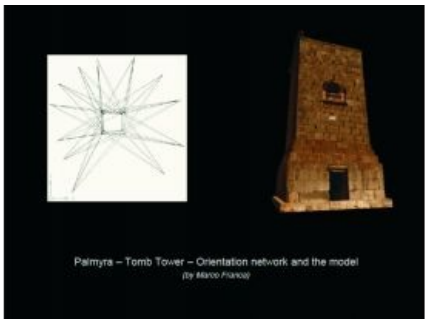
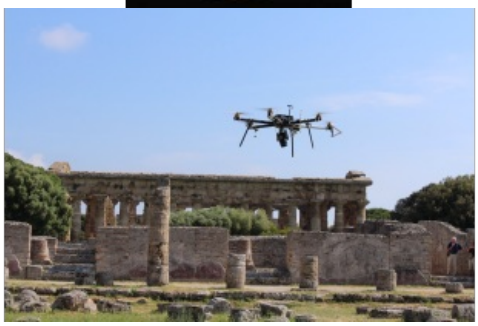
3D RECORDING, DOCUMENTATION AND MANAGEMENT

Geomatics for Cultural Heritage Preservation



Geomatics technology is playing an increasingly powerful and invaluable part in recording, visualising and digitally reconstructing cultural heritage resources for preservation and management purposes. New tools have appeared in the past decades including laser scanning, rapid prototyping, RGB-D sensors, high dynamic range imaging, spherical and infrared imaging, mobile mapping systems, UAS-based imaging, augmented and virtual reality and computer rendering in multiple dimensions. Read on for some international examples of practical applications.

(By Efstratios Stylianidis, Aristotle University of Thessaloniki, Greece, and Fabio Remondino, Bruno Kessler Foundation, Italy)



Cultural heritage conservation relates to maintaining objects, architecture or historic places in their current state in order to preserve authenticity, materials and values. Conservators work thoughtfully as they understand the significance of such places and objects and are keen to ensure that any interventions are carefully deliberated, debated and researched. Cultural heritage conservation has become a multi-disciplinary profession in which a rapidly growing number of buildings, sites, objects and landscapes are being identified for preservation.

Digital geometric documentation has many advantages and can rely on a large variety of sensors and software. Therefore, the application of geomatics technologies for the recording, visualisation and possible restoration and digital fabrication of cultural heritage resources is a powerful tool. The resulting images and data can be used to disseminate knowledge and information for education, research, risk assessment, planning and design related to cultural heritage conservation.

Caravan Cities in the Ancient East

In Roman times, the Silk Road was a major trading route leading between China and Rome. For some years now, a project has been underway to build up an information management system for this route's significant cultural value. The cities of Hatra, Palmyra and Petra in the ancient Near East were 'caravan cities' where the Parthian style was influenced by the Greco-Roman styles of architecture and sculpture. The imposing ancient architecture – with walls, colonnaded streets, temples and tombs of various kinds – has been preserved in these ancient cities and all of them are UNESCO World Heritage Sites.

The city Floruit of Hatra, situated in Northern Mesopotamia in Iraq, dates from the 1st century BC to the 4th century AD. A GIS database was created for the conservation of the city as the basis for integrating all other data collected using other tools. The defences, constructed of stone, include a ditch, tower tombs in the curtain wall (approx. 6km in circumference), massive walls and towers. An Italian team working at the site is building a database using Microsoft Word in hypertext mode for a catalogue. In addition, a geographic database including a topographic relief has been constructed in GIS (ArcView). AutoCAD and Sketch-up 8 have been used to model the defences in 3D. This provides a baseline for the conservation and restoration of the defensive structures.

The ancient city of Palmyra is in a desert oasis in Syria. It enjoyed its heyday from the 1st century BC to the 3rd century AD. The city has suffered severe damage, including to the ancient temple of Bel plus some other valuable remains from antiquity, during the recent Syrian civil war and some looting has taken place. Fortunately, the famous tower tombs that form part of the funerary landscape of Palmyra have been partly digitised using photogrammetric methods and, more recently, one of them has been modelled using spherical photogrammetry (Fangi, 2015).

The Holy Sepulchre in Jerusalem

The Church of the Holy Sepulchre in Jerusalem, Israel, is the central church of Christianity. It is based on the basilica originally built by Emperor Constantine in the 4th century AD on the traditional site of the crucifixion and the tomb of Jesus of Nazareth. Over the centuries, the basilica and the so-called Anastasis rotunda have faced fire, war and destruction. The site, which is currently shared by various churches and Christian denominations, has been documented by photogrammetric methods from as early as 1992.

A Greek interdisciplinary team further documented the monument by generating a cross section of it in AutoCAD. A 3D rotation was applied to project points. All the stereo pairs were oriented and plotted on a Leica DVP digital stereo plotter or Adam MPS-2 analytical stereo plotter. Architects produced the 3D photogrammetric outputs. The seismic vulnerability of the basilica prompted another 3D documentation project, carried out by an Italian team using GPS, total stations, photogrammetry and 3D laser scanning. The main aim was to perform a survey to establish the state of conservation of the basilica, with special attention paid to the rocky area on which it stands.

St. Mark's Basilica

The Basilica of St. Mark in Venice (built from 827-829 AD) is another outstanding architectural monument of Christianity. The wooden domes of the basilica that apparently date from 1210-1270 AD have been 3D modelled to understand the form, composition, wood species and conservation state of the beams and to build a database for analysis and monitoring. The documentation was aimed at understanding the static function of the beams in the architectural study. Traditional survey methods were initially used with a total station (TCRM1101) followed by laser scanning and CAD modelling. Visualisation and rendering of the dome structures was carried out using 3DStudio Max. The mosaic floors of the basilica have been documented in 3D to take into account the undulating state of the floors.

Frescoes and Murals

Irrespective of the medium or substrate, mural paintings require special attention in conservation. Light, humidity and temperature have to be set to a specific level and they must be constantly monitored. Infrared (IR) and ultraviolet (UV) light have been used to study paintings and writing since the 1930s. IR is quite strong and can reveal different layers of paint, if they exist. UV is used to reveal features in organic and inorganic artefacts or, in the case of paintings, to identify varnishes and over-paintings, particularly with fluorescence-imaging systems. Electro-optic holography and IR thermography are used in diagnostics and to assess defects in frescoes. In recent decades, laser-based techniques have become powerful methods in studying frescoes because of their minimum invasiveness. The combination of planar laser-induced fluorescence (PLIF), Raman spectroscopy and laser-induced breakdown spectroscopy (LIBS) offers a way of carrying out diagnostics and cleaning of of approaching the composition of the studied artefacts more authentically, thus improving the documentation procedure. It has been useful in studying pigments, copper-based alloys, ceramics and marble.

During the Vasari project and the study of pre-Hispanic murals in Mexico, a typical digital photogrammetric pipeline was used in order to build a 3D model for the conservation and restoration of paintings that may be adversely affected by the processes of preservation. Parameters such as spectrum, colour, levels of detail and geometric accuracy were taken into account in documenting the murals. Digital photogrammetry enables enhancement of geometric accuracy. It was found that sub-millimetre resolution was needed, and 3-4 pixel accuracy was found to be satisfactory.

A Powerful Tool

Conservation today seeks to retain the cultural past using geomatics technology such as 3D modelling. In a world where cultural heritage is increasingly threatened by abandonment, trafficking of artefacts and conflict-driven destruction, digital information is becoming a powerful tool in the work of multi-disciplinary conservation teams. Current digital information challenges include data fragmentation, lack of interoperability and non-standardised data collection methodologies. It is becoming necessary to adopt methodologies and protocols for multi-disciplinary teams and to establish holistic principles, guidelines and specifications. Moreover, it is important that interdisciplinary communities are involved and that the issues of risk assessment and sustainability are considered. A holistic approach is required, centred on the relevance of information to understanding the significance and integrity of – and threats to – our cultural heritage.

Figure 1, Researchers surveying a Mayan temple at Cópan, Honduras.

Figure 2, Palmyra tomb tower: orientation network and the 3D model (plot by Marco Franca).

Figure 3, 3D visualisation of a wooden dome of St. Mark's Basilica in Venice using 3D Studio Max (Fregonese and Taffurelli, 2009).

Figure 4, 3D digitisation of a painting using a triangulation-based laser scanner.

Figure 5, Capturing optical imagery of the Paestum archaeological site using an ESAFLY A2500 (http://www.salengineering.it).

Biographies of the Authors

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Further Reading

3D Recording, Documentation and Management of Cultural Heritage. Efstratios Stylianidis and Fabio Remondino (eds.) Whittles Publishing, Scotland 978-184995-168-5; to be published 2016

Fangi, G., 2015: Documentation of some cultural heritage emergencies in Syria in August 2010 by spherical photogrammetry. <<*Int. Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*>>, Vol. II-5/W3, pp. 401-408

Fregonese, L., Taffurelli, L., 2009: 3D model for the documentation of cultural heritage: the wooden domes of St. Mark's Basilica in Venice. <<*Int. Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*>>, Vol. 38-5/W1