KEYWORDS: ***Digital photography – 360° spherical image – Panoramic – Documentation***

DOCUMENTING NATURAL AND CULTURAL PLACES WITH 360° SPHERICAL IMAGES, PANORAMIC AND TIMELAPSE DIGITAL PHOTOGRAPHY

John Goldsmith

Abstract. Recent advances in photographic image processing has substantially extended the capabilities and application of digital photographic cameras. Innovative digital photography methods are presented, including the use of 360° spherical images and time-lapse photography, as useful tools for recording natural and cultural places of significance. The methods, uses of these techniques and application to documenting places are discussed, with examples from The World At Night (www.twanight.org), Mulka's Cave rock art site (Western Australia), Second Life (www.secondlife.com), and several cultural sites in Bali, Indonesia.

Introduction

The techniques of digital photography can be applied in several ways to document places of natural and cultural significance. The enhancement of digital photographs is a particularly useful tool for researching and investigating Indigenous heritage sites. Through methods such as contrast enhancement and the selective emphasis of colour, the visibility of faint markings, which may otherwise be very difficult to perceive, can be increased (Anon. 2009). Methods of re-scaling and saturating colours in digital photography have been described by David et al. (2001). The application of digital technology for the documentation and management of rock art has been described by Ogleby (1995), and examples of the use of enhanced digital photography (for Torres Strait rock-art) are described by McNiven et al. (2000, 2002).

The capabilities of digital photography continue to expand with the use of digital photography techniques, including panoramic photography, 360° spherical images and time-lapse photography. These techniques lend themselves to creating useful records of sites. The creation of 360º spherical images is a specialised form of panoramic photography, which has become possible mainly due to advances in computer software. Digital photographs are assembled and processed in a mosaic form to create a 360° view. The extreme wide-angle views of 360° images lend themselves to 'immersing' the viewer into a virtual landscape, giving a realistic sensation of the site and its form. In this way, viewers can gain an appreciation of a site, without needing to actually visit the site. Mercator, planar, cylinder and spherical projections are different kinds of image projection, with spherical projection used for the production of 360° images, hence the term 360° spherical image.

Highly portable digital photographic equipment can be used to record 360° images, which lends itself to documenting sites which are difficult to access or are in remote areas. These photographic techniques have considerable potential to be applied advantageously to Australia's Indigenous sites, which are often located in remote places.

360º spherical images are being developed as a tool for exhibitions, displays and public education. These techniques therefore can play a role in public awareness raising. A key example of this is the PLACE-Hampi exhibition, which documented '... high resolution stereoscopic panoramas that present the most significant archaeological, historical, and sacred locations at the site of the World Heritage of Vijayanagara (Hampi) in southern India' (Kenderdine et al. c. 2008). The PLACE-Hampi exhibit uses 360° images in a public exhibition context. It is a key example of panoramic documentation because it provides a 'framework for a new approach to the rendering of the cultural experience, whose aesthetic and representational features give the general public a dramatic new appreciation of the many layered significations of such historical, archaeological, and architectural spaces' (Kenderdine et al. c. 2008).

Digital panoramas

'Panorama', in the digital photography context, is defined as '[a] stitching of several individual images

Figure 1. *Panoramic photograph of the proposed SKA site featured in Second Life.*

aiming towards increasing the field of view, the dynamic range or the depth of field of the resulting image, or any combination of the three' (Kolor 2009).

For digital panoramic photography, I use a Canon 40D digital camera (single lens reflex camera with interchangeable lens), with an 18–200 mm Canon zoom lens. I usually use the wide-angle lens setting (18 mm) for panoramic photography.

The equipment I use for 360° spherical image panoramic photography is highly portable, light and compact, making it ideal for use in remote locations or places which are difficult to access. The positioning of the camera during site photography needs to be done with care, to ensure an appropriate overlap of consecutive images, in addition to the correct positioning of the camera in relation to the axis of rotation. Various panoramic tripods 'heads' are commercially available. The number of photographs required to produce a 360° spherical image depends mainly upon the focal length of the lens used and the amount of overlap chosen in consecutive photographs. I typically take between 50–100 photographs per 360° spherical image.

There is a wide range of software available for the creation of panoramic images. More advanced software is used for the development of 360° spherical images. Autopano Pro (*www.autopano.net*) is a leading panoramic software that I have used to create 360° spherical images. This software combines multiple digital photographs, with advanced and automated methods for blending images, to produce a seamless and high-quality final image.

Viewing 360° spherical image

360° spherical images are best viewed using a planetarium-style projection system, to appreciate the wrap-around 360° view. However, such images can also be viewed in other ways such as on computer screens, when presented in 'Quicktime' movie format. When viewed in this format, the user can navigate around the image, including a zoom function. Viewing in this way becomes a very interactive experience for the viewer.

Some examples of the use of 360° spherical and panoramic images include the Cosmology Gallery (Gravity Discovery Centre, Western Australia), ICRAR / SKA panoramics and the use of panoramic images in the virtual reality world of Second Life (*www.secondlife.com*).

The Cosmology Gallery was established in 2008 at the Gravity Discovery Centre, in Western Australia. The Cosmology Gallery is dedicated to exhibits which show how various cultures understand and imagine their place in the universe. Artworks and exhibits include Indigenous, Christian, Buddhist, Islamic, Hindu and scientific perspectives (Gravity Discovery Centre 2008). The gallery itself comprises the largest projection dome in Australia. Videos featured at the gallery include examples of night-time time-lapse digital photography.

Panoramics in virtual reality

Panoramic images have also been used in virtual reality environments, such as Second Life (*www.secondlife.com*). The Square Kilometre Array Radio telescope project (SKA) is a collaboration between Curtin University and the University of Western Australia and is part of an international competitive process to design and construct an array of radio telescopes (Brophy 2009). Panoramic photography of the proposed location of the SKA project (near Geraldton, Western Australia) has been used to help visualise the site. Second Life 'avatars' (virtual persons) can walk around and interact with the visual landscape in Second Life (Fig. 1). Panoramic images of the proposed SKA site, Boolardy Station, have been completed by Dr Peter Morse, with virtual visualisation in Second Life by Dr Paul Bourke, The University of Western Australia (Bourke n.d.). The Second Life virtual site of the SKA project can be found at the 'WASP' site on Second Life, adjacent to The University of Western Australia Second Life site.

Time-lapse digital photography

Time-lapse photography is a very useful technique, which can be used to show the apparent motion of the stars above earthly landscapes. By taking a series of consecutive photographs, it is possible to animate the photographs into full motion picture, thereby converting a series of photographs into video. For night-time photography, exposures typically range between 20 to 30 seconds per photograph.

Normally, a continuous sequence of at least 100 photographs is needed for the production of a time-lapse video. The series of photographs are converted into video, via video editing software, such as Vegas Movie Studio, and can be produced in a variety of video formats and resolutions, including high definition video.

In the motion picture field, time-lapse photography of astronomical scenes is being used to great effect in a variety of film productions. Some examples include night-time time-lapse featured in *Tnorala* (2007), *Spirit Stones* (2007) and *Night* (2008).

For time-lapse photography, I use my Canon 40D digital camera (with the 18–200 mm zoom lens, usually at 18 mm) and shutter release cable for activating the shutter. This camera can produce high-quality images that have a considerably higher resolution than high-definition video.

Figure 2. *A scene from the 2009 Wave Rock night-time, time-lapse sequence.*

In 2009, I completed a time-lapse sequence of digital photography, of the stars above Wave Rock, Western Australia. The sequence shows the southern Milky Way and the Southern Cross, with Wave Rock illuminated by moonlight. It is interesting to note the shadow line drifting across Wave Rock during the time-lapse sequence (Fig. 2). Both the still photograph and time-lapse video sequence are featured on The World at Night web site (*www.twanight.org*).

The World at Night

The World at Night (TWAN) project (*www.twanight.org*) is an international collaboration of astronomical photographers dedicated to creating astronomical photography exhibits, linking cultural and natural landscapes together with celestial scenes. The World at Night uses a variety of photographic techniques, including panoramic, 360° spherical images, time-lapse and time-exposure photography.

The goal of The World At Night is to create a collection of stunning photographs of the world's most beautiful historic sites against the night-time backdrop of stars, planets and celestial events (Simmons and Tafreshi 2008).

The World at Night has, during the International Year of Astronomy, 2009, exhibited in many countries around the world. As of October 2009, 46 countries around the world and over 330 individual sites are represented in the TWAN collection. More than 30 TWAN exhibitions have taken place throughout the world to date.

An example of time-exposure photography is the 'star-trail' photo which features as the cover photo of the International Centre of Radio Astronomy Research (Fig. 3). This image is a night-time time-exposure (four hours in duration) illuminated with partial moonlight, and photographed with a 'fisheye' 180° camera lens. The exceptional nature of this image is apparent in that the straight road to the horizon is aligned with the South Celestial Pole, and the road was free of traffic for the duration of the photo. The landscape is naturally illuminated by moonlight, with no additional artificial light sources used (International Centre for Radio Astronomy Research n.d.).

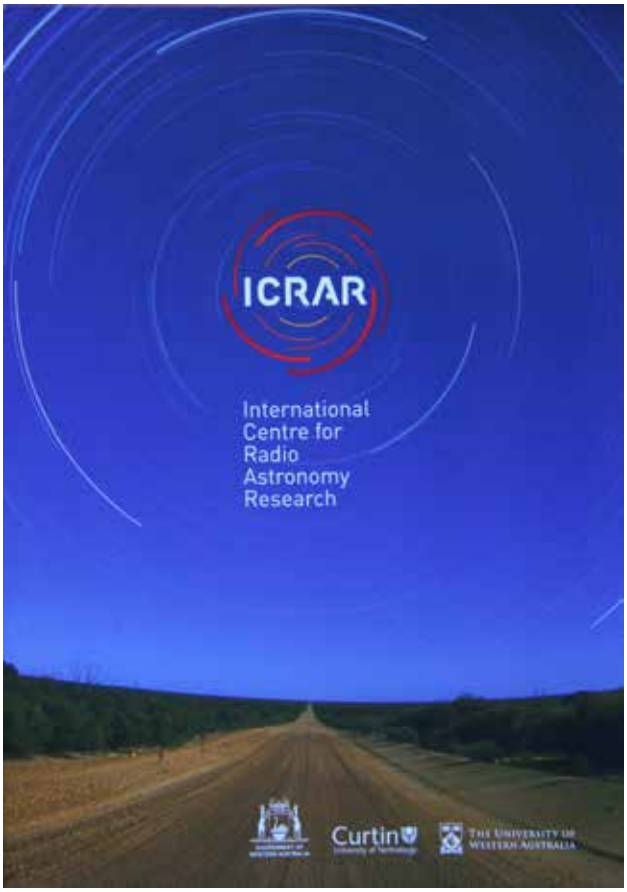

Figure 3. *Example of a 'star-trail' photo, featured on the front cover of the International Centre for Radio Astronomy Research.*

Figure 4. *The 360° spherical image of Mulka's Cave, 2009.*

The World at Night project is continuing to develop its photographic archive of night-time digital photography, time-lapse and panoramic nightscape images, on a global basis. The archive, which is available at *www.twanight.org*, is regularly updated with new images and videos.

Mulka's Cave

Mulka's Cave is an Aboriginal rock art site about 14 km north of Wave Rock, Western Australia, and is described by Serventy (1952) and Gunn (2006).

The significant erosion evident at Mulka's Cave is attributed to the impact from increased visitation numbers at this site (Rossi and Webb 2007). In 2009 I photographed a 360° spherical image of the interior of Mulka's Cave. The resulting image shows the extensive Aboriginal artwork in considerable detail. This 360° spherical image helps to document the interior of Mulka's Cave (Fig. 4 shows the 360° spherical image of the cave).

Other examples; Bali, Indonesia

In 2009, I journeyed to Bali, Indonesia, to photograph panoramic and 360° spherical images of several locations, including the sea temple Ulu Watu, the Sacred Monkey Forest, Ubud, Pejeng Moon Temple, Goa Gajah and the Besakih Temple (Mount Agung). A successful sequence of night-time time-lapse digital photography was also achieved at the Sacred Monkey Forest Temple, Ubud. The result, stars rising above the Monkey Forest temple, was very effective.

During one week of photography, over 2300 photos and more than 4700 photographic files (RAW and JPEG) (more than 38 Gigabytes of photographic data) were obtained, for three night-time time-lapse series, eight 360° spherical image sequences and additional general photography.

Discussion

The use of digital photography as a means of recording places of natural and cultural places of significance provides several opportunities.

From a public exhibition point of view, 360° spherical images provide an exceptional opportunity to document highly realistic and 'immersive' images of a given site. There are several ways in which such images can be viewed, including in an exhibition setting, via the Internet and in virtual reality settings such as 'Second Life'. This provides the potential for sites to be viewed in a virtual setting, rather than visitors having to visit a site physically. Rossi and Web (2007) drew attention to the erosive impact of visitors on Mulka's Cave. A 'virtual' experience of a site could be used to help lessen the physical impact of visitors on sensitive sites, by providing for a way in which visitors can experience a site visually without needing to physically visit a site. This approach has potential to be applied at any site in which a 'virtual' experience of a site is beneficial.

A further benefit of 360° spherical images, in relation to rock art, is that the spatial relationship between different rock art motifs can be readily perceived by the viewer. Groupings of rock art, and their relationship to each other and the surfaces upon which they are located, can be readily perceived. With the interactivity available in 360° spherical images including zoom functions and movement in any 360° direction, the viewer can gain a very good appreciation of the appearance of a site and its rock art.

One application of 360° spherical imaging, and time-lapse photography is to record the astronomical context of a particular landscape or environment. These methods have potential in archaeo-astronomy

research, which focuses on the relationships between the movement of astronomical bodies (e.g. solstice, equinox) and the landscape. This technique could be particularly useful to record the appearance of celestial bodies from a given location in relation to a particular cultural place. Norris (2009) notes the stone arrangement site of Wurdi Youang (Victoria) and its relation to the setting sun at the solstices and equinoxes. This is one such site in which time-lapse techniques could be applied.

Conclusion

The above examples show that there is considerable opportunity for natural and cultural places of significance to be documented via the digital photographic methods described in this paper.

Credits and acknowledgments

My attention was drawn to Mulka's Cave as a result of the research and publication about Mulka's Cave by Alana M. Rossi and Esmée Webb (ECU). The Department of Indigenous Affairs (Perth and Midland offices) and the Registrar of Aboriginal Sites is acknowledged for their assistance. The World At Night Director Babak Tafreshi and Mike Simmons of Astronomers without Borders is acknowledged as the primary source of information regarding The World At Night.

Thanks to Paul Bourke, WASP, University of Western Australia, and Dr Peter Morse for information regarding the Square Kilometre Array radio telescope project, and the panoramic photography featured on Second Life, in addition to Jay Jay Jegathesan, Manager, School of Physics, University of Western Australia (UWA Second Life project). Additional information regarding the SKA project and the 'Out There' exhibition was provided by the International Centre for Radio Astronomy Research (Curtin University of Technology, University of Western Australia). The support of Shire of Kondinin CEO Peter Webster is acknowledged regarding time-lapse photography at Wave Rock.

The support of the Cosmology Gallery, Gravity Discovery Centre, is acknowledged for permissions regarding the Cosmology Gallery information.

John Goldsmith
International Centre for Radio Astronomy Research
Curtin University of Technology
GPO Box U1987
Perth, W.A. 6845
Australia
E-mail: *John.Goldsmith@icrar.org*

Final MS received 3 August 2010

Web sites

ICRAR	*www.icrar.org*
The World at Night	*www.twanight.org*
Second Life	*www.secondlife.com*
Autopano	*www.autopano.net*
Gravity Discovery Centre	*www.gravitycentre.com.au*

REFERENCES

Anon. 2009. Computer technology rocks indigenous art. *University of Western Australia News* 28(4): 8–9.

Bourke, P. n.d. Collecting and creating digital assets for the SKA Radio Telescope Project, Boolardy. Photography: Peter Morse. A joint WASP / Communication Studies / Physics project of the University of Western Australia. Available at: *http://local.wasp.uwa.edu.au/~pbourke/papers/ozviz2007/ozviz2007.pdf*

Brophy, L. 2009. Opening the skies to the past and the future. *University of Western Australia News* 28(14): 1, 8–9.

David, B., J. Brayer, I. J. McNiven and A. Watchman 2001. Why digital enhancement of rock paintings works: rescaling and saturating colours. *Antiquity* 75: 781–792.

Gravity Discovery Centre Foundation 2008. The Cosmology Gallery, unity through diversity in a vast and awe inspiring universe. Gravity Discovery Centre Foundation.

Gunn, R. G. 2006. Mulka's Cave Aboriginal rock art site: its context and content. *Records of the Western Australian Museum* 23: 19–41

International Centre for Radio Astronomy Research n.d. (2009). Produced by the International Centre for Radio Astronomy Research, *www.icrar.org.*

Kenderdine, S., J. Shaw, J. Gollings, P. Doornbusch, Paprikaas Annimation Studio and L. Subramamiam n.d. Augmented Stereographic Panoramas of the Vijayanagara, India. Exhibition brochure. *Available at http://www.place-hampi.museum/pdf/Hampi_A4_Handout_screen.pdf*

Kolor (2009) Panobook 2009. KOLOR, France, *www.kolor.com*.

McNiven, I., B. David and J. Brayer 2000 Digital enhancement of Torres Strait rock art. *Antiquity* 74: 759–760.

McNiven, I., B. David and L. Brady 2002. Torres Strait rock art: an enhanced perspective. *Australian Aboriginal Studies* 2002/2: 69–74.

Norris, R. and C. Norris 2009. *Emu Dreaming, an introduction to Aboriginal astronomy*. Emu Dreaming, Sydney.

Ogleby, C. 1995. Digital technology in the documentation and management of rock art. In A. Thorn and J. Brunet (eds), *Preservation of rock art*, pp: 80–87. Occasional AURA Publication 9, Australian Rock Art Research Association, Melbourne.

Rossi, A. M. and E. Webb 2007. The consequences of allowing unrestricted tourist access at an Aboriginal site in a fragile environment: the erosive effect of trampling. *Conservation and Management of Archaeological Sites* 9(4): 219–236.

Serventy, V. 1952 Cave paintings near York and Hyden. *Western Australian Naturalist* 13(5): 121–130.

Simmons, M. and B. Tafreshi 2008. The World At Night, a new International Year of Astronomy project. *Communicating Astronomy with the Public CAPJournal* 2: 17–21.

RAR 28-999