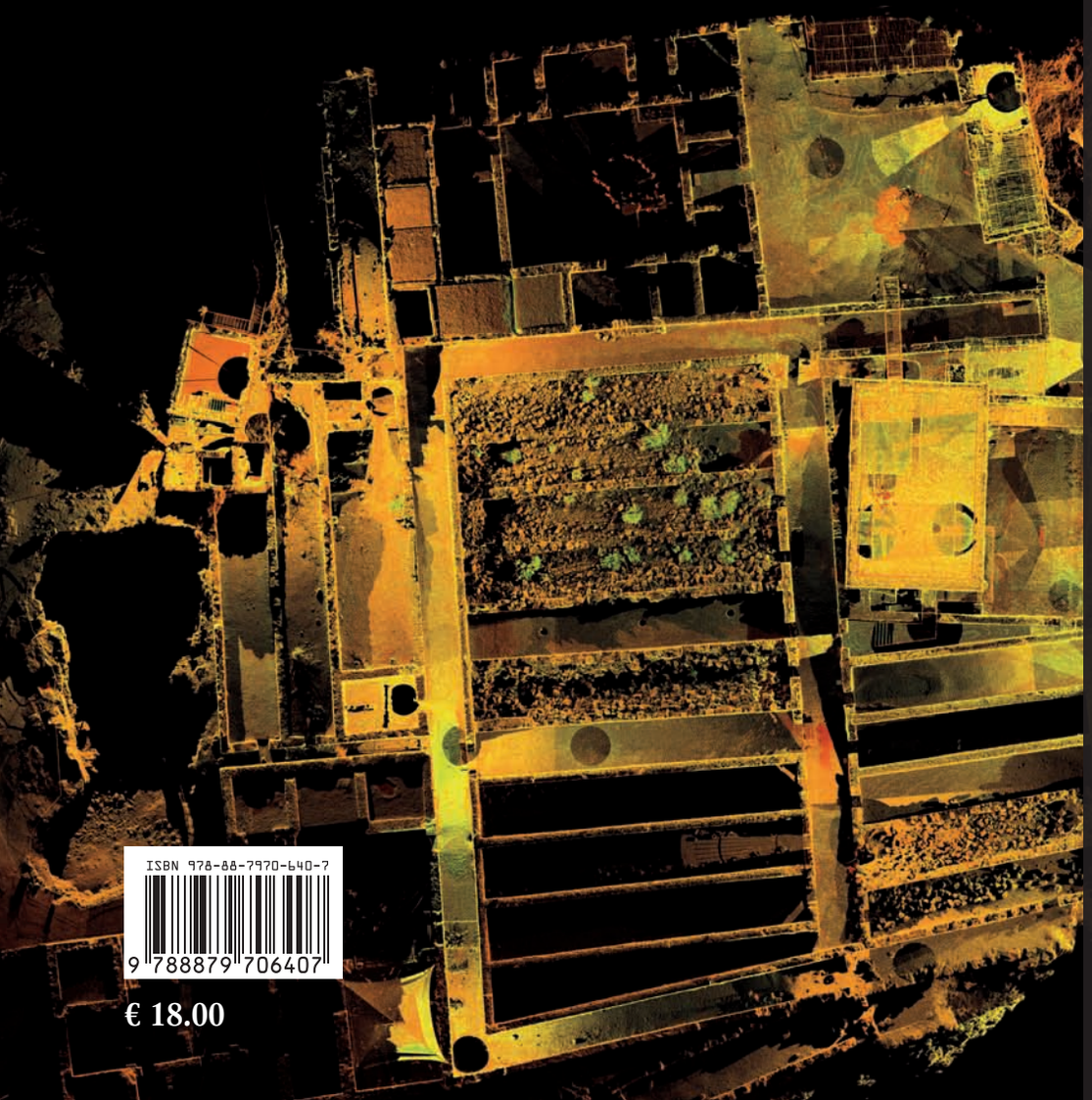
A program of International cooperation Italy-Israel

The Masada project was developed as an on-going research collaboration between the Department of Interior Building and Environment Design of Shenkar College of Design and Engineering, the Department of Architecture of the University of Florence and the Department of Architecture and Civil Engineering of the University of Pavia. Beyond the research aspects, the project has didactic aspects as well. The project, consisting in a proposal for digital documentation of Masada cultural heritage sites.



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STEFANO BERTOCCI SANDRO PARRINELLO REBEKA VITAL

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On cover: General view of the point cloud about Herod's Palace area.

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Data acquisition and automatic processing by 123D Catch

Francesca Picchio

Introduction

The application of surveying and architectural representation in archeology is increasingly oriented towards a shared system of acquisition and graphics, which makes the detection methodology integrated to technology and evolving experimental data. The product of the survey, whether it is an architectural one tending to define the spatial qualities of a place, or an archaeological one accurately describing the surfaces constituting the building, is the result of several operations, most of which are increasingly moving towards an extremely rapid data acquisition, which tends to bypass the measure to provide immediate descriptive scripts.

The photograph, one of the main elements in the context of the survey, shows and characterizes all the procedures of spatial surveying enabling even non- technical personnel to acquire specialized context-specific information. Through specific methods of recovery are acquired to recieve only the most comprehensive qualitative pictures of the place, which makes it is also possible to rebuild metrically and geometrically the environment and obtain the three-dimensional space and coordinates that facilitate the understanding of the architectural system. Analysis systems taking advantage of the photographic instrument fit within the

The understanding of space starts from the analysis of the macro elements of the landscape to the study of the smallest architectural detail.

project survey and analysis of complex contexts as cognitive tools generating output information, as support in defining the spatial and textual qualities about the feature of the surfaces that qualify a particular object.

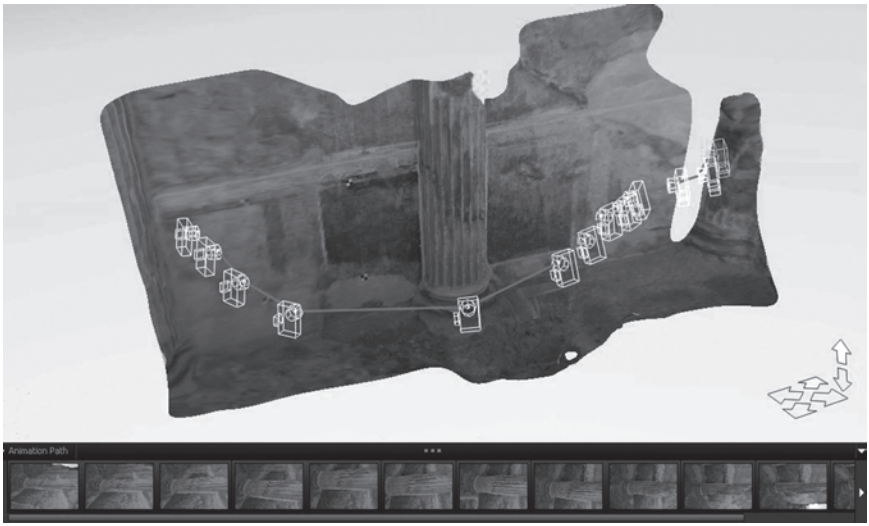
The phase of data acquisition and processing , carried out on a portion of the archaeological site of Masada, provided a detailed photographic survey campaign aimed at the production of three-dimensional models, produced automatically from image sequences. These models, highly descriptive of the specific condition of the structures in height, offer the chance to be immediately compared with the point cloud obtained from surveys carried out with laser scanning and allow to verify the metric reliability, down to the smallest detail , thus enabling reflections and considerations about the best procedures to define the most reliable geometries.

The procedures structure from motion are thus used for the construction of virtual digital cognitive models, directly processed from the images . The rapid data acquisition implies an increase of the potential of these tools, moreover the possibility to employ available and virtually active media helps to implement a common understanding on the quality of the space and on the expected analysis of the places. The resulting systems of reproduction of the real aim to point the issues about spatial representation of the places, where the interactions with the environment are produced not by nature but by the same system; they try to provide support services for the study and development of simplified environmental models thanks to automated systems that, from pictures, are able to process and automatically create highly described three-dimensional models.

Principles of Structure from Motion and 123D Catch :

Recent technological advances in the field of cameras and processing based on cloud computing mean that the procedures structure from motion can now be carried out at different levels and by different users . Open source software such as *Autodesk ® 123D ™ Catch* (beta version) allow to apply very intuitively and rapidly the technology adopted in the field of three-dimensional photography, using a technique that refers to the process of reverse modeling, based on photogrammetry to triangulate the measurements within a 3D space. These software identify common reference points in different picture of the object that has to be digitally replicated, so it is possible to obtain the relative position in space of a virtual camera from photographs series of the object featuring recognizable points in at least three pictures , through rules of triangulation cloud computing entrusted to the network.

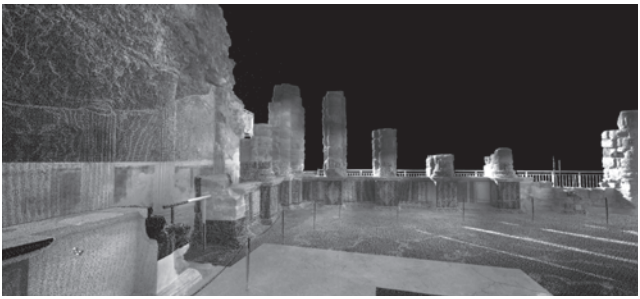
Autodesk® 123D™ Catch Software.

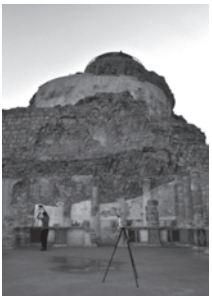


The environment lighting influence the output of the shooting. In the left image the last terrace partially lit by the sun, in the two images on the right the processes of 3D modeling in different lighting condition.

The shooting

Photographic shooting is one of the main factors affecting the final outcome of the 3D model. Such as in a laser scanner relief, the position of the instrument (i.e. camera) affects data acquisition directed to a complete object coverage. Hence, a preliminary organization is required to structure a good shooting and a proper data acquisition. A previous study of the site is necessary to understand the formal and spatial characteristics of the environment that is going to be shot, the main subjects deserving more attention because of their decorative or structural qualities and the obstacles to the correct layout of the camera around the object.
Only after the reconnaissance it is possible to plan movements and clicks around the several objects to acquire them and to record the whole surface. Another issue that has to be studied in the survey is the environmental light: to run a photographic campaign with homogeneous exposure it is crucial to analyze the time of the day to record data and the time it might be necessary to return to the field to complete the recovery. Pictures have to be as homogeneous as possible to avoid color alteration and sharp shadows on the surfaces of the article. This is the reason why most of shooting was set on early morning to exploit the low sun which allowed





The two survey methodologies used in Masada: the point cloud of the laser scanner in the left image and structure from motion with the positioning of the tripod in the right one.

a homogeneous recovery of the environment in a constant shadow.

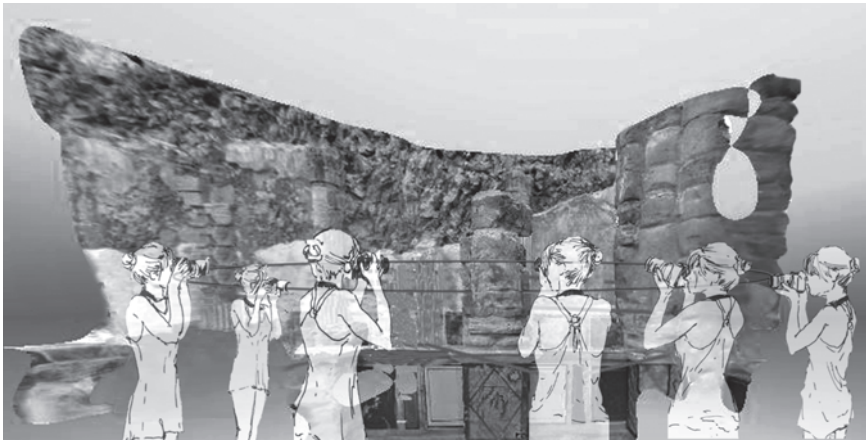
During the survey of the Palace of Herod, the laser scanner was placed side by side with the camera, in order to create compositions describing the condition of the stone surfaces of the building, and to test some automatic modeling procedures through *Autodesk ® 123D ™ Catch*, focusing mainly on the Hall of columns, located on the terrace located on the lower level of the rocky plateau.

The spatial complexity and the presence of settings characterized by columnar elements including portions of capitals or bases mainly still in good condition, has led to a common understanding of the potentials offered by equipment at our disposal and to the possibility, which is generally not too frequent, to be able to compare the output of these two very different documentation systems.

Pictures series were taken along all the stone surfaces and on each prominent decorative element pictures were shot as a semicircle with regular and constant radius centered on the axis of the object, in order to keep a constant distance between the camera and the surface in question and to shoot it in its wholeness. A similar principle has been used to photograph the remains of capitals on the ground, usually relatively

distant from the wall so it has been possible to turn around them completely describing the whole geometry. A regular interval of about 10 ° was held for each consequential pair of shots, considering a minimum of 20 photographs for each three-dimensional object photographed. These criteria allow for a remarkable overlapping of the surfaces in every pair of shots and promote the post-production phase, thus the program Autodesk on which pictures are subsequently loaded can easily recognize all the shared points.
The high level of reliability demanded in the field of archeology required a variety of photographic detail for each stone, implying a double foresight execution: taking two differently distanced shots, where every shot was taken with at least two different exposure settings of the camera. The difference of distance can help to identify common points in individual shots, while varying the exposure may be useful to highlight with higher contrast of the details of the base reliefs or other decorative elements.

Sequence of shots at a constant distance from the object, made along a ideal circle that has his axis in the centre of the object.

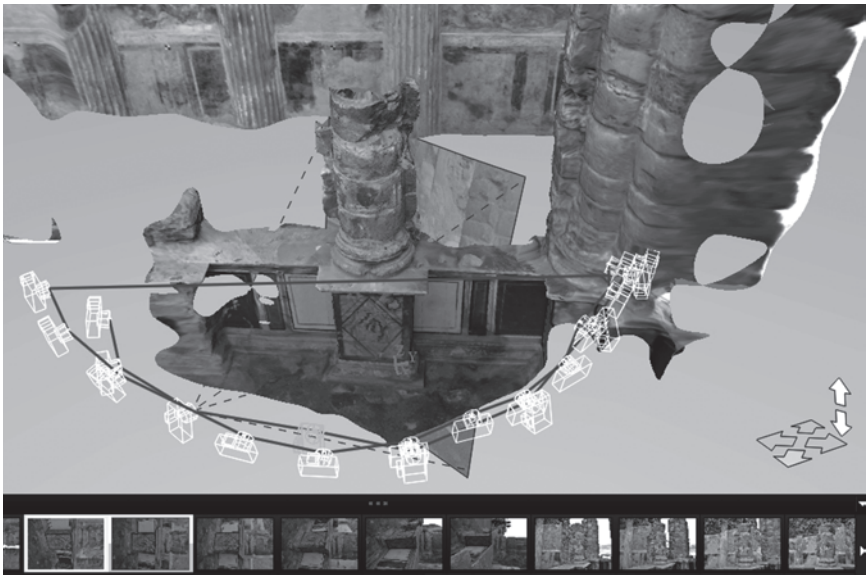


The realization of three-dimensional models

The collaboration between the research team and the technical staff of the Israeli *Autodesk ® 123D ™ Catch* office on the field allowed us to take photos and upload on the program all at once, send them to the server for Autodesk processing and see the immediate result. The chance we had to immediately check on a tablet the quality of the finished product, allowed us to understand, which was the best method of shooting, regulating performances on the set and comparing each time the model with the real object.

The program works out the images over the network through processes of cloud computing sending the final product to the e-mail address of recorded user on the web site, who can download it on local disk and set it to the stage of model processing and management. During the research mission in Israel arose the need to eliminate unwanted elements and to choose the definition level of the mesh; this led to programming a post-production stage of the acquired data: the individual three-dimensional models made from Autodesk have been exported to more specific modeling softwares to verify the adherence of the mesh obtained with those generated from the point cloud that was generated from the laser scanner. In this production we have taken pictures verifying them on the spot via tablet; in the meanwhile we have developed a parallel campaign for the future management of the photo data, in which images are classified by places and environment, then by wall surfaces and finally by details. Eventually data can be taken in post production to organize a proper three-dimensional reconstruction of the whole place, through the photographic tool saved in this file.
Hence it was possible to place on file judiciously both

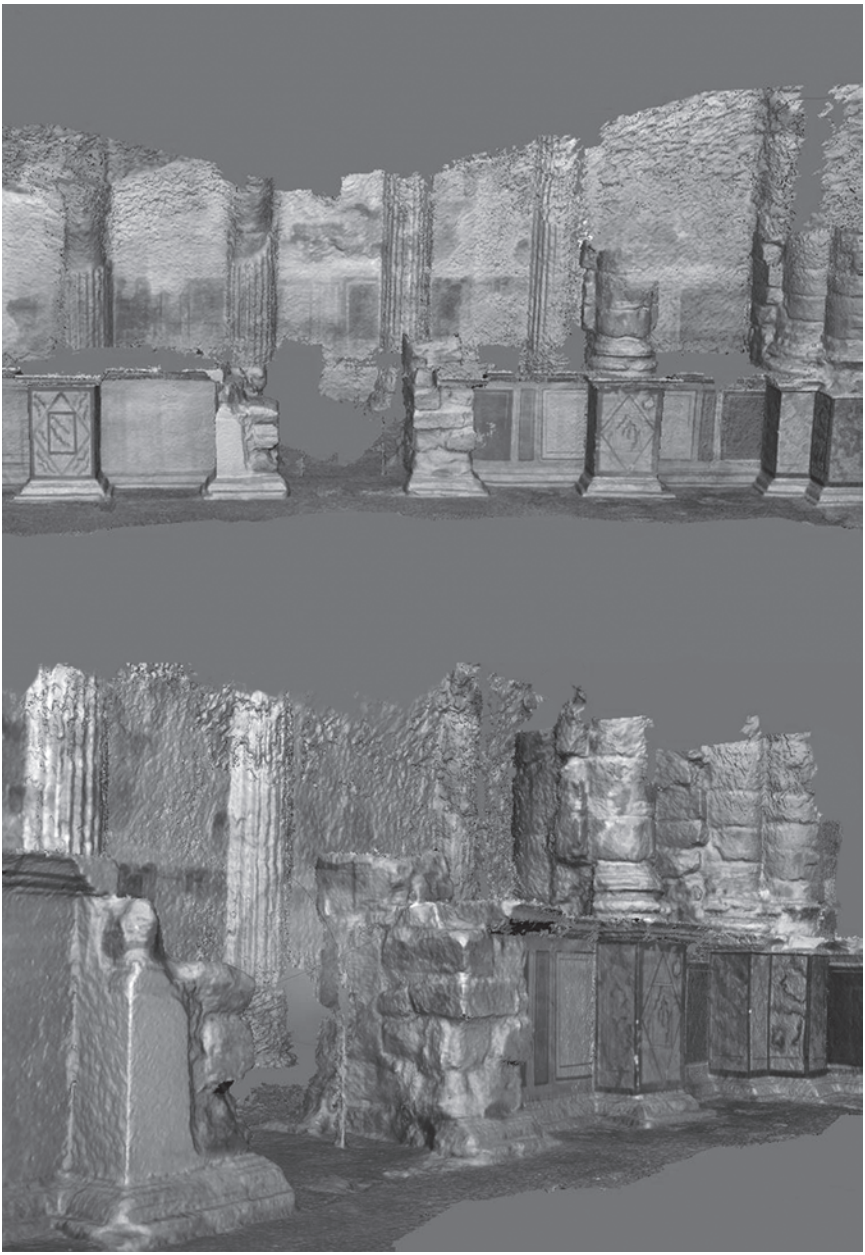
The acquisition data on site: photograph shooting and loading on Autodesk software.

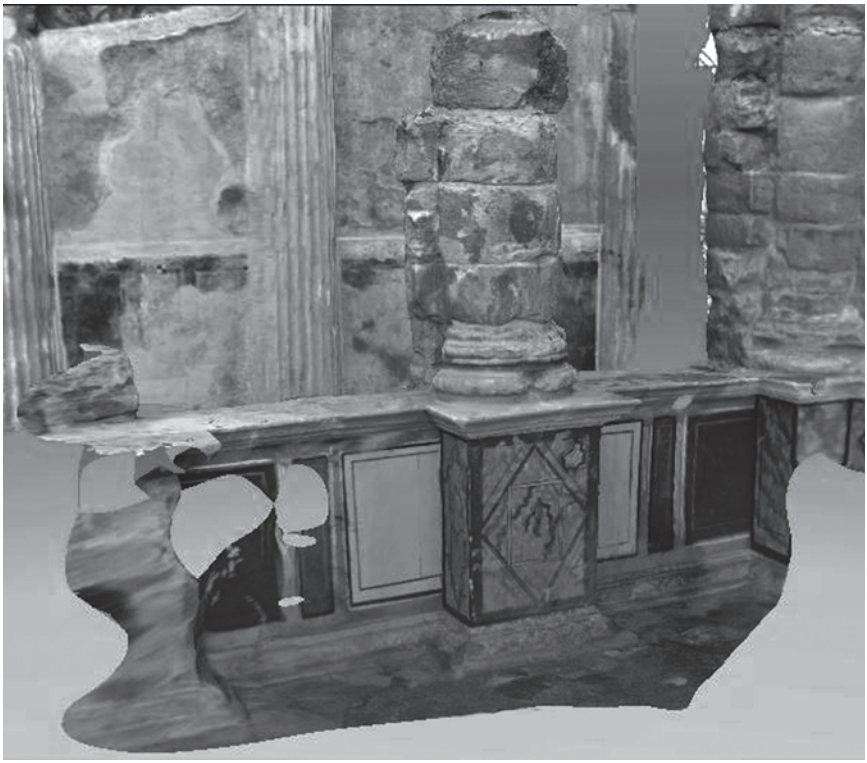


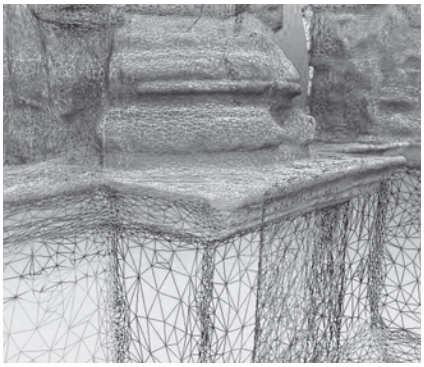
View of 123D catch screen with the model reconstruction of the basement.

the rich array of images and the models generated by them. An immediate and proper placement of individual models on the general point cloud of the archaeological site is a needed prerequisite for the development of observations regarding the metric reliability and the level of description that these methodologies can offer in the field of archeology. Developing virtual environments and interactive three-dimensional models in which specialized users can interact implementing cognitive maps on the cultural and historical context is one of the goals of these procedures: the highly representative models simulate the real conditions of the archaeological structures, which become real virtual simulations, for planning and testing management and context development models.

In the next page: Three-dimensional elaborations of the terrace area, consisting of more complex architectural elements.







In this page the structure polygonal meshes of the three-dimensional model.
In the next page the comparison between the two systems adopted: structure from motion on the left and the mesh of the points cloud to the right side.