Uses of 3-D Scanning Equipment at the Australian Museum

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Abstract

The Australian Museum has been using a 3-D laser scanner for several years as a means of recording objects and reproducing digital or physical copies. The digital data can be manipulated, studied and overlain on older scans to measure condition change. The paper outlines the various uses of this rapidly developing technology in the cultural conservation field and which applications are most effective. Also, it compares the characteristics of 3-d photography against 3-d scanning for presenting museum objects on the internet.

Keywords: 3-D; laser; scanning; modelling; replicating

Introduction

Laser scanning techniques to create 3-D digital models were developed for engineering and prototyping applications. In recent years it has been applied to various tasks in the fields of museums, archaeology and heritage architecture (La Pensee et al, 2006). The ability to create detailed digital maps of a surface without any contact with the object makes the technology particularly suitable for irreplaceable objects which are chemically and physically sensitive.

Equipment

In 2008 the Australian Museum purchased a Konica Minolta Vivid® 910 3-D scanner. This device fires a low intensity laser at the target surface. The reflected light is picked up by the scanner and the position of the each point is calculated by using the principle of triangulation. This enables the machine to produce a matrix of points connected by a mesh of polygons which gives the position of each point in relation to all other recorded points. This is effectively a contour map of the surface.

The maximum level of detail achievable with this equipment is 0.2mm spacing between recorded points. The scanner also takes a digital colour image with each scan which can be attached to the mesh to create a visually realistic object if required.

Output and Post Production

The output of the scanner consists of a series of contour maps saved on a portable computer in Konica Minolta's Polygon® software file formats. The object is scanned from every angle allowing areas of overlap between individual scans. Multi part scans need to be merged together to create a complete model of the subject material. This stage of the process can be quite time-consuming for a complex object as common points need to be marked for the software to recognise the appropriate place to merge the files. The computing power required for these tasks justifies using the best PC available in terms of memory and processing power.

The final model can exported into a number of different 3-D file formats. STL and VRML formats are industry standards and can be viewed with a variety of programmes including Freeware applications.

The Museum also purchased Geomagic® Studio and Qualify software with the scanner. This is much more sophisticated software for processing scans and has proved very useful when cleaning up "noise" in scans and filling gaps in the contour maps. Some corners of objects are impossible scan accurately and the software uses complex algorithms to estimate the curves of missing sections with a remarkable degree of accuracy.

The Qualify® software can be used for overlaying two separate scans and measuring the differences between them. This is a useful conservation tools for highlighting weathering or loss through time. It can also highlight deformation caused by changing environments on panel paintings, for example.

SCANNER APPLICATIONS AT THE AUSTRALIAN MUSEUM

Over the past 5 years, the Vivid 910 scanner has been used by the Australian Museum in the projects listed below. They include conservation applications, exhibition applications and fieldwork recording.

- **3-D Collections on the Web**

The primary aim in purchasing the scanner was to create 3-D models of collection objects to be displayed on the Museum's webpages. This has been successfully carried out by some museums around the world using a variety of software. For example, a site of fossil specimens in the UK has just been released this year - http://www.3d-fossils.ac.uk .

One of the challenges that soon became evident was the size of the completed files that were too big to easily download without a fast internet connection. Also, 3-D viewing software has to be downloaded with the file in some cases. The Museum's Multimedia Unit were firmly committed to using Flashplayer® for viewing moving graphics on the web. For this reason they recommended that we create a Flash animation which shows off the 3-D rotation. An animator created a dramatic animation based on our scans of a carved chalk head from the Solomon Islands which zoomed into the head as it rotated (Fig 1).

The other challenge is to stitch a series of photographs onto the 3-D mesh that has even colour rendition when viewed from all angles. The edges of a curved surface are often of a slightly different hue as the lighting is falling on it from a different angle. Photographing the object with diffused "surround" lighting employing a series of reflectors was the best way to achieve this.

When aiming to display the 3-D model on the internet it is worth considering whether a 3-D camera is more useful than a scanner. The detail of the contour map is of secondary importance to the rotatable image with accurate colour rendition. This allows the size of the files to be greatly reduced by dispensing with the polygon mesh of surface contours which lie beneath the image. Alternatively, a series of shots taken with a conventional camera can be stitched together into a 3-D optical model using several software packages that are now available.

- **3-D Display Models**

3-D display models on screens within the museum are less of a problem as the speed of the internet is no longer a limiting factor. The files sit on a PC which allows the public to manipulate the object in all directions or along any axes on screen using 3-D viewing software.

The equipment has also been used in a similar way for a digital repatriation project to make objects accessible to remote Indigenous communities using good quality 3-D modes viewed on portable computers.

- **Condition Recording of Outdoor Sites**

An engraving of an echidna in Kuringai National Park was scanned (Macgregor, 2011) using a portable generator and laptop computer with the scanner (Fig 2). This has created a permanent record of the physical details of the site that can be used for study, and monitoring of weathering/damage. The 3-D scans also improve visibility of faint detail on objects through software manipulation. This technique will also be applied to Aboriginal scarred and carved trees. For example, this has been used on dendroglyphs in New Zealand and proven to improve the visibility of surface details through the manipulation of the model in the software (NZ Dept of Cons 2010). The absence on the digital scans of the colour variation caused by lichen and staining allows the surface to be viewed free of visual "noise" on the contour map revealing hitherto unnoticed detail. Variable lighting conditions and angles can also be simulated on the computer to enhance the detail. In another impressive application, English Heritage recently scanned all of Stonehenge and revealed previously undetected toolmarks and engraved images in the stone surfaces (Abbott, 2012).

- **Virtual Loans**

A rare vertebrate from an extinct turtle in our Palaeontology Collection was requested for a research loan by an overseas institution. Rather than risk shipping the irreplaceable specimen, it was scanned at high resolution. The detail required for scientific research requires the scans to be done at the maximum possible resolution. This creates a large file of over 100Mb.

This necessitates the use of an FTP upload site for delivery to the client or the posting of a CD-ROM. For this work only the detailed contours and exact dimensions are important, so overlaying   photographic images and visual rendering of the surface colour are unnecessary.

- **Making Physical Replicas of Collection Objects**

Recently 2 rhinoceros horns were replicated for display using scans of the originals and a 3-D printing service. The current spate of thefts of rhino horns in Europe caused by their enormous blackmarket value makes public display of these items extremely risky. The scan files were sent to a Sydney-based company which produced a synthetic replica which is built in layers of resin in a 3-D printer. The white resin required hand tinting to achieve a suitable colour match with the originals. The non-contact nature of the process removes the risks of physical and chemical damage that accompany traditional moulding techniques.

Purchasing a 3-D printer is now an affordable option which avoids the high cost of outsourcing the printing. There are many printers available in a wide range of sizes and price ranges. The quality and speed of the equipment is rapidly improving each year. However, when considering the slow speed of printing, the demand within the museum and the need for hand finishing, the Museum has not considered this justifiable so far.

DISCUSSION

When considering investing in this type of equipment it is important to evaluate the nature of the tasks that are to be undertaken. There is an ever expanding variety of equipment and techniques available. Some scanners are now handheld and will stitch the scans into one model automatically. Also some scanners will capture very fine detail and may be more suited for research on smaller objects.

The cost of setting up a scanning facility is still considerable and if it is infrequently used, hiring a scanner and operator may be the best option. The investment of time in training required to master the complex software for a few jobs may not be justifiable.

As the software becomes simpler to use, new uses will be found for this technology. The use of laser scanners as a conservation tool may become commonplace as the technology becomes more affordable and powerful.

Author Biographical

Colin Macgregor is a Museum Conservator with more than 35 years experience in a range of positions. Colin has been working with the museum's ethnographic, archaeological and natural history collections since 1989. He has been Manager of Materials Conservation since

2001. Before moving to Australia, he worked with the Scottish Museums Council, Sheffield City Museums and the National Museum of Scotland. In 4 years with the Scottish Museums Council he carried out numerous surveys and advisory visits to regional museums across Scotland. At the Australian Museum, he has worked on disaster preparedness, environmental monitoring. Colin has also worked on the conservation and relocation of Aboriginal carved and scarred trees throughout NSW.

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Captions

Fig 1 Flash Animation of 3-D model of a carved chalk head from Solomon Islands on website (Australian Museum)

Fig 2 Laser Scanning a shallow engraving of an echidna near West Head north of Sydney (photo – Finton Mahony)

Fig 3 Finishing the merge of scans from a rhinocercos horn using Geomagic Studio (photo - Kate Jones)

Fig 4 The replica horns produced by a 3-D printer on display (photo - Megan Dean-Jones)

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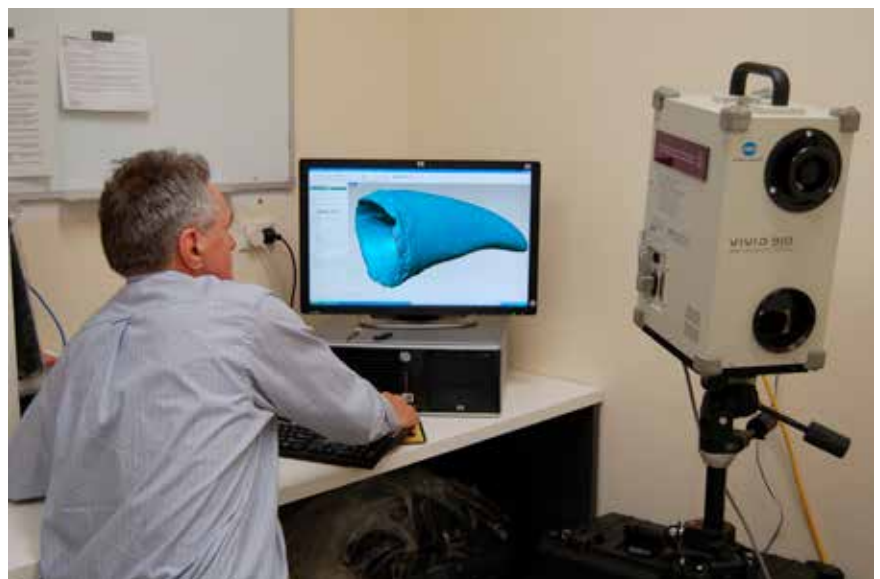
Fig 4 The replica horns produced by a 3-D printer on display. (photo - Megan Dean-Jones)