3D Reconstruction and Printing for Rock Art Archaeology

Paul Bourke (iVEC@UWA) in collaboration with the Centre for Rock Art Research + Management (UWA)

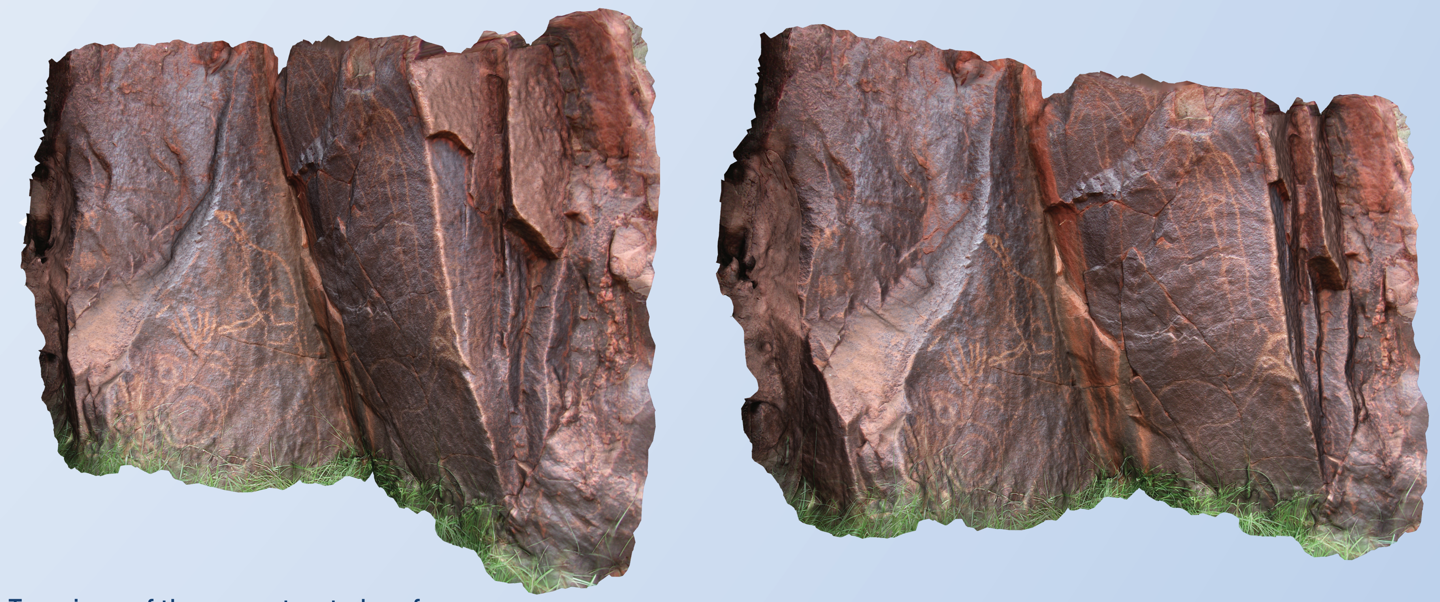
This poster, along with the associated 3D prints represents work being undertaken in collaboration with the Centre for Rock Art Research and Management at The University of Western Australia. It provides an overview of the rock art photography, the photogrammetry to reconstruct the digital 3D models and finally, efforts to print the 3D models for a more tactile visualisation. The example is taken from Wanmanna, a rock art site near Newman in Western Australia. An automated process is a strong driver in this work, the example shown here is just one example from the site where an additional 30 were captured from a total of 250 individual drawings.

The aim of this joint project is to explore forms of data capture and visualisation that result in richer assets than more traditional methods. Creating 3D models of the rock on which the art resides provides a context to the rock art that is more readily appreciated compared to normal photographs, bearings, simple bulk measurements and text descriptions of the rock form. The environment in which the rock art exists poses some challenges for other techniques such as laser scanning and structured light techniques, given the difficulty in accessing the sites, as well as extreme environmental and lighting conditions. While these don't affect photographic techniques, the rugged terrain and access to the art gives rise other issues such as not being able to photograph from optimal positions.

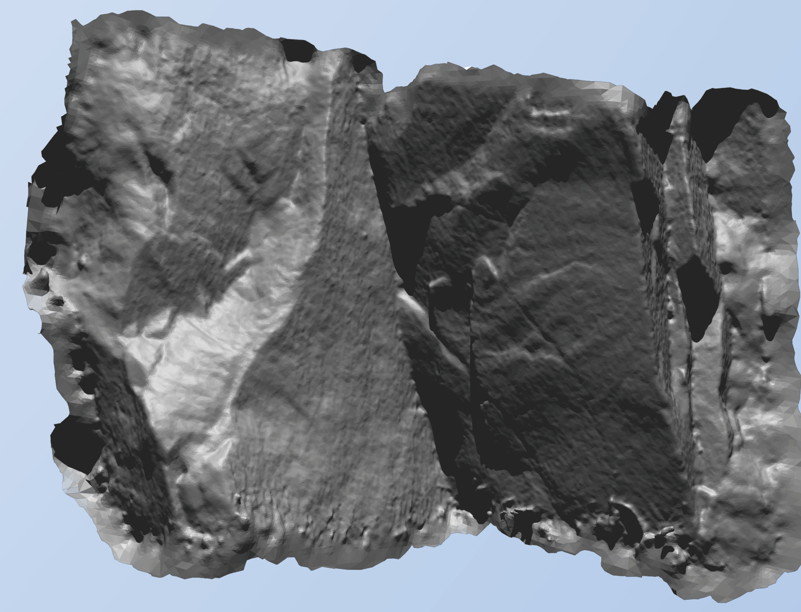
Photography

The process of reconstructing 3D geometry from photographs obviously starts with the capture of the photographs. While much research in this area has focused on reconstructing geometry from ad-hoc photograph collects, such as Flickr, higher resolution results can be achieved by having more control of the photography. An obvious example is that one cannot reconstruct geometry that is not photographed. Unlike panorama photography, there is generally nothing to gain by taking multiple photographs from a single location. Additionally, the particular algorithm being used may impose constraints on the photography, for example, some algorithms are assisted by photographing the object in a consistent orde r, such as moving from left to right.

5 Photographs of the rock face. Canon 5D and 50mm prime lens.



Two views of the reconstructed surface.



The underlying geomeric surface detail.

Reconstruction

A significant aspect of this research project has been the evaluation of various algorithmic offerings that have appeared over the last 3 years. Due to the rapidly evolving nature of the algorithms, this can be an iterative process, being an active area of research in machine vision and computer science. Software that may have been the best even as little as one year ago can be superseded by others that were previously inferior. This software evaluation has covered both open source pipelines that are largely based upon Bundler and the variants, as well as both modest and high cost commercial solutions.

It is claimed here that the reconstructions illustrated are the current state of the art. There are generally two facets of the reconstructed objects, the first is providing a high fidelity visual experience of the rock art, to this end the geometry is perhaps less important than the texture information. The second is to provide an accurate geometric recording. The first has been largely achieved, the challenge now is to create a high quality and dimensionally accurate geometric representation.

3D printing

It is well established that tactile exploration coupled with vision is a powerful visualisation technique, indeed the hand/eye coordination is fundamental to how humans explore physical objects in the real world. The objects being reconstructed here are often of special significance to the Australian Indigenous population and physical faximilies offer a more tangible representation than only digital models.

Various 3D printing technologies now enable physical copies of the reconstructed objects to be created, including the representation of colour however, the printing process cannot represent the infinitely thin mesh surfaces created from the reconstruction process. There are however, a number of algorithms for thickening the surface, the approach here is generally referred to as the "rolling ball" solution. It involves (conceptually) rolling a ball of some thickness across the mesh surface, forming the offset surface by considering the surface formed by the opposite side of the sphere to that touching the mesh surface. This algorithm solves the intersection problems that can occur if the mesh surface were simply extruded.

Online printing service: http://www.shapways.com

Photograph of the 3D printed surface.

Summary

This poster illustrates research aimed at creating more valuable digital representations of heritage objects compared to more traditional forms of recording. It also presents one way of “closing the loop” by creating physical representations (faximilies) from the digital record.

Further reading from the author

Workflow for reconstruction using PhotoScan: A beginners guide
http://paulbourke.net/miscellaneous/photoscantutorial/

Guiding notes for photographing for 3D reconstruction
http://paulbourke.net/miscellaneous/reconstructionphoto/

Examples of Automatic 3D reconstructions from photographs
http://paulbourke.net/miscellaneous/areconstruction/

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