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THE WESTERN HIGH GATE OF MEDINET HABU: PHOTOGRAMMETRIC 3D MODELLING & DOCUMENTATION

LA ALTA PUERTA OCCIDENTAL DE MEDINET HABU: MODELADO 3D FOTOGRAMÉTRICO Y DOCUMENTACIÓN

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Abstract:

This paper discusses the 3D photogrammetric modelling and documentation of the Western High Gate at Medinet Habu by the University of Chicago's Oriental Institute, Epigraphic Survey Project. It provides an overview of technique and approach, along with a discussion of measurement methods and accuracy.

Key words: 3D modelling, documentation, photogrammetry, Medinet Habu, Oriental Institute, The Epigraphic Survey

Resumen:

Este artículo discute el modelado 3D y la documentación fotogramétrica de la alta puerta occidental en Medinet Habu por el Instituto Oriental del Universidad de Chicago, Proyecto Levantamiento Epigráfico. Proporciona una visión general de la técnica y el enfoque, junto con una discusión de los métodos de medición y precisión.

Palabras clave: modelado 3D, documentación, fotogrametría, Medinet Habu, Instituto Oriental, La Encuesta Epigráfica

1. Introduction

The Western High Gate of Medinet Habu (Fig. 1) is located in Luxor, Egypt, on the west bank of the Nile and is one of two fortified gates in the great girdle wall that surrounds the Medinet Habu temple complex. It was first investigated and recorded in 1931/32 by Uvo Hölscher during the 5th campaign of the University of Chicago's Oriental Institute (Hölscher and Nelson 1934).

Figure 1: Overview of the Western High Gate at Medinet Habu from the North (McDonald 2016).

Unlike the east gate, whose stone architecture remains largely intact, the west gate was attacked towards the end of the 20th dynasty, with large blocks toppled from the upper courses of the structure and subsequently buried under rubble and debris. It was then likely razed to the ground along with portions of the adjoining girdle wall during the 21st - 24th dynasties and used as a stone quarry. As such, a few foundation blocks of the south tower are all that remain in situ of the stonework, though large sections of supporting mud brickwork are still in place.

Conversely, the supporting mud brickwork of the east gate was destroyed during a 'clearing' of the temple complex during the late 1800's.

Although their dimensions differ, Hölscher's excavation of the foundation of both gates revealed them to be of very similar construction — the western gate being slightly larger — and this, paired with an analysis and comparison of in situ east gate blocks with those excavated from the rubble and debris at the west gate allowed him to conclude that, "the west gate closely resembled the east gate in construction and surfaces intended for display" (Hölscher 1951). The two gates thus provide a sort of inverse impression of one another; the study of each allowing a better understanding of their whole appearance and function in antiquity.

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The 3D modelling of the Western High Gate undertaken as part of the 2015/16 Epigraphic Survey Project (Chicago House) was a continuation of Hölscher's explorations and conclusions, serving as the best means of thoroughly documenting the area before further excavations under the guidance of Oriental Institute researcher Jen Kimpton, and further research, publication and development of the area for tourism under Chicago House Director Ray Johnson.

2. Technique & Approach

As drone and UAV technology permissions are next to impossible to obtain in Egypt, the 3D model of the western high gate relied on a camera mast system. A 7m aluminum pole, as well as scaffolding were used to obtain the desired heights, angles and overlap required to accurately build the model. 3006 photos were taken with a Nikon D700 and fixed 28mm lens and assembled using Agisoft Photoscan. As Photoscan had no issues determining the make of camera and lens used, no additional camera calibrations were performed.

To facilitate project execution, the overall area was divided into 20 sections (Fig. 2), or chunks. Before field photography of any section began, a series of chunk points were determined and nailed in place using either reflective tape or reinforced tinfoil plaques. These chunk points were labelled sequentially and placed in corner points and along the boundaries of each section, as well as on any prominent features within that section. The points were photographed and a written description noted for each to aid in their total station survey post photography. The section was also cleaned of any garbage and three rulers (2 x 50cm, 1 x 1m) used for scale calibration were placed, in varied locales within that section. To aid in acquisition, the photos required to build the model were grouped into three different types (Fig. 3); Topos, Overviews and Details.

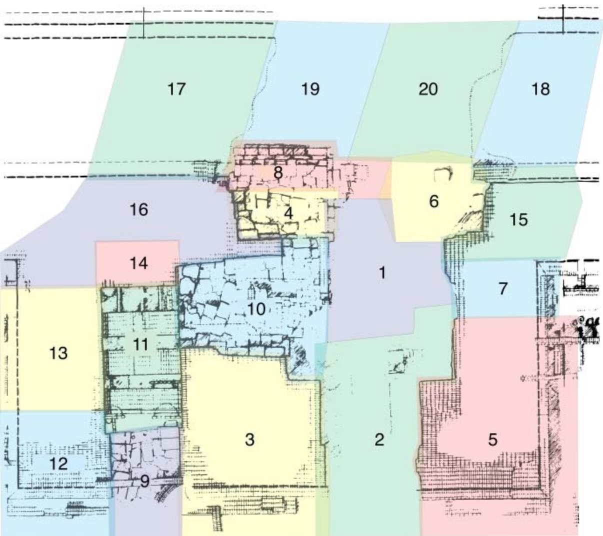

Figure 2: Map of the Western High Gate area divided into 20 sections (Hölscher and Kimpton 2016).

Topos were shot at a height of 4m above ground with the camera angled looking straight down, flush, or parallel, to the ground. This cartographic perspective provided an easily aligned framework in which the other two types of photographs could be further inserted and aligned.

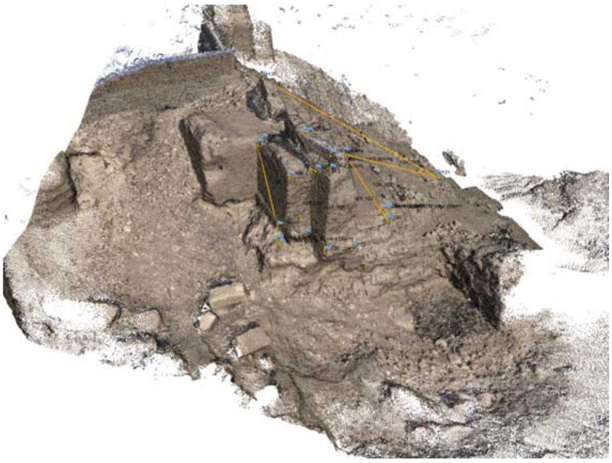

Figure 3: Survey/Chunk points measured (Murray and McDonald 2016).

Overviews were shot with the pole positioned perpendicular to the ground but the camera inclined downwards at roughly a 45º angle, and taken just along, or outside, the borders delineating the section, looking inwards to capture the interior of that section. These overviews were taken at positions of 13m, 7m, 4m, and 2m as dictated by the height of the features the section contained. A final handheld pass of the section was also included in these photos with the camera positioned perpendicular to the ground, but parallel to any wall or block features. The perspective and positioning of these type of photos allowed the geometry of individual sections to be captured easily as well as providing a suitable degree of overlap between sections aiding in their ability to align with one another (Fig. 4).

Figure 4: Overview of the Western High 3D Model as seen from the North (Murray and McDonald 2016).

Details were taken of any features within the section with unusual or obtuse geometry (in relation to the ground) such as undercut mudbrick structures, oddly positioned block fragments, etc that could not be adequately captured by the series of standardized overview photographs. This meant that many details were taken from a low level looking up; camera positioned perpendicular to ground but inclined upwards at approximately 20º - 30º.

Special attention was paid to the time of day and raking light in regards to prominent mudbrick wall features, and in several sections photos taken at different times of day (generally early morning/late afternoon) were combined so as to achieve the best possible lighting result for that section. In a similar vein, attention to shadow cast by the pole often dictated the manner of movement for the Topo type photographs (camera aligned to the East, moving East-West in strips) so as to avoid this cast shadow.

Photos were shot in RAW format and catalogued and developed in Lightroom. Processing generally involved minor colour temperature calibration and major highlight and shadow recovery so as to 'flatten' the photo, making it have less contrast than the conditions in which it was shot, and show as much detail in shadow areas as possible. Processed photos were exported as high resolution jpegs and then imported in Agisoft Photoscan for construction of the 3D model.

Sections took approximately 1 – 2 days to photograph on site, consisting of anywhere from 80 – 320 images depending on the intricacy of the features involved in the section. At the end of each day a low resolution "daily" model of the section was created to check that accurate and adequate coverage was provided by the sequence of photos taken.

3. Discussion

After a majority of the sections had been photographed, it was pointed out that a margin of error could be introduced into each section model as well as the overall model by including total station survey points. This stands to reason, as the accuracy of the measurements are only as accurate as the surveyor taking them — and in some cases, chunk points established on difficult to obtain corners and features would result in a margin of error greater than the normal +/- 0.5mm. A control test of this concept was conducted on section 15, as it provided a good representation of the terrain encountered within the overall west gate area.

Model 15 was assembled 3 times; first using a combination of 14 surveyed chunk points for that section, along with scale bar calibration of three rulers (2 x 50cm, 1 x 1m), the second time using just the 14 surveyed chunk points for that section, and the third time using just the scale bar calibration of three rulers. The distance between 8 points in each of the models was measured and the 3 different models were compared against one another, as well as against the same points measured independent of Photoscan, in Autocad, as well as against the distance ground truthed by hand using a tape measure. Table 1 and Table 1 cont'd list the results between the 3 different model builds and difference in results compared to the Autocad measurements.

4. Conclusions

Although it was initially thought the inclusion of chunk point total station measurements would improve the accuracy of the section 15 model, it appears this is not the case, with the scale bar calibration model having a slight edge over both combined scale bar and chunk point model, as well as just the chunk point model.

Table 1: Section 15 measurement comparisons in metres. SB = Scalebar, CP = Chunk Point.

Points Measured	*Autocad (m)*	*SB & CP Model (m)*	*SB & CP Diff. (m)*	*CP Model (m)*	*CP Diff. (m)*
120 – 121	9.8423	9.846	0.0037	9.844	0.0017
121 – 124	8.2365	8.247	0.0105	8.252	0.0155
122 – 124	4.5305	4.578	0.0475	4.573	0.0425
123 – 124	4.5980	4.653	0.0550	4.649	0.0510
127 – 133	3.6318	3.619	0.0128	3.619	0.0128
128 – 132	3.1382	3.155	0.0168	3.154	0.0158
129 – 127	3.6914	3.175	0.0236	3.716	0.0246
130 – 131	3.9118	3.923	0.0112	3.926	0.0142

Table 1 cont'd: Section 15 measurement comparisons in metres. SB = Scalebar, CP = Chunk Point.

Points Measured	*SB (m)*	*SB Diff. (m)*	*Tape (m)*
120 – 121	9.827	0.0153	9.844
121 – 124	8.231	0.0055	8.236
122 – 124	4.569	0.0385	4.574
123 – 124	4.644	0.0460	N/A
127 – 133	3.612	0.0198	3.164
128 – 132	3.148	0.0098	3.166
129 – 127	3.708	0.0166	3.754
130 – 131	3.916	0.0042	3.194

Regardless of model assembly method, it would appear that measurements within a vertical dimension lose accuracy over a certain degree. It seems that measurements over a 45º angle of inclination are inaccurate at approximately 1% of the total distance measured, whereas those ≤ 45º have an inaccuracy of only 0.1 - 0.2% of the total distance measured. One interpretation of this data is that the placement of vertically aligned scale bars in a 'z' plane — and the resulting number of projections of those points within the model — were not numerous enough to ensure the same level of accuracy as those within 'x' and 'y' planes. Trials in subsequent field seasons and surveys will be conducted to test this premise.

Since preparing and recording chunk points within the context of each section is/was time consuming, and the results are worse to negligible between this method and scale bar calibration, subsequent seasons and model assemblies will rely solely on scale bar calibration. Total station survey points will be used, though only in accurately georeferencing the finished model and positioning it within a global context.

Overall, despite the inability to use drone and UAV technology, the camera mast system and photogrammetric approach utilizing Agisoft Photoscan delivered results that were accurate, resulting in a model agreeable to all involved. The use of these 3D modelling and documentation techniques will continue, with a possible survey of the east gate being done for comparison and more comprehensive understanding of the High Gates of Medinet Habu initiated by Hölscher and now furthered by Kimpton.

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