Studies of the Early Christian Basilica of Christ of Jerusalem on the island of Kalymnos, Greece, through Terrestrial Laser Scanning

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Introduction

With permission from the Ephorate of Antiquities of the Dodekanessa, a study permit was granted by the Greek Ministry of Culture and Sports in August 2016 (May 31st- June 9th, 2017) to conduct Terrestrial Laser Scanning (TLS) of a 5th century early Christian Basilica of Christ of Jerusalem on the island of Kalymnos.

The project involved an architectural study of the 5th to 6th century's triple-nave basilica of Christ of Jerusalem using TLS. The monument lies within the sanctuary of Delian Apollo, just outside the ancient settlement of Damos, in the area of Limniotissa, approximately 250 m west of the Chora of Kalymnos. The basilica was initially investigated and partially excavated by C. T. Newton in 1856 and later by M. Serge in 1937. The first systematic excavations at the site were conducted in 2007 and 2008 by the Greek Archaeological Service under the directorship of archaeologist Mihalis Koutellas.

The island features numerous early Christian basilicas, 26 in total (Karabatsos, 1994) but this particular monument was selected for study because it has been excavated and published; it is one of the earliest and best preserved monumental basilicas erected on the island in an area that was the political and religious centre of Kalymnos in antiquity; and it is constructed of spolia, quarried from the nearby temple to Apollo and other monuments of the sanctuary of Delian Apollo.

Once processing of the data is completed, it will be possible to identify architectural elements (in addition to those already confirmed) originating from the temple of Apollo and possibly other buildings in the sanctuary; enhance our understanding of the architecture and materials of construction; gain detailed knowledge of the form, shape and size of the basilica to an accuracy and resolution never achieved before at this site, including features missed in the earlier investigations (e.g. mason's marks); and provide a more accurate data base that will aid in the future preservation/conservation plans of the monument and assist the Greek Archaeological Service in the final publication of the site.

The goals of this project are to create a new dataset and compare these results (measurements, plans, drawings, orthoimages, models etc.) with those from past investigations and prepare a website to present preliminary results to the public.

Scanning process

A Global Positioning System (GPS) receiver was used to establish the coordinates of the site and enable the point cloud to be tied to a national coordinate system. A portable three-dimensional terrestrial laser scanner, a Trimble TX5 (Faro Focus 3D) owned by the Dept. of Geodesy and Geomatics Engineering at the University of New Brunswick was used to digitally record the monument. The instrument sends out millions of laser pulses while rotating 360 degrees in a horizontal circle and +/- 90 degrees in a vertical direction (Barber et al., 2014; Dare and Ahn, 2014). Once these pulses strike an object they are reflected back to the scanner which determines the 3D coordinates (x,y,z) of every point to an accuracy of a few millimetres. The basilica was scanned in sections with the help of small white spheres setup as boundary markers that served to stitch the images (a process called registration) to produce a coloured point cloud photo of the site using SCENE and Trimble RealWorks v7.2 software.

In total 79 setups were required to scan the monument and six billion points were amassed within eight days. On the first day, eight setups were conducted to scan the interior of the adjacent Chapel of Ypakoui. In total, during the first six days 69 medium resolution quick scans, of 15 minutes each, were conducted and on Days 7 and 8 sections were rescanned. A series of ten one-hour high resolution scans were also conducted in order to reveal details of smaller features that may have been missed (e.g., mason marks) and produce clearer images of the letters found on the inscribed blocks used to construct the basilica.

Despite using new equipment, issues surrounded the capture of the data from early on (Papaioannou et al., 2021). From the start mechanical problems occurred while scanning the interior of the chapel and the exterior of the entire monument. The interior was thus rescanned, and data analysis and processing of the point cloud of the interior were completed with difficulties. At the end of the first day while scanning the exterior of the chapel and basilica the scanner malfunctioned during the 2nd setup and stopped working during the 3rd setup. As a result, all data was lost. Trimble dealers in Greece, Canada and the USA were contacted in order to address the problem, new software had to be downloaded, two firmware upgrades were required including the renewal of the processing license and the problem was resolved within a few days. Data processing continued after returning to Canada. However, a computer malfunction resulted in the loss of all data processed at the site in June and later at home, including the aerial photographs and the video taken with the drone. However, the raw data was not lost.

In addition to the mechanical challenges other problems were also encountered during data acquisition. The bright sunlight made it difficult to view the scanner screen so a temporary covering (in this case a black plastic garbage bag) was required to cover the instrument. The time of day and angle of the sun also complicated matters as scanning the mosaic pavements and the east side of the basilica during the morning and midday, created shadows leaving certain areas in the shade, whereas others were too bright or not visible at all. Consequently, sections had to be rescanned.

Ideal conditions for scanning mosaics includes a cloudy day or direct sunlight from above in order to avoid shadows; the apse for example was rescanned in the late afternoon when the entire east side of the basilica was in the shade.

Results

Processing raw data to create orthophotos and fly-throughs is time consuming (orthoimages and the flythrough completed for a site in Abdera required 346 hours of processing 10,000 images), while equipment malfunctions during the scanning and analysis processes can result in delays and the loss of many hours of work. All processed data was lost in the fall of 2017, but work has resumed on reprocessing the raw data. Fig. 1, Fig. 2 and Fig. 3 show images of the site created from the point cloud.

Fig. 1 and Fig. 2. Aerial and angle view of point cloud of basilica of Christ of Jerusalem and Chapel of Ypakoui (© Peter Dare)

Fig. 3. Point cloud of exterior view of Chapel of Ypakoui (© Peter Dare)

Goals

1) complete the processing of the raw data (orthoimages), 2) obtain GPS information of the basilica (which may require a trip to Kalymnos) in order to geo-reference the TLS material and create

topographical plans, cross-sections, elevations and line drawings (with detailed elevation features), 3) create a relative comparison orthophoto of the site, 4) compare the new measurements by over-laying an existing plan of the basilica onto the TLS orthophoto, 5) use 3D digital images (with photo-realist texture) to create digital elevation models, 6) create a website for the basilica and acquire permits from the Greek Ministry of Culture and Sports to launch the site, 7) develop visualization theories for scientific and public purposes, stemming from basic, technical and extended 3D digital models of the monument, and 8) create a virtual reconstruction and interactive visualization for the study of the basilica and the entire site (once a major pilgrimage centre).

Summary

The TLS results of the basilica-chapel allow researchers to adjust and present an accurate plan of a significant early Christian basilica and ancillary structures. This highly accurate digital data base will aid in future studies involving 3D digital modelling for research, education, preservation/conservation purposes and final publication. TLS data will therefore contribute to our understanding of reli-gious/public architecture of pilgrimage sites and serve as a preliminary study for future archaeologi-cal exploration of the entire site and other pilgrimage centres on the island and elsewhere.

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