DIGITAL TECHNOLOGY IN THE DOCUMENTATION AND CONSERVATION OF CULTURAL MONUMENTS

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Abstract

This paper will discuss the application of appropriate technology in the recording and documentation of cultural sites and monuments in Australia, in particular the use of digital imaging, storage, enhancement and management of site data. Several case studies will be reviewed to illustrate the potential application of the technology.

This paper will show how digital photogrammetry, digital image processing and computer management of this data has been used to successfully document monuments and sites. It will also be shown that the use of state-of-the art information technology facilitates the documentation of more than the material object, much of the social significance of the object or place can now also be recorded.

1. Introduction

The process of creating records of significant sites and monuments has been in action for centuries, with a marked increase in formal activity during the last 50 years or so. Since the Second World War especially, Australians have become more concerned with preserving their cultural heritage. Part of the conservation process is the need to document as fully as possible the monument or site under study. The Venice Charter of the International Council on Monuments and Sites (ICOMOS), and the revised version created in Australia (the Burra Charter) states that any work to be performed on a site "must be preceded by professionally prepared studies of the physical, documentary and other evidence, and the existing fabric recorded before any disturbance of the place" [1] This paper will look at the contribution that modern mapping and surveying technology can make to that recording process. The emphasis will be on the use of photogrammetric recording processes, but will not be confined to this particular branch of *geomatics* [2].

1.1 Photogrammetry

The use of photogrammetry in recording cultural monuments and artefacts has been documented in Ogleby and Rivett [3] as well as in the proceedings of the Symposia of the Comité Internationale du Photogrammètrie Architecturale (CIPA) and in the Archives of the International Society for Photogrammetry and Remote Sensing in particular Commission V. There is a working group within Commission V of the ISPRS which is solely concerned with this application of photogrammetry, which also forms a liaison with the International Committee on Monuments and Sites (ICOMOS) to create CIPA. In fact, what was to become 'photogrammetry' was used to document architectural treasures long before the technology was applied to topographic mapping.

Advances made in computing technology and analytical processes over the last decade or so now means that the photogrammetric system elements like camera lenses and measurement machines can be mathematically compensated for by parameters in algorithms, rather than being constrained by high manufacturing tolerances. This analytical compensation for the deviation of the system from the 'perfect' case offers advantages over the 'traditional' approach in recording cultural monuments. The most significant advantage is that the cameras used are better designed for taking photographs, they accept a greater range of film types, the lenses are generally 'faster', the lenses can be focussed for use close to the object, and there is a wide range of accessories available to enhance the resultant photographic product. Some modern cameras also incorporate film flattening devices like a réseau plate to reduce distortions due to the shape of the film surface during exposure. With an appropriate analytical restitution instrument that permits the real time modelling of lens distortions, and physically limited film distortions, modern photographic cameras can be used as, and assumed to be, survey cameras.

Analytical photogrammetric stereo-plotters also permit a greater flexibility over camera orientation in the field. The 'traditional' geometry of the terrestrial stereo-pair consisting of parallel camera axes, small differential tilts between left and right photographs and limited common tilts between projection surfaces often constrained not only the location of the exposure station, but also the mounting devices used to orient the camera. The use of non-metric cameras and analytical stereo-plotters frees photogrammetry from many of the constraints that limited its effective application in other disciplines, including recording items of heritage value [4].

1.2 Digital Image Processing

The advances made over the last few years in computer technology, especially in the areas of memory and processor speed, now enables the storage and display of images in colour on devices as inexpensive as personal computers. The procedures for scanning a photographic print or transparency are simple, and the technology is affordable.

This paper reviews this application in a number of ways; by storing digital images of artwork within a data base, by enhancing images to facilitate interpretation and analysis, and by treating images as texture maps and mapping them onto CAD models of the sites and structures.

2 Recording and Documentation

The documentation of the cultural heritage of a nation is often the responsibility of government, supported by legislation where this is necessary. This task is not only undertaken by government agencies, but also interested community groups and individuals who see the merit but rarely the recognition. In Australia there are many organisations involved in this type of work, and various Acts of the Federal and State Governments have been enacted to give power to agencies to protect, record, document or police the cultural heritage of Australia.

Several case study examples will now be reviewed in order to demonstrate some of the current applications of using the technology described so far in the recording and documentation process. These studies will cover both the diagrammatic and descriptive aspects of site and monument documentation.

2.1 Rock Art Recording

Paintings in rock shelters, engravings on ledges and boulders, bee's wax, charcoal, ochre and clays combine in Australia to tell the story of the development of the world's longest continual cultural tradition. Rock art occurs throughout the continent in locations both remote and familiar. The styles of representation differ markedly around the country, as does the state of preservation and knowledge of the associated stories and rituals. The varying states of preservation causes two management problems, how to record what is there now and how to preserve or conserve what is there for the future. Although the two problems are part of a coordinated site management strategy only the task of recording will be addressed here.

Rock art recording has been occurring in a very sporadic manner since the arrival of the Europeans, starting with the sketches and paintings of explorers [5]. Methods involving drawing and sketching have been used, often using metric drawing aids like string grids so the record could be scaled. Photography naturally plays a vital role in the present documentation of rock art, and much work has been done in Australia in developing photogrammetric methodologies to provide a reliable metric record of the motifs and the site [3]. See Figure 1 for a measured drawing produced from a conventional photogrammetric recording produced in 1978.

As mentioned previously, recent developments have now made it possible not only to use conventional cameras as a reliable recording instrument, but also to restitute the resultant stereo-model to any reference plane. The facility to digitise line strings within a computer aided design environment (CAD) which is currently offered by modern stereo-plotters enables a three-dimensional model of a site or monument to be created from the photogrammetric record. This 3D model can be viewed from a number of vantage points, the representation of the monument is almost independent of the orientation of the original stereo-pairs from which the model was derived. Raster images can also be combined with the interpreted vector line-strings, Figure 3 shows the incorporation of a three dimensional graphics string with a digital image in the same computer environment. Figure 4 shows the mapping of a digital image onto the gridded surface of a panel of rock art, leading to a 'visualisation' or computer based re-creation of the rock painting site.

2.1.1 Image Enhancement

There has been little work done to date in using digital image processing facilities to increase the information content of pictures of rock art [4,7,8,9], however the investigations undertaken have shown that there is a valuable contribution to be made from an appropriate use of the technology.

As part of on-going research at the University of Melbourne, two image processing systems, Adobe *Photoshop* on the Macintosh (a picture publishing package) and *PC-Erdas* (a system designed for processing multi-channel satellite imagery), were used to determine the suitability of the two different approaches. The investigation found that there was no appreciable benefit in using the more 'sophisticated' remote sensing system, *Photoshop* was able to produce a result almost equal to that of the more 'sophisticated' image analysis package (on these test images at least). Although the 'best' drawing of the motif was considered to be that traced off the original photographs by the researcher who had visited the site, it was successfully shown that the procedure adopted was capable of improving the representation of the motif in the photograph. The results of this investigation are shown in Figures 5 and 6.

2.2 Architectural Recording

Architectural monuments seem to generate sympathy and emotions more readily than other monuments of civilisations' achievements. As a result considerable work has been undertaken to verify the use of photogrammetry to augment conventional measured drawing processes of building façades. This process produced drawings which resembled the conventional measured drawing traditionally obtained by hand (Figure 2 for example).

Once again, recent developments in the analytical restitution of photogrammetric records and image processing has facilitated the derivation of three dimensional CAD models of buildings. Work like that of Cooper, Robson and Littleworth [10] on the Tomb of Christ for example would not have been possible even 10 years ago; the photography could have been acquired but the restitution of this into a useful record would have been extremely difficult. In this project a very detailed three dimensional model of the Edicule of the Tomb of Christ in Jerusalem is being constructed, complete with texture maps generated from images acquired on site. The information is being managed in a GIS on a SUN Sparcstation, and the system can be used to access the photographic collection of the site by using the cursor to highlight regions on the CAD model.

Single images of regular building façades can also be used to derive metric information. Work like that of Georgeopoulos [11] for example shows how a picture processing package like Aldus *Photostyler* (very similar to *Photoshop* mentioned in the previous section) was used to rectify images of the façades of a building so that measurements could be made to aid in its reconstruction. In many cases like this, the original structures have been destroyed so all that remains is the photographic record. Image rectification and restitution facilitates the production of dimensional information of these lost monuments so that they can be conserved, preserved or reconstructed.

3 Animation, Visualisation and a Virtual Reality

The graphic output of computer based animation and visualisation systems is becoming increasingly common, for example most television stations' promotions are produced in this manner. Fundamental to many of these systems is the ability to view shapes and surfaces from any viewpoint, to give surfaces characteristics like reflectivity and translucency, and to map textures or materials onto these surfaces. Much of the input for these systems is produced using CAD, and several CAD suppliers provide packages that perform many of these functions.

A very successful project had been undertaken over the last few years using Intergraph's *ModelView* to produce still images and animations of the reconstructed Late Bronze Age fortified city of *El Qitar* [12], and experience gained from that is being used to achieve similar results at one of the rock painting shelters mentioned above. It is intended to animate the passage of the sun across the face of the shelter (which will assist in the analysis of surface salting), to use a sandstone material-map on the many TIN facets within the DSM, to warp the digital images of the motifs onto the digital surface model (DSM), and to produce animated 'walk-throughs' and 'fly-pasts'.

Virtual Reality is an expression used to denote the 'science' of trying to recreate 'reality' within a computer. The high-end systems generally consist of a helmet which incorporates twin computer screens that display stereo images of a CAD model and high fidelity headphones for playing sound effects. The position of the user in the 'virtual' space (*cyberspace*) is controlled by a hand operated device (joystick or glove) or a larger body suit. In this way, it is possible for the user (wearer?) to walk through a landscape that only exists in the memory of a computer.

It takes only a little imagination to see the potential for allowing people to visit significant monuments and sites (for example rock painting sites) that appear fully three dimensional, with images of the rock paintings in their true positions on the 'rock' surfaces, to turn their head to view the site as if they were there, listening to the story or song that is an intrinsic part of the site record with the breeze whispering through the trees. They could also walk along alleyways long destroyed, or stand at the feet of a mighty Buddha inside a temple. (Vandals could then deface virtual walls leaving the real sites untouched.) Certainly it sounds like science fiction, but the potential to do just this exists today. Could this be the ultimate site record and the inevitable cartography of the future?

4 An Information System Approach to the Management of Monument Data

The recoding and documentation of the cultural heritage of a nation generated an incredible amount of information. A few organisations realise the benefit of allowing this data to be accessed using the spatial location as a search criterion, and incorporate the data in a GIS. They are also being used in non-standard applications like archaeological/anthropological research (for example see [13], [14]) and also in rock art studies.

For example, at one of the rock paintings site mentioned previously the photogrammetric record provided the base map for the establishment of a large scale GIS of the rock shelter. Eventually the GIS will contain the data on the conservation measures being undertaken, the location of and data associated with the salinity test sites on the rock surface, the photographs, the sketches and line drawings, and hopefully the story of the site narrated by one of the traditional owners.

Once this is completed, it is a small step to produce copies of this data base on a convenient distribution medium like CD-ROM so that the information becomes an educational resource.

5 Conclusions

Modern digital technology has a role to play in the recording of cultural heritage. Appropriate use of the technology can measure and map monuments, enhance and store images, add textual attribute data and derive information from a variety of data sources. It is not claimed to offer the complete solution to recording items and sites of a 'cultural' value, but it can be used to add to the other available methods to create a very powerful recording and management tool. The technology is not an excuse to abandon heritage preservation and conservation, no amount of computer technology will ever replace being there.

Acknowledgments

All pictures of rock painting images were acquired and are published with the permission of the traditional owners. Their permission to use this information is gratefully acknowledged.

Figures

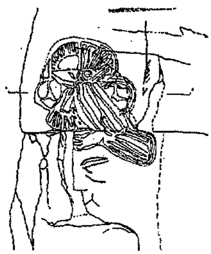

Figure 1 Rock Art Motif From Photogrametry

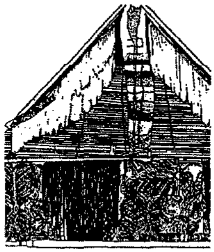

Figure 2 Haus Tambaran, Sepik River

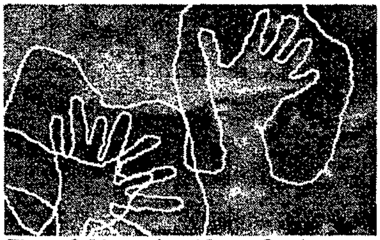

Figure 3 Linework and Image Overlay

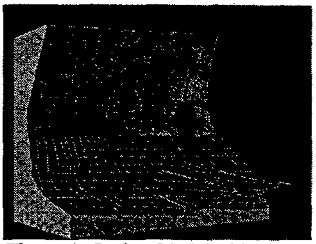

Figure 4 Surface Model with Image

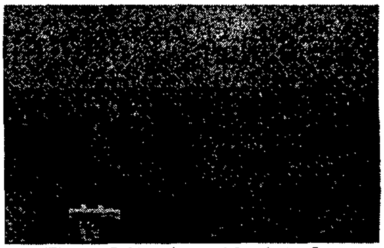

Figure 5 Unenhanced Rock Art Image

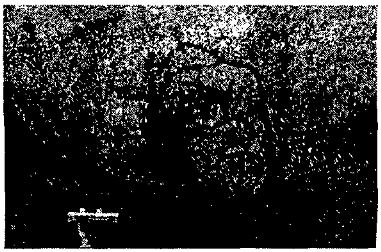

Figure 6 Enhanced Rock Art Image

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