Textured 3D models derived automatically from photographs

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ABSTRACT

Photogrammetry [1] is the general term given to the process of deriving some 3D quantity solely from photographs. While it has a long history in the derivation of terrain models more recently algorithmic advances in computer science and machine vision [2] has seen it applied to the derivation of full 3D textured models [3]. These techniques [4][5] and subsequent models find application in a range of disciplines including engineering, medicine, geology, and archaeology. This paper will present the current state of the art of automatic 3D reconstruction from photographs [6], along with practical applications in archaeology and heritage, particularly the capture of heritage objects as a rich digital recording, for research and presentation.

INTRODUCTION

Numerous areas of archaeology and heritage require objects to be documented, that is, their shape, size, colour, texture, orientation and so on. This may be intended to form a permanent record of the object or as part of a database for research and perhaps public outreach. Traditionally this data capture has involved drawings, note taking, and photography, however more recently these techniques have evolved in terms of fidelity and accuracy, along with the databases designed to make those recordings more permanent and accessible to both the research community and the public. Photographs are however a very limited representation of a 3D object, additionally the ability to store and interact with 3D models is mainstream, supported even on handheld devices. The question then is how to capture and efficiently create digital versions of 3D objects.

A variety of devices exist, for large scale objects [7] such as statues [8] and buildings the approach is traditionally laser scanners which scan the scene with a laser and measure the return of flight time and thus the distance to the reflecting point. While these can scan with high accuracy they do not generally create textured mesh data without significant human intervention. The scanners themselves are still specialist pieces of hardware, often heavy and sites are not always conducive to their use. For smaller scale objects the most common devices are based upon so called structured light techniques, the Kinect being a popular implementation of this but there are significantly higher resolution devices available. This family of device suffer from relatively low resolution, only operate across a limited scale and can be sensitive to environmental lighting.

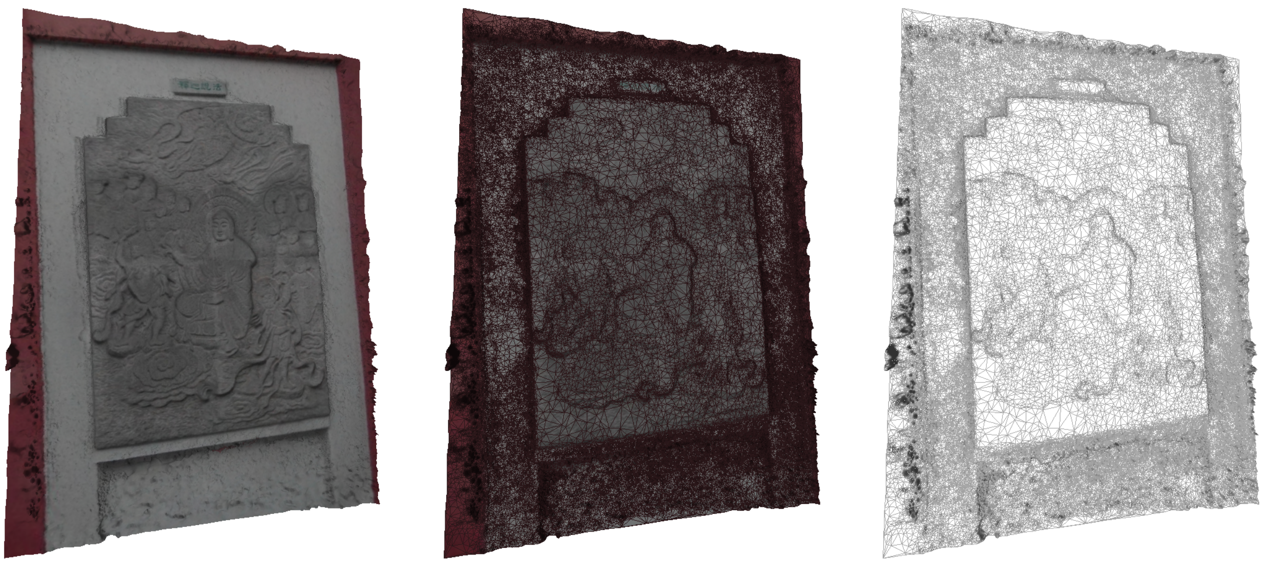

Figure 1: 2.5D engraving, textured mesh [4] on the left, mesh detail shown on the right. 1000 Buddha temple, Hong Kong.

In recent times, as little as the last 6 years, some key algorithms [9][10] have arisen, mainly in the machine vision domain [11]. These are enabling 3D reconstruction of objects based solely upon a number of photographs, generally taken in an ad hoc fashion. Early versions of these algorithms needed in-scene markers as part of a registration process or required a lens calibration [12] process. Currently neither of these are generally required, the camera and lens parameters are derived as part of the processing pipeline. As such, the construction of textured mesh models is becoming increasingly reliable, automated and accessible to the non-specialist. This paper will present applications of this type of 3D capture, discuss the limitations [13] as well as where it is superior to other techniques. The information will be presented in the form of case studies based around 3D data capture in Aboriginal rock art, archaeology, and Indian temple heritage.

Figure 2: 3D engraving, textured mesh on the left, mesh detail shown on the right. Lion statue, Fort Canning, Singapore.

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ABOUT THE AUTHOR

Paul Bourke, Director of the iVEC facility located at The University of Western Australia (UWA), and Visualisation Researcher at the University, provides scientific visualisation services to researchers within the university and to the other iVEC partners. Throughout his career, at various organisations, he concentrated on architectural, brain/medical, and astronomy visualisation. Of particular interest are novel data capture and display technologies and how they may be used to facilitate insight in scientific research, increase engagement for public outreach and education, create immersive environments, and enhance digital entertainment.

The iVEC facility located at the University of Western Australia. The facility hosts supercomputing resources on the campus and acts as an interface to the other supercomputing capabilities provided by iVEC. The facility also hosts display system in support of visualisation, scalable conferencing system, high end workstations, eResearch expertise and a video production unit.