Spherical High Dynamic Range Virtual Reality for Virtual Tourism: Kellie’s Castle, Malaysia

Khairul Hazrin bin Hashim  
Faculty of Creative Multimedia  
Multimedia University  
Cyberjaya, MALAYSIA  
khairul.hazrin@gmail.com

Muhammad Jafni bin Jusof  
Faculty of Creative Multimedia  
Multimedia University  
Cyberjaya, MALAYSIA  
jafni@mmu.edu.my

ABSTRACT

The study is focused on documenting the process and creating a prototype for a virtual tourism experience of Kellie’s Castle in Malaysia. The castle is an incomplete construction of the residence of William Kellie Smith, a British rubber planter who commissioned it in the 1800s. It stands today as a cultural and historical tourism site, with background stories of Kellie’s intention of wooing his wife to live in Malaysia (Malaya at that time) through elaborate architectural design, the loyalty of his plantation workers, and his untimely death during the final stages of construction. High Dynamic Range Imaging (HDRI) photography was used to create a user-navigable view in a spherical virtual environment. Viewed in QuickTime, the immersive visual experience is enhanced with detailed luminance between the lightest and darkest areas and comes with zooming capability.

Spherical Virtual Reality, High Dynamic Range, Virtual Tourism, Kellie’s Castle

1.0 INTRODUCTION

Tourism is one of Malaysia’s main income generating sectors and is primarily based on cultural and heritage sites. There was an increase of 4.4% in the number of tourist entering Malaysia from January to August 2009, making it a total of 15.38 million (Mindbranch, 2009)[1]. Promotions are planned and conducted by the Malaysian Ministry of Culture, Arts and Tourism to attract even more tourists to Malaysia. Virtual reality used to be a term confined to applications in games, simulators, and sci-fi movies. Over the years, technological advancements have made virtual reality accessible in terms of its creative process and viewership in many other areas. In this paper, virtual tourism takes the meaning of presenting and immersing the viewer into a tourist destination heritage site. The process involves photographing (capturing), constructing, and delivering the content through digital media. Spherical High Dynamic Range Virtual Reality (HDRVR) is an attempt at combining two photographic genres: Spherical Virtual Reality (SVR) and High Dynamic Range Imaging (HDRI).

Spherical VR is a combination of spherical panorama and virtual reality. It is a projection in which the viewpoint is from the center of the sphere. Interaction in this virtual environment provides the user non-linear navigation and interaction abilities, similar to the way we navigate in the real world, albeit in a virtual environment (Woeste, 2009)[2]. A series of digital photographs are taken at different angles and stitched together to create one panoramic image. The seamless stitched image provides a 360-degree view of the environment. Murphy (1999)[3] explained that such interaction especially in a spherical panorama is a replication of how humans see in the real world. HDRI photography is a technique of capturing a series of images with multiple exposures in order to capture the details in the darkest to the lightest areas. Dynamic range refers to the wide range of the luminance and radiance of a scene. As explained by Fitzgerald (2008)[4], the process of HDRI is to capture a wide range of light so that the image created will be as close to what a human eye can see of the scene. In conventional photography, even when using the best and feature-packed camera, it will still endure clipped details due to the need to compromise the exposure reading in one single shot (Brown, 2006)[5]. The basic working principle is that a minimal of 3 exposures, consisting of 1 under-exposed image that holds the ‘highlight’ details and 1 over-exposed image to capture ‘shadow’ details are layered over a normally expose image; creating a single HDRI image.

1.1 KELLIE’S CASTLE

The half-completed building is located in Batu Gajah, approximately 25 kilometers from Ipoh, the capital city of Perak, a state in West Malaysia. It is of a Moorish adapted architectural design on a hilltop that was constructed in 1915 by William Kellie Smith, a successful Scottish rubber planter who came to Malaya in the late 1800s. He went back to Scotland to marry Agnes Smith and returned in early 1900s with her. The elaborate building was meant to make his wife with their newly born son contented to live in Malaya. Construction of his castle was critically delayed as tragedy struck in the form of the deadly Spanish flu that killed many of his plantation and construction workers. As work labored on with new workers, he left for Europe to purchase an elevator system and died of pneumonia in Portugal. The half-constructed castle was left in decay and was almost reclaimed by the jungles surrounding it until professional preservation work was done in 2000 by the Perak and Malaysian Tourism authorities.
1.2 RELATED WORK

Most spherical panoramas are created using wide-angle lenses to reduce the number of images that need to be captured, depending on the location and environmental conditions. Lohrman (2007)[6] used an 8mm fisheye lens to capture a scene at a local airport. He took only 4 pictures and stitched them together to form a complete sphere. Also in the work by Gawthrop (2007)[7], utilizing the wide-angle view of a 15mm lens. Even though as suggested by Clark (2009)[8] that human eye covers a wide field of view, similar to wide angle lenses, they do not distort the image (Weitz, n.d)[9]. Therefore the usage of a normal lens is more suitable for capturing process, closely replicating how humans see the environment.

There is also a similar work of panorama for tourism purposes in Malaysia. Done by Yuki (2006)[10], it is a study of immersive imaging through the documentation of the Mulu Caves in Sarawak, Malaysia. It is a similar but creating only a cylindrical panorama as the main method of viewing the cave environment and HDRI was not part of the study. By using HDRI, this project seeks to enhance and improve Spherical Virtual Reality Photography to another level of immersion and visual experience.

2.0 DIGITAL CAPTURE OF IMAGES

The first step in the process of creating the spherical HDRVR was to capture a series of photos with different exposures at different angles from a single nodal point. There are 2 elements to consider in the capture process; the intended Spherical VR and the quality of HDRI. Finding the most suitable spot as the nodal point is the most critical part before photographic capture begins. A 50mm lens was used as it gives an equivalent field of view as the human eye, whereas a wider lens (<50mm) would produce ‘distorted’ images. Any narrower field of view (>50mm) produces more images that will require more effort in the stitching process. The nodal point should also be decided over having almost equivalent distances with surrounding significant objects. The setup also required a decision of how many degree of camera rotation, both horizontally and vertically, between each individual image. Smaller degrees that require more images to be captured will ensure more overlapping areas that make the stitching process easier. In capturing the half-constructed building, the nodal point was set-up at the central courtyard with a 15-degree horizontal rotation to produce 24 images and a 30-degree vertical up and down tilt for 7 images. 3 images were captured for every angle of rotation with exposure value ranging from +2EV to -2EV. The aperture was kept constant at F8 to capture details and ISO setting was set at 100, as there was good daylight. The process of capturing the HDRI images was repeated for every horizontal rotation and vertical tilt. Images were shot in vertical format to avoid distortion.

2.1 ORGANIZING CAPTURED IMAGES

The images were captured in under-exposed, normal exposure, and over-exposed sequence. Capturing the images with proper sequencing and arrangement for all angles will provide for better file management during the HDRI generating process.

3.0 CREATING SPHERICAL HDRVR FOR KELLIE’S CASTLE

There are 2 techniques of creating spherical HDRVR. One is to create an HDRI image sequence-using batch processing for all the intended images prior to stitching them into a spherical panorama. The other technique is to create the spherical panorama with 3 different exposures before fusing them into an HDRI image. In the first technique, images have to be in correct sequence or set. There should be the same number of images of under-exposed, normally exposed and
over-exposed in a set of 1 angle. This is to avoid confusion and miss-calculations in the HDRI software. The advantage of using this method is there will only be one third of the total images that need to be stitched which translates to easier to manage image sequences, less time and memory resources requirements. The second technique is to stitch the images first into spherical panoramas with 3 different exposures and then blend it together to form an HDRI image. This study will discuss the creation process of spherical HDRVR of Kellie’s castle using the first technique.

### 3.1 Making HDR Images

Captured images are organized in a sequence of under-exposed, normally exposed and over-exposed sequence in a set of 3 images for every angle (as shown in Figure 4). This ensures that there will be no overlapping of exposures or angles in the whole capture sequence. The software used for creating HDRI images in this study is Photomatix 3.1. The software is relatively straightforward with a simple and easy to use interface. Batch runs of the images can save a lot of time and reduce unwanted aberrations. The number of images needs to be fused into 1 HDRI image is the set of 3 exposures captured earlier. There are 2 image alignment features in Photomatix; they are correcting through vertical and horizontal shifts, and by matching subject features. Both are provided in case there are camera or subject movements between frames. Normally, HDRI photos are created using a tripod-mounted camera for accurate alignment of exposures. Here, the shift alignment is used, as it is a rigid subject devoid of movements.

![Image 4](https://via.placeholder.com/150)

**Figure 4.** The sequence of processes involved in creating HDR images using Photomatix.

### 3.2 Spherical VR Image Stitching

The next step is stitching all the HDR images into a spherical projection using the PTGui software. The HDRI Images are then loaded into PTGui to create a spherical panorama. The time taken for image loading depends on the number and file size of the images. The software will then automatically try to align the images based on auto-generated control points. The control points are used to determine the anchor points of 2 side-by-side images. Control points are fixed based on similar features between the 2 images. Sharp images and bigger overlapping areas provide for more accurately matching control points between the images.

There will normally be errors when it comes to a scene with empty space such as clear sky where control points cannot be generated automatically. There are 2 ways of stitching images if such errors occur. The first is using the Control Points Assistant, which pops-up a window showing a list of numbered images at the top, and the 2 side-by-side images. The control points can then be set manually by selecting the same pixel from 2 side-by-side images visually. This method is time consuming as spherical panoramas have many images that need to be stitched around 1 single image and the process need to be repeated for all the loaded images. The second method of aligning the images is by using the Panorama Editor. It is based on approximate alignment where the user tries to arrange the images similar to assembling a jigsaw puzzle. This method is easier and less time consuming but requires visual and cognitive dexterity to be able to see the similar features between images. In the Panorama Editor window, Spherical projection with 360 degree by 180 degree equirectangular dimensions need to be set as the spherical projection will have a curvy top and bottom when applied onto a flat planar projection. This later will become useful when doing manual alignment and if needed to be exported into an image file. In this study both methods were used simultaneously. Manual alignment using the Panorama Editor was used for bright empty sky and blurry clouds areas while automated Control Points Assistant was used for sharp and highly distinguishable areas such as the tiled floor of the building. Errors from the stitching process such as minor misalignments can be corrected using any image editing software.

![Image 5](https://via.placeholder.com/150)

**Figure 5.** Image stitching using PTGui.

### 3.3 Exporting Spherical HDRVR

The final stage of the creation of Kellie’s Castle spherical HDRVR is to export the aligned final image into QuickTime movie format. In the Create Panorama window, there are several settings, which allow different panoramic sizes and file formats. The size (width x height) of the panoramic image can...
be set to a maximum number of pixels. The higher the pixel number, the more detailed the image will be. The file format choices can be Flat Planar JPEG, TIFF, Photoshop PSD or QuickTime movie.

4.0 Result

The end product of this spherical HDRVR is a QuickTime VR movie. Using a normal lens in this test resulted in all of the vertical lines in the scene not being distorted, even in the corners of the frame. The adaptation of HDRI into the panorama presented a high level of object details, providing a similar experience of how human eyes see the world, as suggested by Fitzgerald (2008)[4] and Austin (2007)[11].

4.0 Conclusion

The Spherical HDRVR of Kellie’s Castle was created as a prototype to explore the possibilities of virtual tourism; a concept and application to further promote cultural and historical tourism of Malaysia. The objective of the study is to create high quality photo-realistic VR in lieu of the more commonly used computer generated (CG) environments, which are prone to visual inaccuracies and misleading enhancements. The documentation and output of the study will be used to further understand and acquire more efficient ways and means of communication through photography and virtual reality.

References


