

# 1. OVERVIEW AND OBJECTIVES

## 1.1. WHO IS THIS GUIDE FOR?

The IATH Best Practices Guide to Digital Panorama Photography is written for researchers and photographers looking to use digital technology to build digital panoramas of cultural heritage sites, architecture, and art works. There are several types of expertise required to create this kind of tool, and the guide contains advice and guidance on some of the technical, administrative, legal, and interpretive issues that may arise at each step of the process.

The contents are designed for three groups of users: the commissioner, the photographer, and the developer. The commissioner is the person or group who commissions the panorama, whether for research or educational use. In many cases the photographer and developer are the same person, but this guide deals with their tasks separately: the photographer is the person (or persons) who travels to the site and creates the source images and the developer creates digital panoramas from the source images and makes them available in some way, usually through a virtual tour on a website.

This guide will focus mainly on the workflow for academic uses of panoramic photography. The guide aims to give practical guidance on the many issues involved in the creation and use of digital panoramas, as well as to provide suggestions for the creative use of the resource. We urge the reader to begin by considering the project's end use, the intended audience and their information needs. These considerations will be the crucial basis for numerous decisions that need to be made throughout the process. For example, if the end user will be viewing the panorama on a normal computer display and will not need to zoom in on decorative details of a building, then lower resolution JPEGs will be sufficient in the initial data capture phase. However, if zoom functionality will be important to the end users or if the panorama is to be printed by offset press or larger display prints, then the data capture process must yield high-resolution TIFs.

We advise both novices and experts to read the entire guide. There are many steps involved in this type of undertaking and even a seasoned photographer may not have

thought of all of them. Many of the topics are interrelated and various aspects of the topics are covered throughout the guide.

Please note that the guide assumes a general knowledge of photography, computer literacy, and experience in travel. There are many fine books and web sites that specialize in those topics and readers are encouraged to seek them out. Whenever possible, World Wide Web links are provided to illustrate examples and point towards further information.

## 1.2. INTRODUCTION AND EXAMPLES

Panoramas began as a way to broaden the field of view of ordinary cameras, but have evolved through digital techniques to provide an entire "sphere of view," that is the entire field of view surrounding one point in space. The "sphere" is further enhanced by zoom options that allow the viewer to focus on details that would normally be difficult to discern from the original vantage point. Multiple panorama techniques extend the range of viewpoints and provide a functionality for more complete guided tours. This evolution of digital panorama photography has made it particularly well-suited to virtual representation of three-dimensional sites such as architecture, archaeological sites, and sculptural works and when documenting geographically or politically inaccessible places.

Digital panoramic photography is sometimes referred to as "QTVR," referring to Apple's QuickTime Virtual Reality software. "QTVR" is not quite accurate at two levels: other companies provide software with much of the same functionality, and the fixed point of view (albeit with pan and zoom) on each panorama does not allow the unrestricted "fly through" control that is often part of "virtual reality" displays. To obtain the "fly through" functionality, virtual reality displays are most often based on Computer Aided Design (CAD) modeling, in which case the structures and textures on the surfaces of those structures are computer generated. In contrast, the panorama displays are more realistic in that they derive from photographs of the original building, site or sculpture.

Digital panoramas, as with other digital presentation methods, do provide a very natural connection to additional information sources that enable extremely rich guided tour experiences. At its most intricate, multiple digital panoramas are combined into a virtual tour that provides varied viewpoints into and about a space, accompanied by ambient three-dimensional audio recorded on-site and video clips and additional high-resolution still images. As with any guided tour, a floor plan of the space provides the visitor with an important abstraction for orientation and navigation. In the digital media domain, the floor plan can be made interactive and thus form the basis of a deeper understanding of the space through the availability of additional contextualizing information.

Digital panoramas have recently been used in the classroom and for scholarly research. There are many wonderful examples of stand-alone digital panorama and full-featured virtual tours available via the World Wide Web. A few notable sites are:

- BetterLight
- The Original Worldwide Panorama Event
- Panoramas.dk
- A Virtual Walking Tour: The Alhambra
- A Virtual Walking Tour: The Suleymaniye Mosque

There are also good websites and lists that provide guidance on the creation and displaying of digital panoramas. For example, Panoguide has guidance on creating and displaying panoramas as well as an active user forum.

### 1.3. BRIEF HISTORY AND USE OF PANORAMIC PHOTOGRAPHY

Human vision is essentially a spherical panorama of approximately 140°. Although our vision is in sharp focus only in the center, our peripheral vision is sharp enough to help us navigate safely. The seamless flow of information in vision is intellectually beyond computing. We can identify and avoid an obstacle that we have seen days or months in the past. The importance of panorama as a human experience can be found in Paleolithic cave art dating from 35,000 years ago in Chaveut and Lascaux, France. These unconstrained artists drew grazing animals and carnivores on the walls and ceilings up to fifteen meters in width.

Over time, the proportions of five units in one dimension and four in the other became normal in response to the media that conveyed the image; canvas stretched over wood frames, book printing and, more recently, early photographic processes.

The notion of a sweeping *panoramic* view goes back well beyond the invention of photography. The Roman poet Horace, in one of his odes, complains of hilltops with fine views being levelled for the building of houses, and Pliny the Younger refers to the importance of panoramic views to the owners of Roman villas. At the excavated Roman seaside town of Herculaneum, some of the finest houses were positioned overlooking the Bay of Naples. There has been a long tradition of drawn and painted depictions of panoramic views (usually thought of as panoramic if width exceeds height by a factor of 2:1 or greater).

However the word "panorama" itself did not enter the language until it was coined in the late eighteenth century to specifically describe a new type of large curved painting depicting vistas,<sup>1</sup> an early example being those of Edinburgh by Robert Barker (who received a patent for his method) exhibited in London in 1792. These large-scale works were mounted on the inside surface of a cylinder and viewed from the cylinder's center, generally with an attempt to fill the viewer's field of view through the full 360° and create

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1. With the disappearance of the art form it was invented to describe, the original, quite specific, definition has now been effectively replaced by other usage and meanings: a circular or extra-wide vista, overview, even a survey. These new forms themselves developed not long after the term was coined.

a sense of immersion. During the nineteenth-century displays of this kind — usually depicting landscapes or historical events and created by teams of specialist artists — grew in size, ingenuity, and variety. They were generally exhibited in specially built rotundas and enjoyed great popularity. Many of these works were of epic proportions, perhaps ten meters high and one hundred meters or more long.

Soon after the 1839 introduction of the first widely used photographic process (the daguerreotype), photographers were rotating their cameras to capture several views of a scene, then assembling the resulting pictures to create the impression of a single panoramic image (although these would almost inevitably be flawed by visible seams and jarring mismatches of perspective). This period also saw early experiments with rotating cameras or lenses and curved focal planes in efforts to overcome these deficiencies. As time went on, especially after the introduction of flexible film in 1887, many new and increasingly successful cameras were specifically designed to create seamless panoramic images. One such improvement was the short rotation or swing lens camera, which typically captured a horizontal field of view of 100-140° or so. Other designs allowed for full 360° rotation; the rotational scanning camera employed clockwork or motorized systems to synchronize the rotation of the entire camera. During exposure the film moved around a curved focal plane. A narrow slit (typically less than one millimeter wide) often interposed between lens and film, so that the scene was "painted" onto the film during the rotation. Descendants of such cameras, in one form or another, continue to be manufactured and used today.<sup>2</sup> Both of these types of cameras produced images with cylindrical perspective, an unavoidable result of their rotation: straight horizontal lines in the subject take on distinctive cigar-shaped curves once imaged (though not vertical features, as with fish-eye lenses). Another invention was the fixed lens camera, where the perspective was rectilinear (i.e., normal). Most conventional cameras use this approach; it employs stationary lenses and flat film planes, relying on the use of wide angle lenses and/or extended film planes to achieve a panoramic field of view. Another variant is the panoramic pinhole camera.



Figure 1. Circuit camera panorama. Photo by Tom Watson.

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2. Some typical modern examples of short rotation cameras include the Noblex, Widelux, and Horizon. Full rotation models include the Hulcherama and Seitz Roundshot. Of the latter group there are now digital models, which include (at the time of writing) the Panoscan, the Seitz Super Digital model, Spheron, and others.

A student engineer, named Arthur C. Pillsbury, invented the circuit camera in 1906. Today we take “circuit” to mean an electronic circuit, but the circuit camera was a spring-wound, gear-driven camera weighing about twenty pounds. It exposed a piece of 8"x20" negative film which was then contact-printed on photographic paper. These cameras are still in use. Many veterans of World Wars I and II had their platoon pictures taken with the circuit camera.<sup>3</sup>If the negative and print were properly fixed and washed, these images last hundreds of years. With digital technology we can recreate the look of the circuit camera portrait (Fig.1). The image, when reproduced with archival ink on acid-free paper, will last an estimated two hundred years.

Late twentieth-century developments in digital imaging gave a new lease of life to the assembling of multiple images. Where early panorama photographers used a segmented approach (taking a series of photos of segments of a panorama and then placing them next to each other to create a single view), it became possible to use digital tools to *stitch* a number of discrete digital images into a single seamless panorama, making the seams and discontinuities of tone, contrast and color mostly invisible. Since about the mid-1990s, this has been the most commonly employed technique for creating digital photographic panoramas. Not only can stitching replicate the kinds of cylindrical images made with often costly purpose-built panoramic cameras, but it can create images recording an entire 360° by 180° scene, including the zenith and nadir (imagine standing at the centre of a sphere instead of a cylinder). Such images are usually mapped in equirectangular projection and have an aspect ratio of 2:1. The recent introduction of digital versions of rotational scanning cameras also enables direct creation of such images. An equirectangular projection exhibits increasingly severe distortions away from its center, and photographers who are primarily interested in printing their images (or displaying them digitally as stills) consequently most often use cylindrical (Fig. 2) or equirectangular (Fig. 3) projections.



Figure 2. Cylindrical projection, 110° vertical field of view. Photo by Tom Watson.

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3. Someone will always be in the picture twice, having run from one end of the picture to the other while the camera swings through its arc.



Figure 3. Equirectangular projection, 180° vertical field of view. Photo by Brian Donovan

It also became possible to view digital panoramas on computer displays in such a way that the images are warped back into 'normal' rectilinear perspective (image-based rendering). These systems offered viewers interactivity: by clicking and dragging with a mouse, any arbitrary viewpoint could be panned left and right, and up and down. This interactive immersion in a scene naturally invites comparison with concurrent developments in virtual reality systems and recalls the experience of viewing nineteenth-century painted panoramas where the viewer's position near the center of a cylindrical environment provided a natural perspective.

The most well-known and widely used example of this is Apple's QuickTime VR (QTVR). The technology was developed around 1995 by Eric Chen and other members of Apple's Advanced Technology Group and was an extension of the existing QuickTime digital media framework (as such it became an integral part of any installation of the Macintosh operating system<sup>4</sup>). While any installation of QuickTime allowed playback of QTVR content both in movie-playing applications and on web pages, the early authoring software employed to create QTVR content lacked a graphical user interface and was difficult to use. By 1997, Apple (and others) had introduced user-friendly stitching and authoring tools. QuickTime VR Authoring Studio software (QTVRAS, released in late 1997) simplified the creation of multinode QTVR panoramic "scenes," where a series of individual panoramas (or nodes) could be linked to create virtual tours. A "hotspot" in an image (such as a doorway) could be clicked to switch the view to a new node, so that the viewer could explore a complex location. QTVRAS also had a capable stitcher. At this point, QTVR was limited to creation and playback of cylindrical panoramas; version 5 of QuickTime, released in early 2001, added support for cubic QTVR, enabling playback of full 360° by 180° equirectangular mappings (cubic because the source image was mapped onto six cube faces, although the end result for the viewer is essentially indistinguishable from a spherical environment [Fig.

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4. A version of QuickTime (which includes QTVR playback capability) is also available for the Microsoft Windows operating system.



Figure 4. Six rectilinear cube faces ( $90^\circ$  by  $90^\circ$  each) derived from the equirectangular image in Figure 3. Photo by Brian Donovan.

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4). At the time of this writing, Apple has not upgraded QTVRAS: two other Apple options are MakeCubic, a legacy application that allows creation of cubic QTVR panoramas from six faces or from equirectangular images, and VRMakePano, which converts a panoramic image into a QuickTime VR panoramic movie.<sup>5</sup> But such has been the popularity of navigable panoramas in general, and QTVR in particular, that many other companies have developed a range of stitching and authoring applications.

A notable and influential early contributor to the field of stitching, image mapping, and panorama creation and playback, was a German professor of mathematics, Helmut Dersch, who freely distributed his suite of software utilities, known as Panorama Tools. Versions of this software, still widely used, are available for Linux, Mac OS, and Windows.

Since the introduction of interactive navigable panoramas (which occupy an uncertain space somewhere between the still image and the time-based linear movie), the continued growth in the power and speed of computers has meant that photographers can now deploy their panoramas at high resolution and at screen-filling image scales, something barely imagined in the mid-1990s. Today a richly detailed digital panorama can not only fill a large computer display, but can move (Fig. 5).

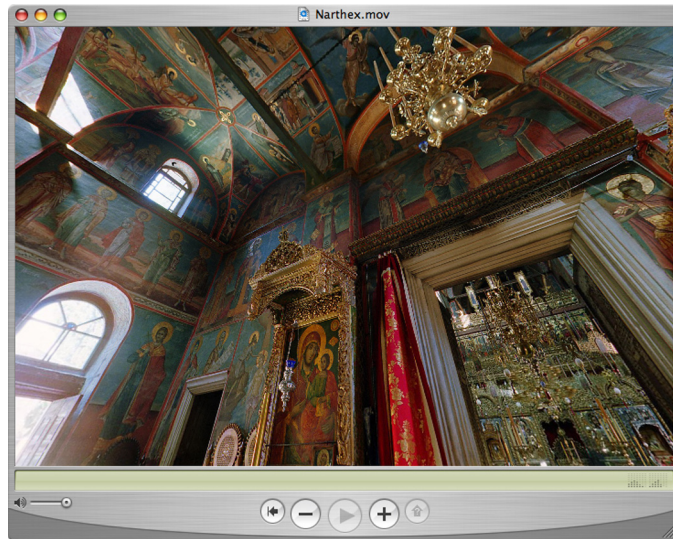


Figure 5. A screenshot from the QuickTime Player viewing application. Photo by Brian Donovan.

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5. See Web References, below, for URLs.

## 1.4. BASIC DIGITAL PANORAMIC PHOTOGRAPHY METHODS

There are many methods for capturing panoramic images. Generally, a photographer will take a series of photographs or use a scanner to scan a space. These source images can be made with traditional or digital film. They are then either digitized or imported into a computer where they are edited and “stitched” into a complete digital panoramic image. These images can then be projected by a computer and printed on paper in a flattened form. The various methods of photography, editing, stitching and display are discussed in depth throughout the guide.

### 1. **Segmented, stitched**

A camera is mounted on a turntable that segments arcs of a circle. An image is made, the camera is turned a few degrees manually, another exposure made etc. The images are stitched together later to make a complete panorama.

### 2. **Continuous**

A camera is mounted to a step motor that is connected to a computer. The operator enters the degrees of rotation, the lens length, and exposure requirements. The software captures a seamless panorama (Fig. 6) and little or no post production is necessary. This method induces curvilinear distortion.



Figure 6. Port of Seattle. Photo by Tom Watson.

### 3. **Flat stitched**

This method takes advantage of the fact that light passes through a camera lens as a cone, the radius of which is much larger than a single piece of 4x5 film. A digital scanning array makes an image on the right and then on the left and stitches them (Fig. 7). Done carefully, this is the most accurate method of stitching and induces no curvilinear distortion.





Figure 7. Museum of the Earth. Photo by Tom Watson.

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## 1.5. HOW TO USE THIS GUIDE

The guide is divided into five main sections, each divided into smaller subsections. Below is a list of the sections of this guide and a brief description of what is covered:

### PRE-PRODUCTION

This discusses choosing a subject and a goal for the project, as well as choosing a site and specific site nodes, and the legal issues involved, such as intellectual property rights, restrictions and permissions, copyright, agreements, and professional liability insurance. There is also discussion of environmental considerations and scheduling the shoot, choosing equipment, travel preparations, local site liaison, site access and resources, and project budgets.

### PRODUCTION

Production covers methods of image capture and the photographic workflow. Topics include selecting image file formats, using image capturing systems and lenses, hardware, lighting, color management, environmental issues and special situations, site data documentation, short-term image storage and back-up, and organizational structure.

### POST-PRODUCTION

This section includes in-depth discussion on stitching and rendering and data documentation. Subsections include preparing raw data, software, color management, high dynamic range (HDR) and multiple exposure compositing, batch processing, scripts, hot spots and hyperlinks, executable scripts, selecting file formats and output types, watermarks, sprite tracks, copyright, and converting historical images.

### VIEWING, PUBLICATION, AND USE

Topics include viewing platforms, presentation, viewing pitfalls and solutions, incorporating additional media, virtual tours, track synchronization, controlling access, and standards

for data interchange. The section also discusses some possible applications for the end-user, including use of panoramas and VR in the lecture/classroom/labs/home, scholarly use, practical use for engineers, hand-held devices at site/landscapes, and historical and heritage site preservation and restoration.

#### PRESERVATION

This section focuses on the long term physical storage and preservation of the archive and the global digital preservation arena

## WEB REFERENCES

Arthur C. Pillsbury. [http://en.wikipedia.org/wiki/Arthur\\_Clarence\\_Pillsbury](http://en.wikipedia.org/wiki/Arthur_Clarence_Pillsbury)

BetterLight Large Format Photography. <http://betterlight.com>

Chaveut. <http://www.culture.gouv.fr/culture/arcnat/chauvet/en/index.html>

Lascaux. <http://www.culture.gouv.fr/culture/arcnat/lascaux/en/>

Helmut Dersch suite of tools. <http://webuser.fh-furtwangen.de/~dersch/>

MakeCubic.

<http://developer.apple.com/quicktime/quicktimeintro/tools/index.html>

The Original Worldwide Panorama Event, March 20, 2004.

<http://geoimages.berkeley.edu/worldwidepanorama/wwp304/>

Panoramas.dk. <http://www.panoramas.dk>

Panoguide. <http://www.panoguide.com>

A Virtual Walking Tour: *The Alhambra*.

<http://www.saudiaramcoworld.com/issue/200604/>

A Virtual Walking Tour: *The Suleymaniye Mosque*

<http://www.saudiaramcoworld.com/issue/200605/>

VRMakePano. <http://developer.apple.com/samplecode/vrmakepano/index.html>