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Architectural Drafting Standards in Archaeological Computer Modeling: Reconstructions from Drawings and Surveys of the Metropolitan Museum of Art Egyptian Expedition

Abstract: In the professions of architecture and engineering, computer modeling is frequently used to make geometrically accurate representations of three-dimensional objects with an arbitrary degree of precision and complexity. It is also generally recognized that any set of conventional measured plans, sections, and elevations can be redacted in a computer model with no loss of precision. In collaboration with the Egyptian Expedition of the Metropolitan Museum of Art, the Museum of Reconstructions has developed computer models of seven major archaeological sites, including the pyramid complexes of Senwosret Ist and 3rd, the mastabas of Knumhotep and Senwosretankh, and the solar temple of Nuiserre. These projects were supervised by Dieter Arnold, field director of the Metropolitan Museum's excavations at Dahshur and Lisht, and computer modeled by David Johnson of the Museum of Reconstructions. Each of these projects was intended to completely and accurately incorporate all relevant dimensional data from definitive measured drawings and surveys (*Figs. 1 to 5*). This paper will review the standards and methodologies used in the development of these models, as well as their relationship to drafting and surveying techniques which have historically been applied in the documentation of ancient buildings. It will also consider the varied objectives and standards which have been used in the development of computer models of ancient buildings, including movie special effects and abridged sketch models abstracted from definitive measured drawings. The problems involved in verifying and reviewing the accuracy of measured drawings will also be discussed, with particular emphasis on the essential and comprehensive responsibility traditionally held by draftspersons and surveyors. In conclusion, this paper will suggest that the computer modeling of ancient buildings should conform to standards and methodologies which have traditionally governed architectural drawings in archaeology.

The Potential of Computer Modeling in Archaeological Reconstructions

For five centuries, architects and draftsmen have recorded millions of measurements collected from hundreds of ruined buildings and sites. At all periods, the objective of this activity was the documentation and visualization of ruined buildings with the highest possible degree of accuracy and completeness. But it has only been in the last fifteen years that the new technology of computer modeling has brought a comprehensive realization of this project within reach. Computer modeling is capable of combining any number of plans, sections and elevations, each containing any number of dimensional coordinates, into a single drawing with arbitrary precision and complexity. The limitations of accuracy and scale which constrain conventional drawing simply do not apply to computer modeling. Through decades or centuries of effort, by re-

dacting the measurements in existing publications in computer models, it might eventually be possible to make this data available in a visual form which would allow both specialists and the general public to appreciate everything that is known about a great number of ancient sites.

Architectural Drafting Standards and the Accuracy of Dimensional Data

In the documentation of architectural ruins, as in other applied sciences, certain scholarly standards have generally been observed in the use of quantitative data. The widespread application of these standards has resulted in a continuous accumulation of knowledge concerning ancient buildings. In the case of the primary documentation of ruined buildings, it has always been considered essential to collect the greatest possible number of meas-

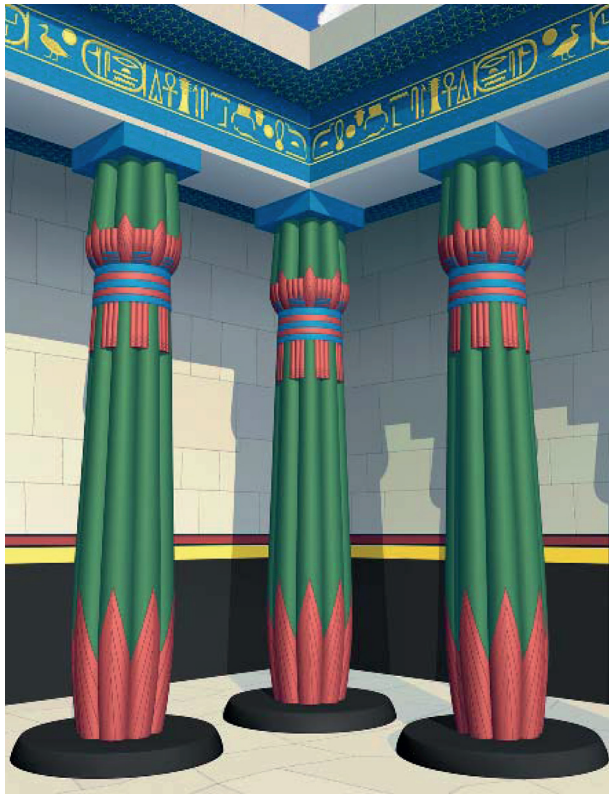


Fig. 1. Computer reconstruction of papyrus-bundle columns from the south temple of the pyramid of Senwosret III at Dahshur (computer rendering: D. Johnson).

urements of a ruin's actual state. In the secondary use or reconstruction of these primary sources, efforts have typically been made to maintain the accuracy of the original source data to the greatest extent possible. Technical limitations meant that a certain degree of abstraction was unavoidable when traditional drawing methods were used; however this was largely overcome through the use of detail drawings, and is not a factor in the development of computer models. In architectural scholarship it has also been considered essential to cite the use of any sources of dimensional data in a way which would make clear the reasons for any revisions, simplifications, or modifications. In the past these requirements have been satisfied by publishing reconstructions as part of architectural studies, which typically included supporting descriptions, citations, and the reproduction of drawings used as sources.

The Distinction Between Archaeometric and Sketch Models

It is important to make a qualitative distinction between two different approaches to the electronic reconstruction of ruined buildings. When the dimensions from definitive drawings are completely redacted in a computer model with no loss of accuracy, this could be called archaeometric reconstruction. The term archaeometric is proposed because such reconstructions are comprised of quantitative, metrical data which can be accurately copied through the use of specific, well-defined methodologies derived from architectural practice. Archaeometric reconstructions can be contrasted with "sketch" or "pedagogical" models, which only incorporate a subset of the authoritative dimensions, or which simplify the geometric forms in published drawings for reasons of expediency. It can be fairly difficult to determine whether a given reconstruction is archaeometric or a sketch model in the absence of a comprehensive publication, but in terms of the dimensional data in a computer model the distinction is absolute. Either a computer model includes every relevant dimension from every authoritative publication, with no loss of accuracy, or it does not. The term "relevancy" has a particular meaning in this context, as it is really the accuracy and completeness of the coordinates *in specific perspectives* which are important. If all the dimensions in a particular view or rendering are drawn from definitive publications, are as dimensionally accurate as those recorded in definitive drawings, and are not geometrically simplified or abridged in any way, this might be called an archaeometric reconstruction of a given source.

Architectural Publications and Computer Reconstructions

The importance of conventional architectural publications becomes clear when we begin to ask whether a given computer-modeled reconstruction is archaeometric or a sketch model. As is often pointed out, the apparent realism of a computer model has nothing to do with the accuracy of the dimensional data it contains, as well as having the potential to mislead the unwary. When very high-resolution prints or zooming images are available, a handful of architectural experts might be able to detect significant omissions or simplifications in a computer-

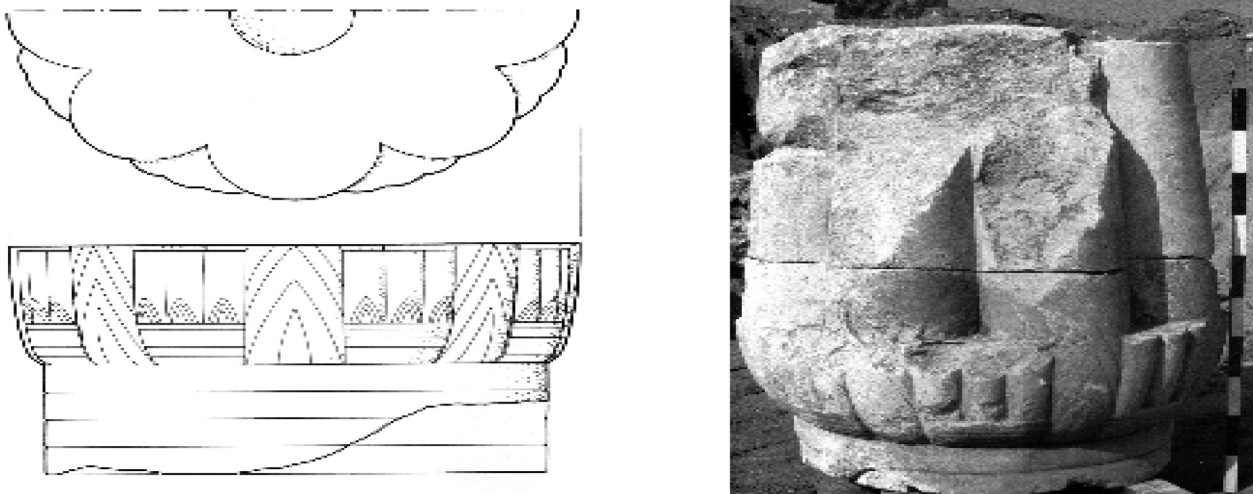


Fig. 2. Fragments of papyrus-bundle capitals from the south temple of Senwosret III at Dahshur (drawings: D. Arnold, B. Girsh, photograph: A. Oppenheim).

modeled reconstruction. But these kinds of high-resolution views are not always made or published, so that it is often impossible to determine whether a reconstruction is archaeometric or a sketch model. Without the kind of supporting documentation which has been typically found in architectural studies, it becomes very difficult to be sure of the status of a given computer model. If one is familiar with a given bibliography, it is often possible to detect certain omissions, at which point one suspects that some parts of a model are accurate, and others not. This uncertainty concerning the accuracy of reconstructions in no way results from anything inherent in computer modeling technology, which is nothing more than a very advanced drafting tool, but is instead a result of the limited extent to which computer reconstruction projects are sometimes published and documented.

Sketch Modeling and Architectural Studies

There are a number of considerations which suggest that all scholarly reconstructions of ruined buildings should be made using an archaeometric methodology. Unlike conventional drawing methods, computer modeling does not suffer from technical limitations which make it difficult to achieve arbitrary accuracy and complexity. Any pedagogical point which could be made using a sketch model could be just as effectively demonstrated using an archaeometric computer model. An archaeometric model is capable of depicting all the data in existing

publications with perfect accuracy, whereas sketch models will show some points correctly and others in a distorted or simplified fashion. And without a traditional architectural publication exhaustively describing these simplifications, it will be virtually impossible for a non-expert to detect them.

For technical reasons well known to computer modelers, it is often easier to start over from scratch than it is to incrementally improve the complexity or accuracy of an existing model. In this respect, fully modeling one small block of a building is a contribution towards the eventual completion of an archaeometric reconstruction, whereas the development of a sketch model does not generally amount to progress in this respect. As sketch models proliferate, there is the danger that scholarship will erroneously come to believe that some of them accurately reflect the data in existing definitive publications. This may give rise to the idea that the reconstruction of a site has already been accomplished, resulting in a lack of interest or funding for truly archaeometric versions. In a similar fashion, the lack of certainty concerning the status of a given reconstruction may prevent it from being accepted as definitive, with the result that multiple competing models of the same site will be developed.

The development of sketch models of ruined buildings makes complete sense in the case of television documentaries. In the context of traditional architectural studies, abstractions and simplifications of prior scholarship have generally been avoided, except to the extent they were necessitated by technical limitations of traditional drawing



Fig. 3. Computer reconstruction of the south part of the east facade of the mastaba of Senwosretankh at Lisht (computer rendering: D. Johnson).

methods. In a similar fashion, the dimensional inaccuracies and simplifications of sketch models are not typical of drafting practices in contemporary architecture, which have historically had a strong influence on the application of such methods in archaeology.

The Role of Peer Review in Archaeological Drafting

In most pure and applied sciences, the quantitative data supporting a paper is subject to both peer

review and confirmation through the repetition of experiments according to published protocols. If one were to follow the conventions which prevail in these other sciences, each measurement of a ruined site, and every one of the coordinates recorded in measured drawings, would be independently reviewed and verified before publication, and then remeasured and redrawn by other researchers after publication to confirm the results. In reality, the review of architectural studies has never included any kind of point-by-point confirmation of the accuracy of each of the dimensions in surveys and drawings. Instead, for better or worse, there has always been a more-or-less total reliance on the diligence and accuracy of individual draftspersons, just as in the architectural and engineering professions.

There seems to be a great need for new forms of publication which would make it possible for a reviewer or scholar to directly compare each of the dimensions in a computer model with those in the published record. In traditional and electronic architectural practice, this has been done using orthographic drawings and layering. Although high-resolution plans, sections, and elevations are not always produced as part of computer modeling projects, they are invaluable for making comparisons with source drawings. By superimposing a source plan or elevation and a corresponding rendering with transparency, it is easy to verify that each aspect of a computer model matches the details of published drawings exactly. In this way the “layers of percep-

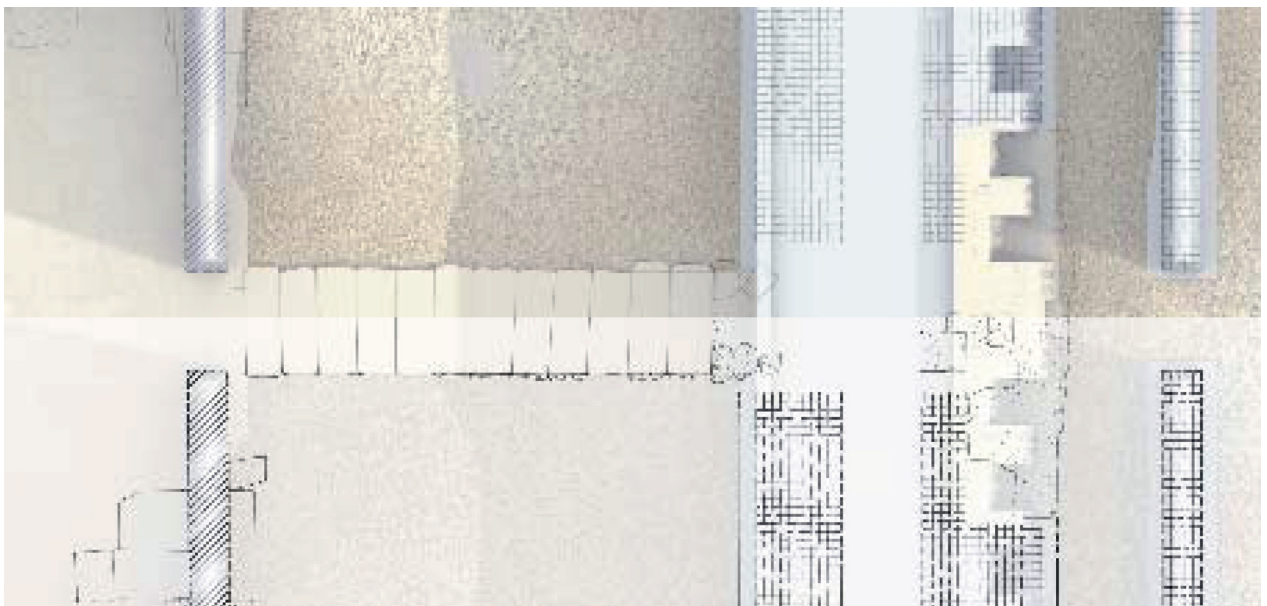


Fig. 4. Superimposition of computer-reconstructed and actual state plans of the mastaba of Senwosretankh at Lisht (computer rendering: D. Johnson, drawing: Dieter Arnold).

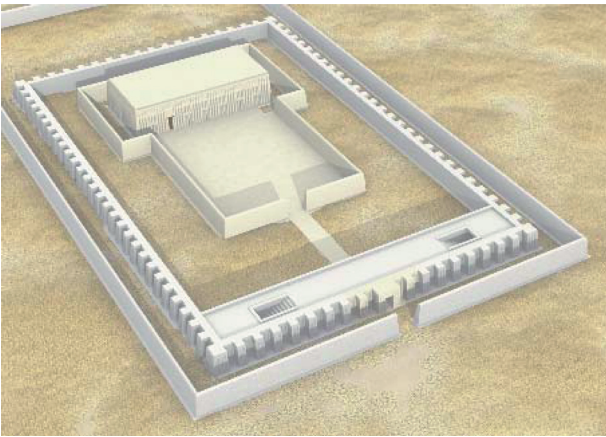


Fig. 5. Aerial view of computer reconstruction of the mastaba of Senwosretankh at Lisht (computer rendering: D. Johnson).

tion" which arise when the accuracy and completeness of a computer model is uncertain could be replaced by "layers of proof".

Layers of Proof: Towards the Interactive Architectural Monograph

The existing form of the architectural monograph has a number of limitations which would make it difficult to fully document an archaeometric computer model in this medium. To completely demonstrate the accuracy and completeness of a given reconstruction, hundreds of source drawings and orthographic computer renderings would need to be composited with transparency and at a variety of scales. In order to confirm the accuracy of each detail, it would be necessary to zoom in and out of each layer while adjusting its transparency. These kinds

of graphical presentations are not a problem for electronic media, which perhaps suggests a need for a new type of publication which might be called the interactive architectural monograph or reconstruction report. Having completed the development of seven archaeological computer models (ARNOLD 2002, in press), the Museum of Reconstructions is now developing a database-driven web application which will implement the essential features of traditional architectural studies in an electronic form. This software will use MySQL as a relational database, PHP as a server-side language, and Flash remoting as a graphical front-end, and will include tools for visualizing and verifying the accuracy of complex computer-modeled reconstructions.

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