8. Resource Delivery and User Issues

8.1. Overview of resource delivery issues and user interface (VR tours)

There are many ways to view digital panoramas: over the Internet via a web browser, on a DVD-ROM, or directly off of a computer's hard drive. Each of these methods has choices and limitations for preferred viewing options. Because of the vide variety of playback applications it is possible to view panoramas on almost any type of modern computer or operating system. No special display or projector is required; any properly calibrated color display will do. And the software required to view digital panoramas is (more likely than not) already installed on the user's computer or easily accessible.

However, internet connections can be slow or limited and publicly available machines may be constrained or out-of-date. DVDs and hard drives are convenient and can include necessary software, but of course the user has to be in the same location as the disc or drive, limiting access and distribution. There are other factors that may influence choice of one delivery system over another, including the panorama's size, complexity, and intended audience.

8.2. Viewing platform

Because computer hardware evolves so quickly, it is difficult to attempt to nail down specific standards for the minimum and platinum systems for viewing digital panoramas. Successful deployment depends largely on file size, network speed, memory and power of the computer, quality of graphics hardware and amount of video RAM, playback software and compression used, and many other factors. Be sure to check the minimum and recommended system requirements provided with the viewing software that will be displaying the panoramas. In general, most viewing software requires either a Windows or Macintosh OS X system with at least 256 MB RAM, and a fairly new video card (probably from within the last five years). The user will also need a mouse or trackball and a keyboard to interact with the panoramas.

Depending on the intended audience, the ideal deployment strategy may be aimed at several types of viewing environments in order to take full advantage of high-resolution

images. One arrangement might be to offer a full-resolution version via DVD-ROM and optical fiber intranet commonly used by many colleges and universities and a lower resolution internet version better suited to a wide audience. Alternatively, both full- and low-resolution versions could be offered on-line.

Display devices include CRT, LCD, plasma flat panels, and large-scale LCD multimedia projectors. Any of these is perfectly acceptable, but a higher quality display will show higher quality images. The larger the projected image, the more realistic it will feel to the audience, particularly with high-resolution panoramas. One of the main advantages to a high-quality display is that more colors will be visible. A CRT display may have thousands of colors while a cinema LCD can reproduce millions of colors. A high-quality LCD is fine for individual use, but when presenting in a classroom or lecture hall, an XGA with 1024 x 768 resolution with at least 35,000 ANSI lumens would be required.

There are also software packages being developed for viewing panoramas on portable devices, such as cellphones and PDAs. While the viewing quality is not going to be as detailed or high-quality as on a larger monitor and there are complications with navigation and file access, there are practical uses to being able to download panorama data onto a small handheld device. Possible applications might be for patrons visiting museum exhibits or buildings, tourists in scenic areas, or classes touring historic sites. Helmut Dersch has written several software applications for placing panoramas on handheld devices and in PDF files.

8.3. Presentation: software and viewing options

There are many options to choose from for viewing digital panoramas. There are essentially three methods for viewing these files: via a web browser or locally from a DVD-ROM or off a computer's hard drive. Below are some of the more popular playback applications that allow viewing of panoramas over the Internet and embedded within a webpage:

- QuickTime Player/Pro
- SPi-V (hardware accelerated, based on Shockwave 3D)
- Java
- SpinControl (based on the QuickTime Player)
- iPix
- PTviewer
- PangeaVR (OpenGL accelerated)
- ActiveX (for PCs)
- Flash (based on Shockwave 3D)

Some of these players can simply be embedded into an HTML page, while others require a bit more coding. The vast majority of users will have the QuickTime player installed on their machines, though SPi-V and Java viewers are becoming more prevalent. Most modern web browsers will be able to use these playback applications, notable Mozilla Firefox, Apple Safari, Shiira (Mac only), and Camino (Mac only). While this allows for easy

distribution, viewers may not have the time or resources or skills to install the necessary software, and those with slow connections may not be willing to wait for large files to download.

For viewing panoramas on a CD-ROM or DVD-ROM, many developers use Macromedia Director/Flash, LiveStage Pro, or iShell by Tribalmedia. Third-party viewers (such as CubicNavigator or QuickTime player) can also be used in conjunction with these authoring environments. DVD-ROMs are a good way to distribute projects while maintaining security over the intellectual property. They are quick and convenient, and can hold large amounts of data.

Directly loading panoramas onto a computer's hard drive makes for the fastest loading and playback. While not practical for wide distribution, this is a good method to employ within a single university department. It also avoids any potential disruption from poor internet connections and there is no need for peripheral devices, such as a DVD drive. The computer will need sufficient hard drive space and RAM, a decent video card, and appropriate viewing software (such as QuickTime Player). VRML is also popular, especially with projects that integrate CAD environments and 3D sound. Click Here Design's CubicNavigator is a good choice viewing cubic panoramas on a Mac OS X

QuickTime Player vs. QuickTime Pro

Virtually all current Apple computers have Apple's QuickTime Player installed, and many machines equipped with Microsoft Windows do as well. The program is available for free on the Web for either Mac OS X or Windows and is distributed with Apple's iTunes. This is by far the most popular playback application used to view digital panoramas, largely due to the high-quality playback, ubiquity, and (zero) cost. However, due to the proprietary nature of the software, it is not ideal. As Apple releases new versions, third-party companies that provide auxiliary functionality may not have the resources to keep up. Case in point: the Zoomify VR plugin, by Zoomify. This is a very popular mosaic-compression plugin for the QuickTime player that enables very high-resolution, large QTVR movies to be viewed much faster than if one had to queue the entire file at once. Currently, however, the plugin does not work properly because of QuickTime updates.

Upgrading to QuickTime Pro ($30 at the time of this writing) provides some very nice features, particularly for the developer or heavy user of QTVRs. The most important feature for the developer is the ability to edit and add new annotations, such as author and copyright information (see section 6.10). Included is the ability to save-as source, that is, save the content of a movie to the hard drive, similar to right-click or ctrl-click saving. For the viewer, the biggest advantage is the enabling of full-screen viewing. Whether these additional features are worth the cost of the upgrade will have to be up to you to decide.

machine. The major advantage of this application is that it employs OpenGL, a feature of the computer's graphics hardware that comes with most computers built after the mid-1990s, instead of relying on a software engine as the QuickTime Player does. The result is amazingly smooth motion (panning, tilting and zooming), even when viewing very high-resolution panoramas. Additional features of this program include fully customizable controllers and cursors, automated motion, and hot spots in VR tours.

It is possible to display panoramas within a presentation program, such as PowerPoint (Microsoft) or Keynote (Apple), or to integrate panoramas with playback in QuickTime Player or the SPi-V engine. It is also possible to create a "kiosk" presentation for museum settings. This generally gives the user access to the panorama/virtual tour but blocks access to any other computer functions.

8.4. Aliasing, moiré patterns, and other viewing pitfalls and solutions

The perceived on-screen image quality of a digital panorama when viewed in a playback application (both when the image is static, or moving during panning) is the result of a very complex interaction between many factors, including:

- Size and tiling of the source image
- Type of compression (codec) used, and degree of compression
- Degree of sharpening of the source image (if any)
- Settings chosen for quality (motion and static) during authoring (QuickTime VR only)
- Size of the playback window
- Display calibration

Undesirable effects can include moiré patterns; other unwanted image artifacts, often arising from aliasing; posterization (banding in areas where there should be smooth tonal gradients, such as skies).

The smoothness of the moving image during panning is also a factor. In large part, this is a function of the power and speed of the particular computer system being used; the "on-the-fly" image warping taking place in real time during playback — to restore rectilinear perspective to cylindrical, spherical, or equirectangular source images — is in most players (such as Apple's QuickTime Player) achieved by software-based rendering, and is reliant in large part on the computer's CPU.

It is difficult to devise hard-and-fast procedures that will eliminate these problems, but here are a few factors to consider.

Size of the source image

This will vary depending on the intended use and distribution of the final product. For deployment over the web, smaller images (and hence movies with smaller file sizes) have faster downloads. For deployment by means of DVDs or local files, larger images show more detail, allow greater zooming capability, and are capable of effective full-screen

playback. For example, a 2000-pixel-wide image would be acceptable if playback was in a small window (such as 360 x 240). For more detail (allowing greater useful zooming) and a larger playback window the source image could be around 3000 to 5000 pixels wide. For effective full-screen presentations, it might be 6000 pixels or more across. Some authoring applications suggest or require that the source image's pixel dimensions be divisible by 4 (or even 96 in the case of QuickTime VR Authoring Studio); check instructions for individual applications.

Tiling

This refers to the way QuickTime VR panoramas are diced into rectangular tiles during the authoring process, so as to enable efficient playback when panning. Some authoring applications enable manipulation of the number and even the ordering of tiles.

When saving a QTVR panorama file, there is a setting for "tiles" or "tiling." This indicates how many sections each cube face is divided into, with a 1x1 setting meaning no division, and a 2x2 meaning four tiles, up to 8x8 for 64 tiles. Choosing more tiles may make a panorama file appear to load faster because the viewer will see many smaller parts of a cube face appear quickly rather than larger blank areas that fill more slowly. Higher numbers of tiles may result in better performance when viewing a panorama, especially in motion, if the machine displaying it lacks sufficient processing or graphics card capabilities to render smoothly as the view changes. Increasing tiling may increase file size however (although not necessarily to a significant point). Tile settings probably won't matter all that much, with high-bandwidth internet connections, high-speed media drives, and fast CPUs and graphic cards. However, a little experimentation may lead to one choice over another for purely aesthetic reasons.

Compression (codec)

While source images should as a rule be uncompressed, interactive panoramas derived from them can use a variety of compression schemes (codecs). At the time of writing, by far the most widely used codec for photographic images is Photo-JPEG.

Sharpening

Almost all digital panoramas, whether scanned from film or stitched, will benefit from some careful sharpening at the end of the production process and before conversion to interactive movies. But, as with digital imaging in general, sharpening should be limited to no more than required for the final product. Overly aggressive sharpening may result in shimmering or moiré-like effects.

Motion and static quality

Most authoring applications for QuickTime VR movies offer the ability to change these image quality settings, which affect the degree of anti-aliasing applied to images in the viewer when either moving or at rest. Their usual defaults are to set anti-aliasing to off (for better responsiveness) while panning, and on when the image is stopped.

Size of playback window

As computers have increased in power and speed, and faster connections have become widely available, the trend has been to increase the size of the playback window. Full screen interactive panoramas are now commonly encountered. Larger windows require larger, more detailed source images, especially where zooming is enabled. Note that there is a difference between window size and file size (see section 4.4).

Display calibration

Panoramas (and indeed all digital images) should be authored and viewed on computer displays that are properly calibrated and profiled to produce accurate color. There are a number of utilities available to help achieve this, some using software only, and other more advanced systems using hardware.

Posterization

This appears as banding or striations most noticeable in areas of even tone or gradients such as skies, and can result from one (or both) of two main causes: source images that have been too-heavily processed, evidenced by gaps or "combing" in their histograms; and viewing certain movies on computer displays set to 16-bit color. (For the best viewing of interactive panoramas, and indeed for any serious work with digital images, displays should be set to 24-bit or higher.)

Screen rendering

The CPU-intensive task of displaying an interactive panoramic movie during panning can result in a perceived sluggishness or jerkiness where slower computers and/or large movies are concerned. An alternative method of displaying many VR formats is to use hardware-accelerated OpenGL rendering, which, by using the computer's graphics card rather than software rendering, will provide very smooth, fluid rendering both in a window or at full screen. At the time of writing, a number of such systems are available or in development, two of the most widely used being CubicNavigator and PangeaVR.

8.5. Incorporating additional media

When incorporated into a larger virtual presentation with audio, video, and other types of multimedia, the immersive effect of digital panoramas is greatly enhanced. The acoustic quality of a building is often as important as the visual (e.g., performance halls, libraries, and religious architecture). Video can provide a directed view and seamlessly demonstrate the transition from room to room as one moves throughout a building. Incorporating CAD reconstructions of a site that is no longer standing can provide an experience that hasn't been possible for thousands of years.

Many virtual tour authoring packages and stitching programs provide a tool for creating hot spots to be embedded within a panorama (see section 6.9).

Ambient audio recorded at the site can be an exciting effect in a virtual tour (see section 5.2). This audio can either be embedded into the QTVR file, or can be embedded in the HTML as an MP3 or other file type. It is possible to include several different audio tracks in one panorama, and when the user pans around the image, the audio tracks can respond by fading left-right and increase or decrease volume, creating a 3D effect (see section 8.8).

Incorporating clickable maps and plans with "you are here" symbols adds another dimension of understanding to the virtual presentation. Plans aid not only in the understanding of the physical space in relation to the location of the panoramas, but are useful navigational tools, particularly in large areas with many node locations.

There is no limit to the possibilities for creating fully featured multimedia presentations. The subject of building virtual tours is discussed further below.

8.6. Virtual tours

Stand-alone panoramas work very well for many educational and documentary purposes. However, in many cases incorporating panoramas into a larger multimedia presentation provides a deeper and more interesting view of the subject. The simplest method is just to add one or more panoramas to a web page with text and external sound files. For optimal results, though, a full-featured authoring package (such as LiveStage Pro) allows the developer to incorporate elements, such as directional sound, reactive compass bearings, and animation that give viewers a better sense of location and direction; interactive clickable maps to select nodes; transitions between nodes; voiceovers; and hotspots that jump from one node to another (or to still images, other URLs, etc.).

The full use of authoring packages of this sort lies beyond the scope of this document, but commissioners with access to technical support staff and interest in producing high-end virtual tours should take advantage of local resources. University academic or IT departments may already own the appropriate software and offer training. Given the power of authoring packages, anyone delving into them for the first time should be prepared for a steep learning curve. Such projects might be best given to students already comfortable with multimedia authoring and interested in learning new software packages.

When virtual tours are used in lectures, museum exhibits, or some other situation that involves repeated presentations of the material, it may be best to generate scripted routines that can be executed with the click of a button. For example, if the presenter wants to discuss the features appearing in a panorama's opening window, then pan right 30° and up 45° to show a second feature, breaking the flow of the lecture while fumbling with a trackpad and trying to change the view smoothly and steadily distracts the presenter as well as the audience. While this kind of transition gets easier with experience, it would be much easier to click one or two keys and start a script that moves down a pre-set path, so that the presenter can continue talking while the panorama changes. This type of script

can be added by an authoring package or found on the support web sites devoted to the authoring package, if the package itself does not include them.

Before/after and real life/virtual comparisons of reconstructed or recently discovered sites can also be useful and insightful. One nice way to demonstrate data of this type is to run two or more panorama files showing the same location in different states. Some authoring packages allow two or more panorama files to be synchronized on the same screen, so that each panorama has the same view as the other. When the viewer pans, tilts, or zooms in one panorama those actions are mirrored in the other. This allows comparisons of objects or data from an identical point of view. Alternatively, the viewer might want to see two completely different panoramas, so as to contrast different but similar sites.

Using LiveStage scripts to program a route with pre-determined points

Using interactive panoramas in a classroom setting can give viewers a strong sense of place when looking at architecture and can be used effectively to show context and detail in parallel with lecture material. However, an otherwise effective presentation can be disrupted by the requirement for precise control at the computer, especially when it is not optimally placed or lighted for easy use of keyboard or mouse to control pan, tilt, rotation, and zoom in a panorama.

Scripting packages are the solution to this. An authoring product can assign a key or a short combination of keys to set a sequence of events, which can then be run during a presentation or lecture. This avoids fiddling with navigating and panning and allows control over speed and direction of movement. The scripts can be matched up to the cadence of the presentation, so that the narrator or lecturer can concentrate on the audience rather than the technology.

For example, imagine a lecture on the interior space of an important building, using a pair of panoramas that illustrate key points. It might be accompanied by a script such as this:

1. Open panorama A and wait thirty seconds.
2. Over a span of sixty seconds, pan 30° to the right and tilt up 10°, zoom in by a factor of two, then wait 300 seconds.
3. Over a span of ten seconds, pan 10° to the right, then wait 180 seconds.
4. Over a span of twenty seconds, pan 45° back to the left, tilt down 30°, automatically click an embedded hotspot on a doorway, which leads to panorama B.
5. Over a span of 120 seconds pan 360°, then tilt up 90° and zoom in by a factor of three. Wait 600 seconds.
6. Over a span of thirty seconds tilt down 90°, zoom back to the original magnification factor, then pan 180° and click a doorway hotspot leading back to panorama A and load it.

This could be started with a single key stroke. Conditional statements or status checks could be added so that the narrator could interrupt the script during the talk. The panning can be set to end at an exact or relative location and can be precisely timed to allow for a given chunk of narration. For example, step three above could also be set to start 300 seconds from when it is stopped or 300 seconds after step two ends. A "cancel" option to terminate the script might also be helpful.

A script like this is relatively easy to program once the software has become familiar. It may take patience and dedication to master use of timeline, scripting, and adding tracks. However, these authoring applications are very powerful and may be worth the investment.[1]

8.7. Applying panoramas

Panoramic images can be used to add detail to 3D, VR, and CAD environments. It is possible to apply photographs to the surface of polygonal wire-frames as a sort of texture, lending realism to a 3D model that a synthetic texture created artificially by computer cannot. A model's geometry may have varying levels of detail, ranging from simple geometric shapes to complex polygons of minute detail. Laser and multi-spectral scanners can help capture a high level of spatial detail. Applications such as 3D Studio Max and Rhino can "bake" photo-realistic textures onto object surfaces to create models that virtually represent a site to a remarkable extent. The inclusion of additional media (section 5), such as audio recorded on-site, can greatly enhance the immersive qualities of a virtual model.

Specialized viewing software may be needed to view 3D virtual reality models. Additionally, the large amounts of data these models generate require a highly capable computer system.

Photogrammetry is a technique that uses images of a single object from various viewpoints to create a 3D environment. Software such as RealVIZ's ImageModeler and VTour identify like-objects in several images. These can then be extruded into polygonal forms to create a wire form that give depth to a scene, adding a third dimension to what was previously a set of 2D images.

These techniques can help create a highly immersive virtual experience of an existing site. They are also helpful in creating a representation of a site undergoing restoration or reconstruction and for combining photo-realism with computer-created structure and forms.

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1. Anyone working with LiveStage Pro should also have Matthew Peterson's *Interactive QuickTime: Authoring Wired Media* (Morgan Kaufmann Publishers, 2004) close to hand.

8.8. Track synchronization

It will greatly extend the usefulness of immersive panoramas if you can use an authoring tool to add synchronized components to their presentations. This kind of software allows the addition of such things as:

- A rotating arrow on a map to show direction of view.
- A scrolling compass wheel to show a bearing.
- A sound file linked to an object in the panorama, such that panning causes the source of the sound to float from one speaker to another for listeners with stereo sound.
- A parallel panorama meant to show the same node at a different time or under different conditions (when one panorama is panned, the other automatically turns to match the same point of view).
- A parallel panorama generated from software (rather than a photograph) to show the same point of view, such as a site now in ruins, with a virtual reconstruction of how it might have looked.

Essentially, a program such as LiveStage Pro uses a large workspace to lay out a project where the panorama appears in one area and other components, such as a map or plan, alongside. The user can then add an arrow graphic, for example, orient it, and bind it to the panorama's view through the use of synchronized tracks. Moveable components of this sort are often called sprites and can be controlled through the authoring package's scripting components as well. When complete, the authoring package generates a file that includes the panorama as well as the sprites.

The inclusion or creation of these components into a virtual tour or web page requires some expertise with authoring packages but usually provide results worth the efforts to learn.

8.9. Controlling access

Total protection of panorama files is impossible: determined users will usually find a way. That being said, there are a number of techniques that can discourage unauthorized access and copying. The various options available depend on delivery methods (such as web page or CD-ROM), the authoring platform, the security requirements of the institute distributing the panorama, and the technical abilities of the project staff. Consult the technical support staff to see what options are available. Full discussion of these can be found on Apple's web site and in the book *QuickTime 6 for Macintosh & Windows*.

QuickTime offers some basic approaches to preventing unauthorized copying as detailed in Gulie (2004: 95-99) and Stern and Lettieri (2003: 418-422). Essentially, someone creating a QuickTime panorama can disable the "Save As" feature to prevent making copies from QuickTime's own menu or from the QuickTime viewer plugin used within a web page. This approach, however, does not prevent someone from duplicating an

entire CD-ROM of panoramas nor block a web user from copying the original file from the browser's cache when using the Internet to view the panorama.

If you want to protect your web-based panoramas you may be able to achieve a level of security well beyond the reach of all but the most determined and knowledgeable copiers, depending on your technical expertise and willingness to research the latest options and approaches. For example, the aforementioned authors detail how to create pointer files and provide tools to create them, however these may not work on your system.

The basic idea is that you store the original panoramas on your web server but do not embed them directly into web pages. Instead, you create files that point to the panoramas and then embed the pointer files within the web page. The pointer files themselves cannot be saved and and cannot be played directly - they work only when they have access to the original file. One drawback of this system is that no one can see your panoramas unless they have Internet access, your server is available, and you haven't moved or removed the original files. Of course creating and managing the pointer files requires more work.

QuickTime itself, like other panorama creation and viewing packages, does offer a feature that may serve to prevent most copying when a panorama is embedded within a web page. As detailed on Apple's QuickTime tutorial web site[2], the QTSRCDONTUSEBROWSER parameter used with the <EMBED> tag will cause the browser to not cache the file. Despite this attribute, someone might still view the source of the web page to find the URL of the QuickTime movie and load it directly.

2. http://www.apple.com/quicktime/tutorials/embed2.html

Web References

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