Photogrammetric Documentation of Mosaics from NI Stobi, Republic of Macedonia

Queen's University | Balkan Heritage Foundation | National Institution Stobi

Introduction

The city of Stobi in the Republic of Macedonia, inhabited from the Hellenistic to Late Antique periods, is an internationally important ancient site. Many teams have excavated Stobi, beginning with Serbians in the 1930s and continuing with the Americans in the 1970s. Currently it is being excavated and conserved by a team employed by the Macedonian government. The Baptistry of the Episcopal Basilica, dating to the late 4th or early 5th century AD, is home to of of the most renown mosaic floors in the Republic of Macedonia. The Baptistry was discovered in 1971 by the joint Yugoslav-American excavation project.[1] Initial conservation was undertaken soon after the discovery of the mosaic, but with the exception of regular maintenance, no major conservation has been done until a project for the conservation and restoration of the Baptistery mosaic begun in April of 2017. The mosaic was left uncovered after initial excavation and over the decades, environmental factors have caused serious derioration of the lime mortar bedding and tesserae of the mosaic making conservation and restoration necessary for the future condition and structural stability of this prominant mosaic.[2]

Problem

As soon as a mosaic is uncovered, deterioration begins and it is imperative that immediate action is taken to prevent that. The documentation of mosaics presents considerable technical challenges. Before conservation on a mosaic is performed, a 1:1 drawing is created of the tesserae to document the current state of lacunae, cracks, and distortion. Manual drawing at 1:1 scale on mylar sheets is time consuming, introduces geometric distortion over large areas, and produces a difficult end-product to communicate digitally. These mylar drawings are scanned at 1:1 and transformed to a larger scale such as 1:20 which causes information to be lost.

Photographic documentation is invaluable but the requirement for scaled orthophotos demands considerable investment in mechanical systems to elevate the camera above the mosaic for nadir shots. In addition, it is extremely difficult to avoid improper stitching when attempting to combine nadir photographs into a single orthophoto which makes the use of simple nadir photography an unwise replacement for mylar drawing alone. For three years NI Stobi has conducted extensive trials of photogrammetric software for the documentation. The ADAMTech 3DM Analyst Research Suite, designed for the mining industry, offers an ideal system for the documentation and analysis of mosaic floors. The proposed technique of georeferenced photogrammetry offers a single form of documentation that maintains the 1:1 scale from start to finish and can provide all documentation and analysis required.

Methods

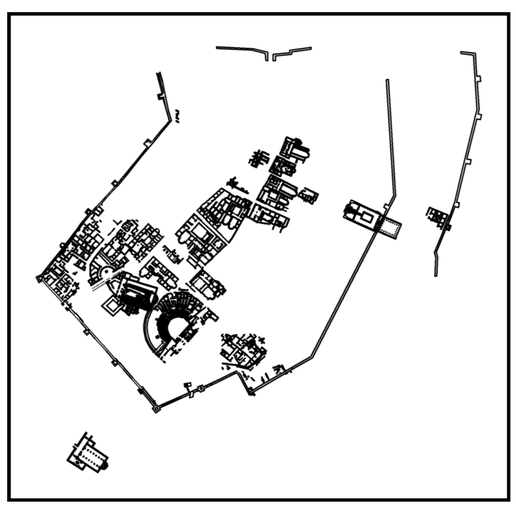
The photography was performed using a Nikon D800E 36 megapixel DSLR camera and a 24mm lens mounted on a camera pole at 3m height. The lens was precalibrated to account for lens distortion and optimize the accuracy of our resulting model. To accurately scale and postition the 3D model within the site, a series ten centroiding targets were measured using the Leica TPS1201+ Total Station. To maintain quality control, we performed seven random, reflectorless shots with the total station. The calculation of the deviation from these random shots to the 3D model provide us with our accuracy of 3mm in both height and plane which is adequate for high resolution visualization of the mosaic and tesserae by tesserae mapping. The limiting factor for accuracy of the georeferenced photogrammetric models is the quality of the existing survey, not the photogrammetry.

Parameter	Value
Ground Pixel Size	0.6mm
Image Accuracy	0.2 pixels
Base-Distance Ratio	1:2
Expected Accuracy (photogrammetry only)	<1mm
Actual Accuracy (georeferenced)	~3mm

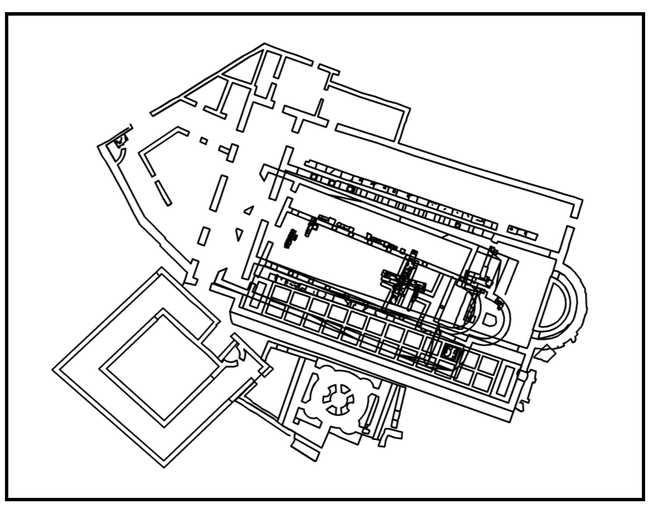
Photogrammetric methods allow us to efficiently and accurately document mosaics at every step of conservation and monitor their deterioration over time through comparison analysis. A 3D model of the mosaic was created using ADAM Technology's CalibCam and a number of analyses were performed using ADAM Technology's 3DM Analyst[3] and CloudCompare.[4]

A high-resolution orthophoto was generated of the mosaic floor that can be printed on a 1:1 scale, as well as dense 3D data that can be used for measurement. This 3D data can be used for drawing individual tesserae, quantifying the deviations from ground-level in the floor surface, and for monitoring subsequent changes on a yearly basis.

From the deviation map, areas of the mosaic floor where it deviates from a flat surface can be identified. In general, there is more deviation due to saggin that buckling, with the latter only present on the edges. The average deviation is about 2.8cm with the maximum deviation reaching 5-6cm in certain areas highlighted by the deviation map. The micro topography map was generated with contours every 2mm to show patterns in the irregularities. The photogrammetry is able to fully supplement the use of mylar for 1:1 drawings by drawing the tesserae digitally directly on the 3D data and all measurements and analysis are performed at a 1:1 scale. This data is being used as a documentation reference for the ongoing conservation project of the mosaic by NI Stobi, as well as for a virtual reconstruction of the entire baptistry.



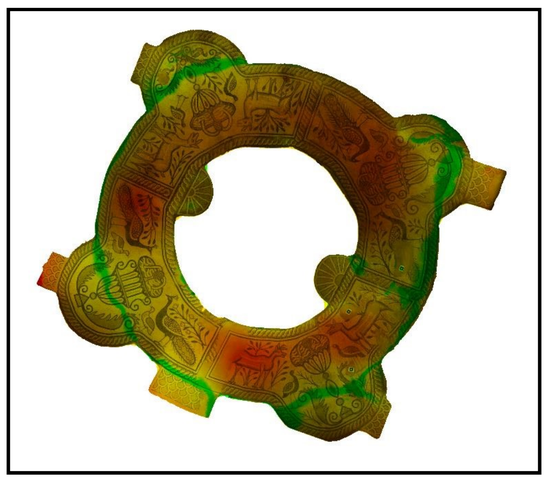
Stobi Ground Plan



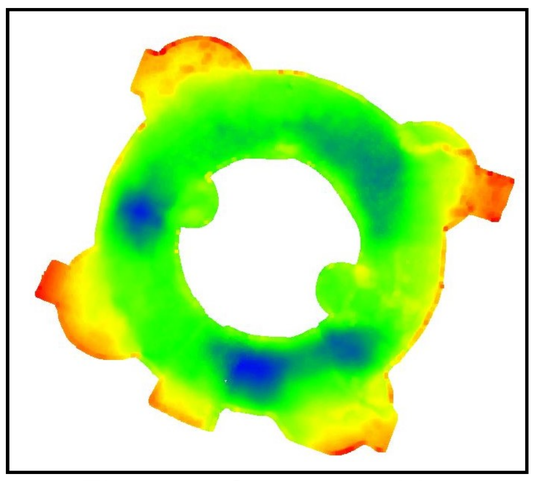
Episcopal Basilica

Results

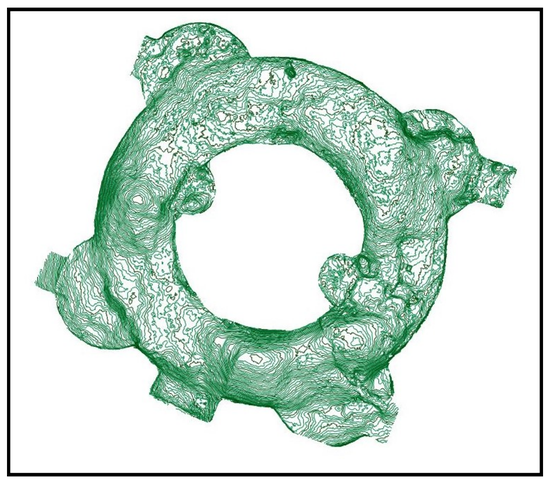
Orthophoto



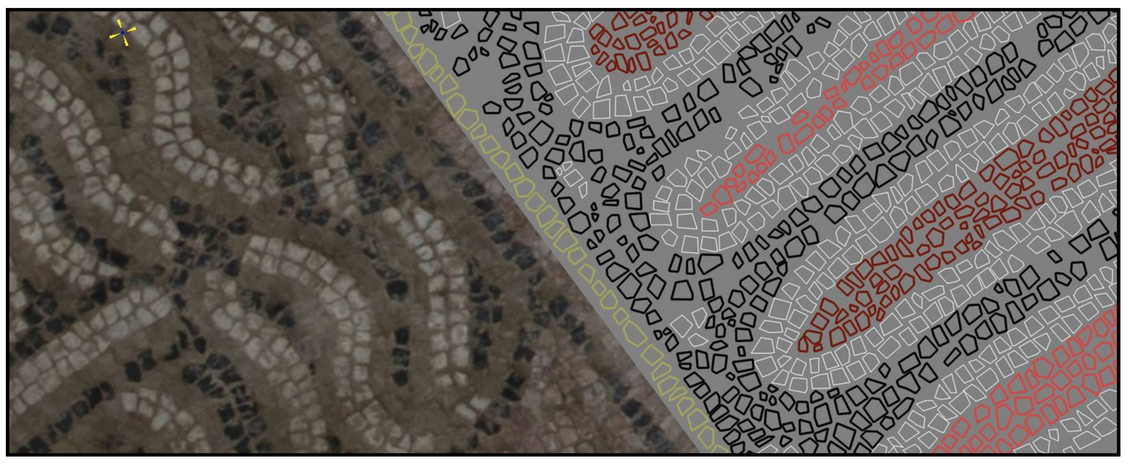
Deviation Map



Thermal Spectrum Map



Micro-Topography Map



Tesserae Mapping

References

[1]Wiseman, J, Mano-Zissi, D. "Excavations at Stobi, 1972." *American Journal of Archaeology* vol.77.4 (1973): 391-403.

[2]National Institution Stobi. "AFCP Stobi: Conservation of the Mosaic in the Baptistry." Posted September 7, 2017. http://www.stobi.mk/Templates/Pages/NewsArticle.aspx?page=3827

[3]CloudCompare (Version 2.8.1). http://www.cloudcompare.org/

[4]ADAMTechnology Mine Mapping Suite 2.5 (Build 1661). http://www.adamtech.com.au/3dm/analyst.html

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