

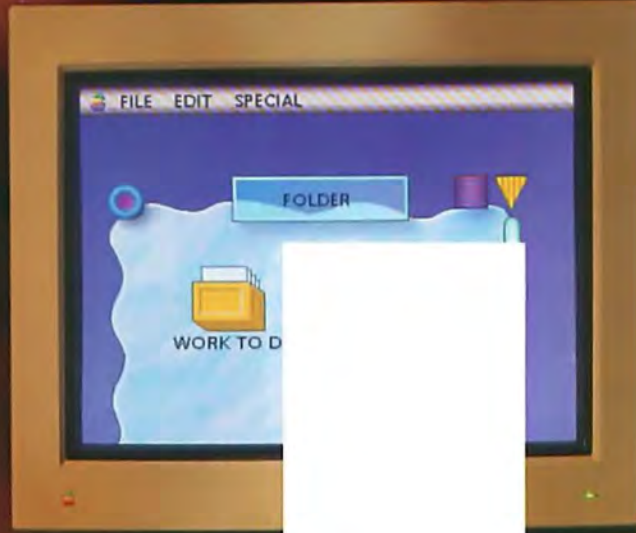
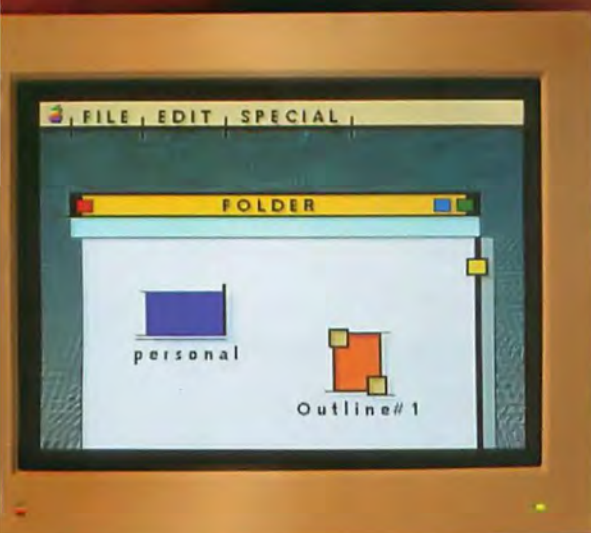
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VR: QUICKTIME'S

VIRTUAL REALITY—THE GOGGLES-AND-GLOVES TECHNOLOGY THAT IMMERSSES you in photo-realistic three-dimensional worlds that you can explore—requires more computing horsepower and hardware than a personal computer provides. Apple's QuickTime VR technology brings the best parts of virtual reality—user-controlled exploration and examination—to Macs and Windows computers. QuickTime VR doesn't demand goggles or gloves; you view a virtual world on the computer's screen and move around using your mouse or keyboard. QuickTime VR doesn't provide the total immersion of true virtual reality, but neither does it impose virtual reality's hardware requirements. Think of it as virtual VR.

A software supplement to QuickTime 2.0, QuickTime VR is the brainchild of two gifted programmers in Apple's Advanced Technology Group: Eric Chen, who invented the technology back in 1991, and Ian Small, who's been responsible for refining it for release. Together with QuickTime VR senior content engineer Ted Casey and program manager Eric Zarakov, Chen and Small gave me a day-long QuickTime VR introduction.



Apple's QuickTime VR brings the best of virtual reality to personal computers

NEW EDGE

by Jim Heid



MARK SCHANN

STAR TREK: YOU ARE THERE



The QuickTime VR Experience

Initially, QuickTime VR will find its way into multimedia CD-ROM titles, where it will join images, sounds, text, and conventional QuickTime movies. QuickTime VR adds a unique benefit: the ability to explore scenes and objects for yourself. A developer who uses QuickTime VR creates a virtual world that you can control instead of simply observe.

A conventional QuickTime movie is viewed from a single perspective. You can watch it from start to finish or skip around within it, but your view of the subject—say, an orchestra on a stage—was cast in stone when the original video was shot.

With a VR movie, you can change your view by clicking and dragging within the movie or by using the keyboard's left- and right-arrow keys. For example, dragging to the left causes the view to change as if you were turning your head to the left, while dragging up is the equivalent of looking up (see "Star Trek: You Are There"). Not only can you see the orchestra, but you can also turn around to see who's sitting in the row behind you. You can zoom in on the orchestra for a closer look, or zoom out to see the big picture. Apple calls a VR movie that provides this freedom of navigation a *panoramic* movie.

When creating a panoramic movie, a developer uses Apple's QuickTime VR authoring software to create a 360-degree image; it's this image that you navigate. Because the panoramic movie is actually a single still image, it can't contain motion—you can see the orchestra and audience, but you can't see the conductor's blurring baton or the latecomers scurrying to their seats. This is QuickTime VR's biggest disadvantage compared with goggles-and-gloves virtual reality.

QuickTime VR movies can also con-

tain hot spots—areas on which you can click to perform an action, such as display some text, play a sound, or most commonly, switch to a different VR movie. Our VR movie of the concert hall might have a hot spot below the exit sign—click on it to move to the lobby.

There's a key difference between QuickTime VR hot spots and the hot spots in non-VR CD-ROM titles: a QuickTime VR hot spot is embedded in the movie itself, and moves along with its object as you move around in the panoramic. In non-VR CD-ROM titles, hot spots are just static points on the screen; they aren't part of QuickTime movies.

Clicking on a VR hot spot might also allow you to examine a specific object from different angles by clicking and dragging—it's the QuickTime VR equivalent to picking up an object and turning it around. This kind of exploration is provided by a different type of QuickTime VR movie, the *object* movie.

Fortunately, as with linear QuickTime movies, QuickTime VR movies' consumer hardware requirements are modest. Apple recommends a 25MHz 68030 or faster Mac with 5MB of memory, or a 33MHz 386 Windows machine with 8MB of memory. And QuickTime VR movies themselves are remarkably compact—one panoramic movie uses only about 800K of disk space.

Unfortunately, QuickTime VR movies are expensive and complex to create. Apple's QuickTime VR authoring tools, the only software available for making VR movies, cost \$2000 and are difficult to use. ("You've got to be a wirehead to get this stuff to work," one QuickTime VR developer told me.) They also require a fast Mac with 40MB of memory. The authoring landscape may change over time, but initially, most of us will be QuickTime

VR consumers, not producers.

Here's a look at the process and the technology that developers use (see the diagram, "How Apple Makes QuickTime VR Feel Real," for other details on creating QuickTime VR movies).

From Pictures to Panorama

If you're a shutterbug, you've probably experimented with panoramic pictures: snap a picture, turn, snap another, and so on, until you've photographed a vista too grand for a single picture. Then you arrange the photos on a tabletop, aligning them where they overlap.

The first steps in creating a QuickTime VR panoramic movie are similar. Mount a camera on a tripod, orienting it vertically to capture as much of the subject's height as possible. To avoid distortion, the camera must be level and aligned so that it rotates around its optical center. Because a camera's tripod mount is on the camera body and not on the lens, a tripod-mounted camera will not rotate around its optical center unless you offset the camera slightly. Creating this offset today means using a heavy-duty tripod and an array of brackets and tripod heads containing levels (see "Photographing for QuickTime VR"). Apple is working with third-party developers to create simple low-cost brackets that would enable the use of lightweight tripods.

The number of pictures required for a full panorama depends on the camera and lens. Apple recommends using a 35mm camera with a 15mm lens. (A fish-eye lens won't work.) Apple also recommends that each image have 25 to 40 percent overlap with the adjacent images. That's more overlap than you'd use for tabletop panoramas, but it leads to a better panoramic movie.

You can also take 360-degree images

QuickTime VR lets you explore locations using the mouse or the keyboard's arrow keys. The scenes shown here are from the first CD-ROM to use QuickTime VR, Simon & Schuster Interactive's *Star Trek: The Next Generation Interactive Technical Manual*.



Left: We're on the bridge of the USS Enterprise. We can look left and right or zoom in and out if we want, but in this screen, we're about to jump to a different bridge location—the helm station. (The arrow pointer means the mouse is over a hot spot that leads to a different location.) **Middle:** We've arrived at the helm station and we're in the process of turning to the right, as indicated by the right-pointing arrow. **Right:** We've turned almost 180 degrees to look at where we came from. The mouse is over the hot spot that, if clicked, will return us to our original location. (For information on this \$69.95 CD, call 212/698-7000.)

using panoramic cameras, which contain motorized mechanisms and special shutters for capturing a 360-degree image in one fell swoop. One drawback, however, is that panoramic cameras are expensive, ranging in price from \$1000 to over \$15,000. Another drawback is that the resulting image is likely to have areas that are poorly exposed—for example, in a panoramic of a sunrise scene, the area opposite the sun will be too dark. By comparison, if you take individual photos and adjust the exposure for each, the QuickTime VR software can blend adjacent images to provide a smooth dynamic range across the panorama.

You'll snap a dozen or so photos to capture a 360-degree scene. Your next job is to get them into digital form by scanning them or having them transferred to Kodak Photo CDs. Many QuickTime VR developers prefer the Photo CD approach—Photo CD scanners yield better images than most desktop scanners, the Photo CD supplier does the grunt work behind scanning the images, and the discs are an ideal archiving medium.

The previous descriptions assume you're working with photographs, but you can also create a VR movie from a series of images generated by a 3-D rendering program—a prospect likely to lead to a new generation of *Myst*-like adventure titles.

Stitching Time

The job of combining individual images into a 360-degree panorama falls to a program called the *Stitcher*, part of the

QuickTime VR authoring kit. The *Stitcher* is the most important component of QuickTime VR—without it, creating a photographic QuickTime VR movie would require one of those expensive and inflexible panoramic cameras.

The *Stitcher* combines multiple images into a single file. That's the simple description. The *Stitcher* performs what computer graphics gurus call *environment mapping*—mapping, or projecting, an environment (such as a concert hall) onto the inside of a shape, such as a cube or sphere. In QuickTime VR's case the shape is a cylinder. When you navigate a QuickTime VR movie, you are in essence moving within a vertically oriented tube whose inner walls contain the panoramic image. The *Stitcher* distorts the original images—which were intended to appear on a flat surface—then combines them into a seamless panoramic image.

The *Stitcher* usually performs its magic automatically by comparing the pixels in each image to locate the points where they overlap. If the images don't overlap neatly—perhaps one was scanned crookedly or the tripod moved during the photo session—you can use a manual-stitching mode, which lets you use the keyboard's arrow keys and number pad to move and resize images. But according to Apple, 80 to 90 percent of properly photographed panoramas can be stitched automatically. On a Power Mac 8100, automatic stitching takes about 5 minutes; on a Quadra 900, it takes about 40. Exact stitching times depend on the resolution and quantity of the images.

As it combines images, the *Stitcher* blends the intensity levels of each one to compensate for differences in lighting or exposure. The more the images overlap, the smoother the blends.

Painting Hot Spots

The *Stitcher*'s end product is a PICT file containing the complete panoramic. When opened in an imaging program such as Adobe Photoshop, the PICT file appears warped and distorted. But the scene is clearly recognizable, and you won't find a single seam that gives away the image's past as a dozen separate images.

At this stage, you can use any image-manipulation program to correct color balance, retouch a flaw, or remove an unwanted object. You can also create hot spots that will cause things to happen, such as a text description to appear or an object movie to be displayed.

If you've created hot-spot buttons in an authoring package such as HyperCard or Macromedia Director, you're probably used to using a click-and-drag tool to select the area to be made hot. QuickTime VR approaches hot spots differently: you actually paint them using an imaging program. For example, to create a hot spot for a sculpture, you paint over the sculpture with a solid color. To create another hot spot for another sculpture, choose a different color and then paint it. By giving each hot spot a unique color, you enable QuickTime VR to distinguish between hot spots.

After painting hot spots, erase the rest

of the image and then use the Save As command to create a new image file containing only the hot spots. During a later phase of the development process, a QuickTime VR authoring tool combines this hot-spot image with the original panoramic. The painted hot spots don't appear on the screen when the VR movie is playing, but QuickTime VR knows where they are. When the mouse pointer moves over a hot spot, its shape changes to tell the viewer that he or she can click on the spot to make something happen.

The painting approach to creating hot spots is more laborious than an authoring program's draw-a-selection approach, but it has unique advantages. It allows you to create extremely precise hot spots—right down to the single-pixel

level. And this makes possible dramatic on-screen effects, such as everything except the hot-spot object disappearing when you click on the object.

From One Place to Another

An important part of the QuickTime VR experience involves moving between locations. Making this experience possible requires creating a separate panoramic for each location, or *node*, and then using QuickTime VR's HyperCard-based scene editor to link the locations.

Making a conventional QuickTime movie means thinking like a movie director; making a multinode QuickTime VR movie means thinking like a tour planner. You must address such issues as where a user is looking and where the user

can go from a given location. Multimedia developers have always had to think about navigation, but because a VR movie can display any portion of a 360-degree panoramic, developers must decide which portion of a panoramic should be visible when a user jumps to it. That view would vary depending on where the user came from. For instance, in my concert hall example, when you click on the exit-sign hot spot to jump to the lobby, you'd expect to be looking out at the lobby when you arrive there. It wouldn't make sense to click on the exit sign and then find yourself looking at the lobby door that leads back into the concert hall.

The scene editor helps you plan a virtual tour by enabling you to draw a top view of the entire scene and then add

HOW APPLE MAKES QUICKTIME VR FEEL REAL

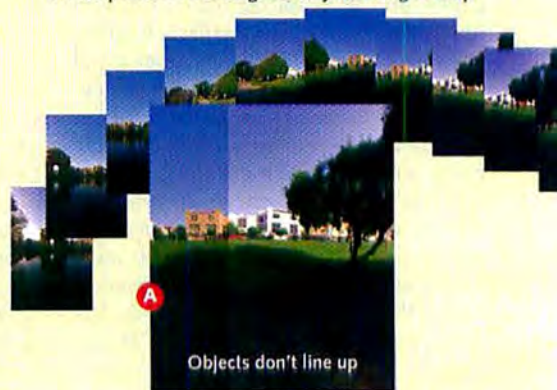
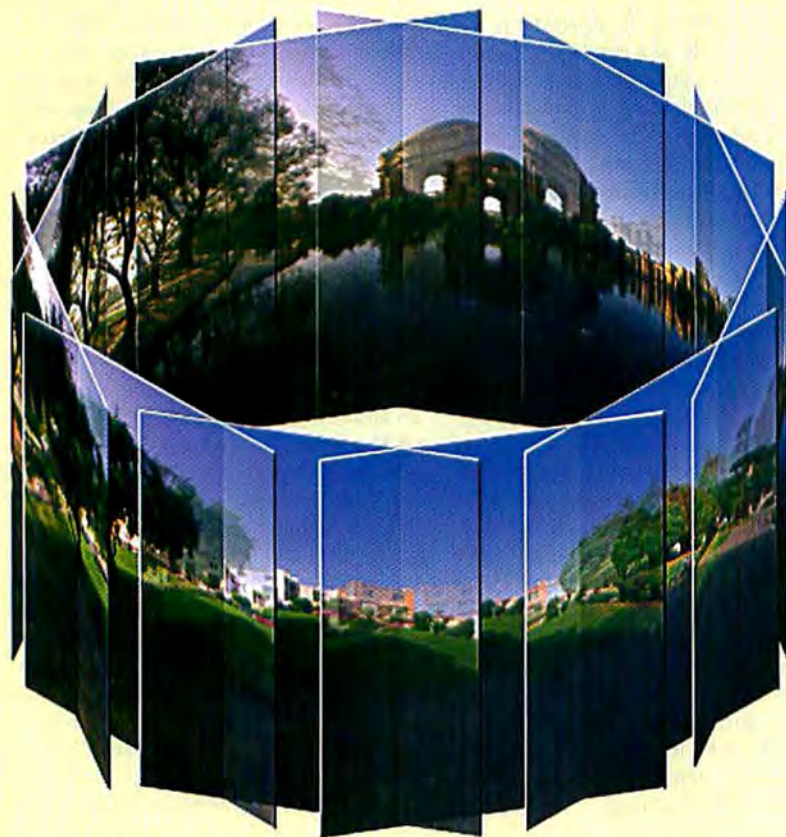
Apple's latest foray into you-are-there technology, the QuickTime VR movie, sets you in the midst of a navigable, 360-degree scene and lets you explore the virtual environment. Apple's VR approach overcomes various problems inherent in patching together a series of flat images and projecting them onto a cylinder to create a three-dimensional feel. While competing technologies require the use of special, expensive, panoramic cameras, VR developers can use an ordinary camera to capture a scene that surrounds you and lets you pan up, down, and side to side.

Capturing the Scene

You capture a scene by shooting a series of overlapping photos. Mounting the camera on a tripod lets you keep the same center point as you swivel the camera; the tripod also keeps the whole series on a level plane, ensuring that the first and last shots in the sequence will line up.

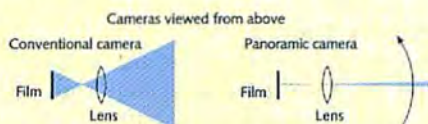
Making the Movie

You might think you could create a scene by simply butting pictures taken with a conventional camera up against each other (A). But unless taken with a panoramic camera, the pictures won't normally match up. QuickTime VR compensates for misalignment by distorting or warp-



Why QuickTime VR Emulates Panoramic Photography

A conventional camera exposes a whole rectangle of film all at once, and only the center of the frame faces the scene straight on. Toward the sides, the scene is exposed at an increasingly oblique angle, creating distortion. A high-end panoramic camera pans around a scene, exposing the film through a narrow slit. At any given moment, the camera captures a thin slice at the center of the camera's view, and the incoming light for each exposure hits the film straight on and without distortion.



nodes corresponding to each of the panoramics you've created. You can draw hot spots on a given panoramic that, when clicked, will display other panoramics. You can specify what part of a panoramic will be displayed when a user jumps to it.

The scene editor generates a series of PICT files containing the hot spots along with a file containing information that tells QuickTime VR what part of a panoramic to display. Another utility in the QuickTime VR authoring kit combines these files into a finished QuickTime VR movie—a single file containing as many locations as you defined.

The Bigger Picture

Most QuickTime VR movies are built into multimedia productions that also

contain text, sound, still graphics, and linear QuickTime movies. Apple has created a series of external commands (XCMDs) that enable developers to access QuickTime VR movies within Director or HyperCard. The XCMDs extend Director's and HyperCard's capabilities, letting them open QuickTime VR movies, scale them to a specific size (most CD-ROM titles display QuickTime VR movies at the quarter-screen resolution of 320 by 240 pixels), and display a specific portion of a movie at a specific zoom setting. For developers, integrating finished QuickTime VR movies into a production is similar to integrating linear movies.

The QuickTime VR XCMDs also enable QuickTime VR to communicate with the authoring program by sending

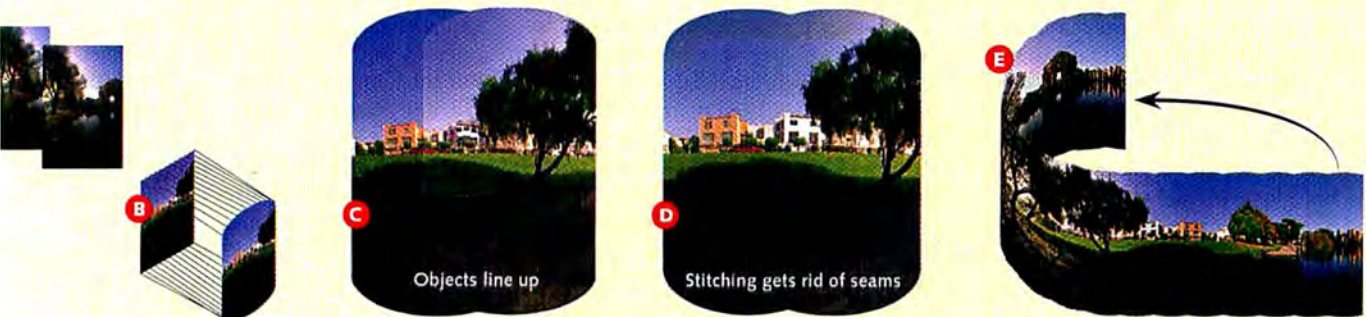
messages when various events take place. These messaging features enable a production to display text or pictures when someone clicks on a VR movie's hot spot.

Developers can also use the messages to play sounds—indeed, this is the only way the first release of QuickTime VR can work with sound. Future versions are likely to have more sophisticated sound features that will enhance the virtual reality experience. Imagine a virtual walk in the woods, where a babbling brook becomes louder as you approach it; imagine exploring a hotel room and hearing traffic noise increase as you approach the window. For now, you have to imagine these things, because the current incarnation of QuickTime VR is geared toward the eyes, not the ears.

ing (B) each image so that it appears as if it were taken by a panoramic camera. Once warped, images will match when they overlap (C). QuickTime VR then analyzes the areas of overlap and blends, or *stitches* the images together (D).

Once all the images, including the first and last, are stitched together into a virtual cylinder, the panorama is complete (E). Because QuickTime VR treats the scene as a single image wrapped inside a cylinder, you can pan around the image (instead of sliding

along it as you would when it's flat). You can even pan up and down and continuously from side to side in either direction.



Viewing the Scene

Now that you're done making the movie, you'll want to view it on a flat medium. As you might suspect, simply projecting a series of slices from the cylindrical image onto your monitor won't create a realistic view. To compensate for distortion caused by warping, and to heighten the realism, QuickTime VR manipulates the image, instantaneously, as you pan around the movie.



QuickTime VR compresses the image in the center. This compression makes objects increase in size as they move toward the edge of a view, giving side-to-side panning a more realistic feel.



To increase the realism of a vertical pan, QuickTime VR brings data in from the sides of the image at the top (as you pan up) or bottom (as you pan down). This simulates the sensation that your field of vision broadens as you look up or down, as it does in real life.

PHOTOGRAPHING FOR QUICKTIME VR



To avoid optical distortion when creating a photographic panoramic, you must mount the camera so that it rotates around its optical center.

The camera on the far left uses an array of brackets (available at photo dealers) to offset the camera from the tripod head. Small levels attached to the camera's flash mount enable you to adjust the tripod head so that the camera is level—if it isn't, the last photograph in the panoramic will not match up to the first. A simplified mounting bracket (near left) is being developed by Peace River Studios (617/491-6262). Rube Goldberg tripod mounts aren't all you need for QuickTime VR development. You also need a fast Mac with at least 40MB of RAM to run Apple's \$2000 QuickTime VR authoring tools software. And don't expect click-and-drag moviemaking; the authoring tools, which rely on Apple's Macintosh Programmer's Workshop (MPW) programming environment, use a crude text-based interface. They're extremely powerful, but the learning curve is steep.

The Last Word

The future of QuickTime VR looks auspicious. Apple has already demonstrated enhanced versions of QuickTime VR that enable Power Macs to display full-screen VR movies. And there's no reason that QuickTime VR couldn't be made to work with the inexpensive video-game gloves and television glasses available today. Low-cost peripherals like these would help make QuickTime VR more like goggles-and-gloves virtual reality.

In the near term, though, consumers will encounter QuickTime VR on their video monitors, and primarily in CD-ROM titles. That's too bad—you've probably thought up a few fun ways to use QuickTime VR already, and if you're an architect, real estate agent, teacher, or travel agent, you can probably imagine some genuinely valuable ways to put it to work. For now, we'll explore QuickTime VR movies instead of creating them.

As for developers, there are definitely content and marketing advantages to catching the QuickTime VR bandwagon, but the cost of ridership is high. In addition to the mountainous learning curve of the QuickTime VR authoring tools, there's the price: besides the \$2000 it charges for the authoring tools, Apple requires a royalty of 40 to 80 cents per

unit on CD-ROMs containing QuickTime VR movies. (The amount varies depending on how many VR movies a title has; there are no royalties for non-commercial applications.)

Pioneering QuickTime VR developers I talked to were not pleased with the idea of paying Apple royalties in perpetuity. Some have halted their efforts in the hopes that Apple's policy will change. Peter Black, president of Xiphias, whose titles include a CD-ROM based on the Mighty Morphin Power Rangers, expressed similar frustrations: "The technology and its visual effect are extraordinarily powerful, but Apple has treated it as if it were a crown jewel... I've seen this at Apple before—it's very frustrating."

What's more, QuickTime VR has competition—and wouldn't you know, it's from Microsoft. At the Winter 1995 Consumer Electronics Show, Microsoft announced Surround Video, which provides full-screen panoramic movies for 486 or faster Windows machines. Surround Video has serious limitations compared with QuickTime VR, starting with the fact that it's vaporware: it won't be available until Windows 95 ships. Also, you can't zoom in and out on Surround Video movies, and developers must use a panoramic camera to shoot scenes—

there's no equivalent to the QuickTime VR Stitcher. (This impacts not only costs but also quality: panoramic cameras typically have a smaller vertical field of view than the camera configuration Apple recommends for QuickTime VR movies.) But the Surround Video development tools will be free, and Microsoft will not charge royalties on Surround Video titles.

QuickTime VR is an impressive achievement that reinforces Apple's role as the innovator in personal computer multimedia. But Apple's zeal to turn QuickTime VR into a profit center may slow its initial adoption and perhaps even relegate it to the backseat of Microsoft's limousine. As this issue went to press, Apple was reconsidering its requirement that developers pay royalties on titles that incorporate QuickTime VR. As well it should. Whether we're talking about QuickTime VR or the Macintosh Operating System itself, Apple needs to make its technology more accessible in order to gain the market share it needs. There's nothing virtual about that reality. ■

Contributing editor JIM HEID is the author and producer of *Macworld Complete Mac Handbook Plus Interactive CD*, third edition (IDG Books Worldwide, 1994).