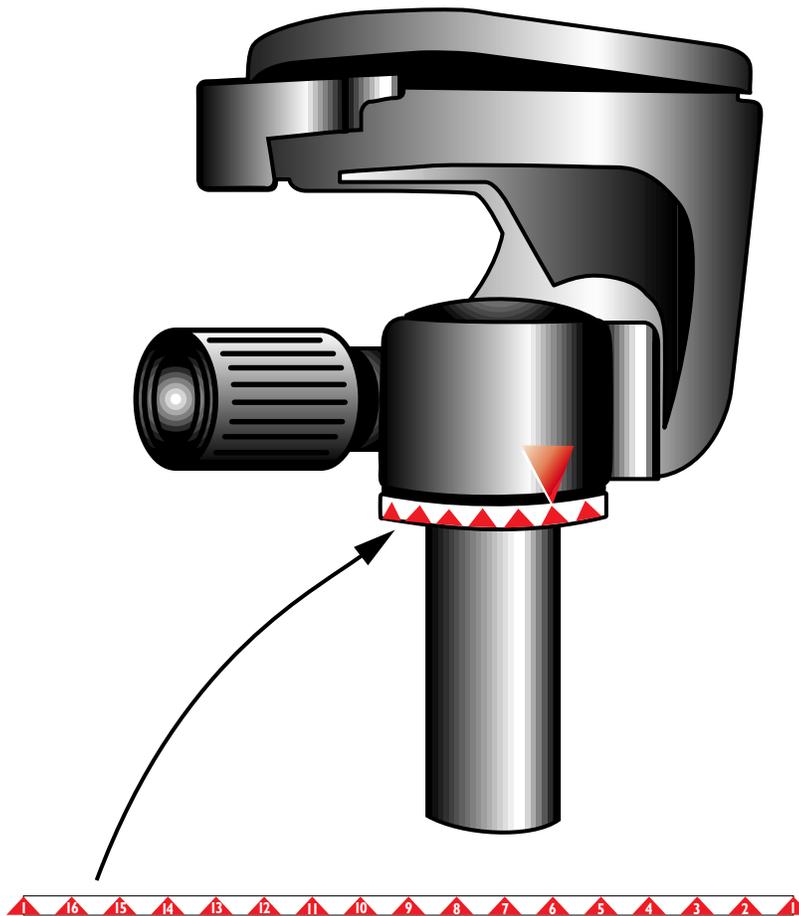
Making and affixing a rotational index is fairly easy. Measure the diameter of the rotational base of your tripod; multiply that diameter by pi, then build a strip to that length in an illustration program. Subdivide the strip into the correct number of steps needed for a 360° panorama with the lens you have chosen (see FOV chart on Page 3). Print it out and affix it to the tripod with double-sided tape. The pointer is a piece of drafting tape, cut with scissors to a point. This is low tech, high-quality technology!

tools. You can produce panoramic images, object images (photos of objects that can be viewed from any direction on the computer screen) or "scenes" which are a combination of panoramas, object movies, still images, and other graphic information to be navigated by the viewer on-screen.

The stitching step is the most impressive part of the QuickTime VR process. The software takes the images in the order you have designated, and looks for commonalities and points that can be stitched together to make a complete image. The stitch will cause the images to be stretched and blended together into a single seamless image.

The software can also sharpen the result before saving it, though I prefer to do this in Photoshop.

After stitching, the image is saved as a vertical panorama in a single PICT file. This is handy (except for the vertical part) because you can open it in Adobe Photoshop and retouch it if necessary, then save it again before continuing the process.

Dicing and finishing

When you are ready for the next step, the image is "diced" by the QTVR software into a number of tiles that work together to make the QTVR panorama. After dicing, the finished panorama is saved in a format that can be read by the player software on Mac or Windows computers (QuickTime is the preeminent time-based image format for both Windows and Mac).

Each of the panoramas I have produced is a single node image consisting of 16-20 frames taken on one level plane.

Hot Spots

QTVR panoramic images can also have what are called *Hot Spots,* these being image areas that can be used as buttons to activate other panoramic movies, still photos, sounds, and other actions.

The process of creating Hot Spots is pretty simple. When the vertical stitched PICT file is complete, a new bit-mapped single-channel image is created that has solids painted in for the Hot Spots. Then, using the QTVR authoring tools, these hot spots are assigned actions.

It's possible then to use the hot spot in one panoramic image to activate another node or another movie to "walk" though a scene comprised

of numerous QTVR panoramic images.

This is amazing technology, and it has opened my eyes to the potential for interactive panoramic images and scenes.

It requires a leap of imagination to put yourself inside the cylinder of an interactive panoramic image, but once you have experienced it, you'll begin to see opportunities for this kind of image everywhere. You'll begin to see things panoramically!

Sources of images

I have made panoramas now on three continents and in a several dozen locations. The results have been exciting (with a few notable exceptions).
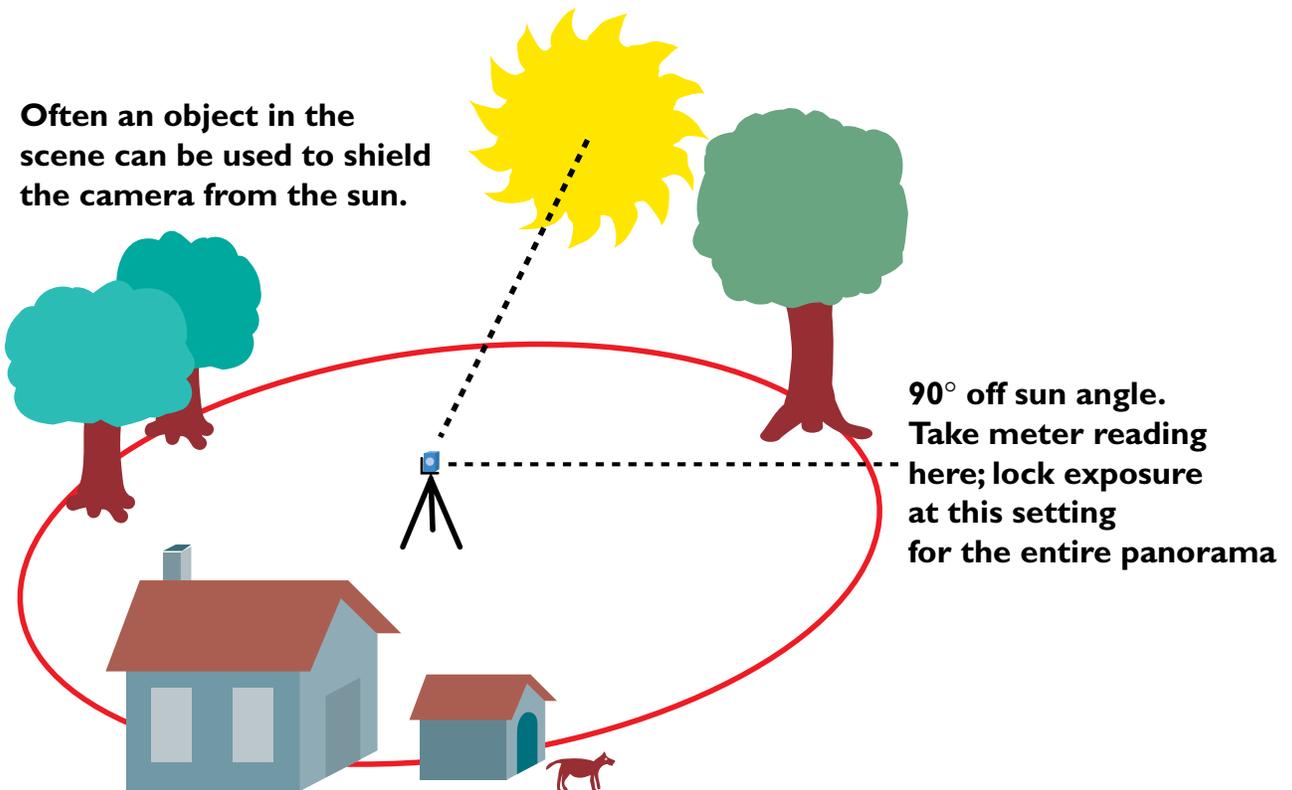
I have used four different digital cameras, the

consistent, and the positional accuracy of the frame in each scan is almost absolute. I never have to worry about the accuracy or squareness of the scans I get on Photo CD discs.

And, though I own two very nice film scanners, the difficulty of scanning and storing 20 or 40 images to get the files necessary for a panorama is too great. I'd rather pay the modest fee for Photo CD images to be made from my film. The results are better and more accurate than any scans I can make, and storage is not a problem.

Many happy panoramics to you!

Good luck, and have fun with this fascinating technology!

Often an object in the scene can be used to shield the camera from the sun.

90° off sun angle. Take meter reading here; lock exposure at this setting for the entire panorama

Kodak DC20 and the DC50, the Nikon Coolpix 900 and the Olympus D600L. The Nikon camera seems to have better color saturation than either of the other brands I have tested, so I like it best.

My film-based panoramas have been made with both my point-and-shoot Nikon camera and a fantastic Nikon N70 camera on a wooden panoramic mount (see next page).

After shooting the images on film, I have them processed and scanned to Kodak Photo CD disc by my favorite supplier – Color 2000 in San Francisco, California.

Compared to digital camera images, film has tremendously more information, more exposure latitude and better color. In a phrase, shoot film if you have time – the results are vastly superior.

I like Photo CD scans because they are

■ This is one of a series of free essays I have written on graphic arts and computer subjects. Subjects range from dot gain and halftone screens, to preparing files for the World Wide Web. For access to the others, please direct your browser to my site on the World Wide Web: **www.thelawlers.com**

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