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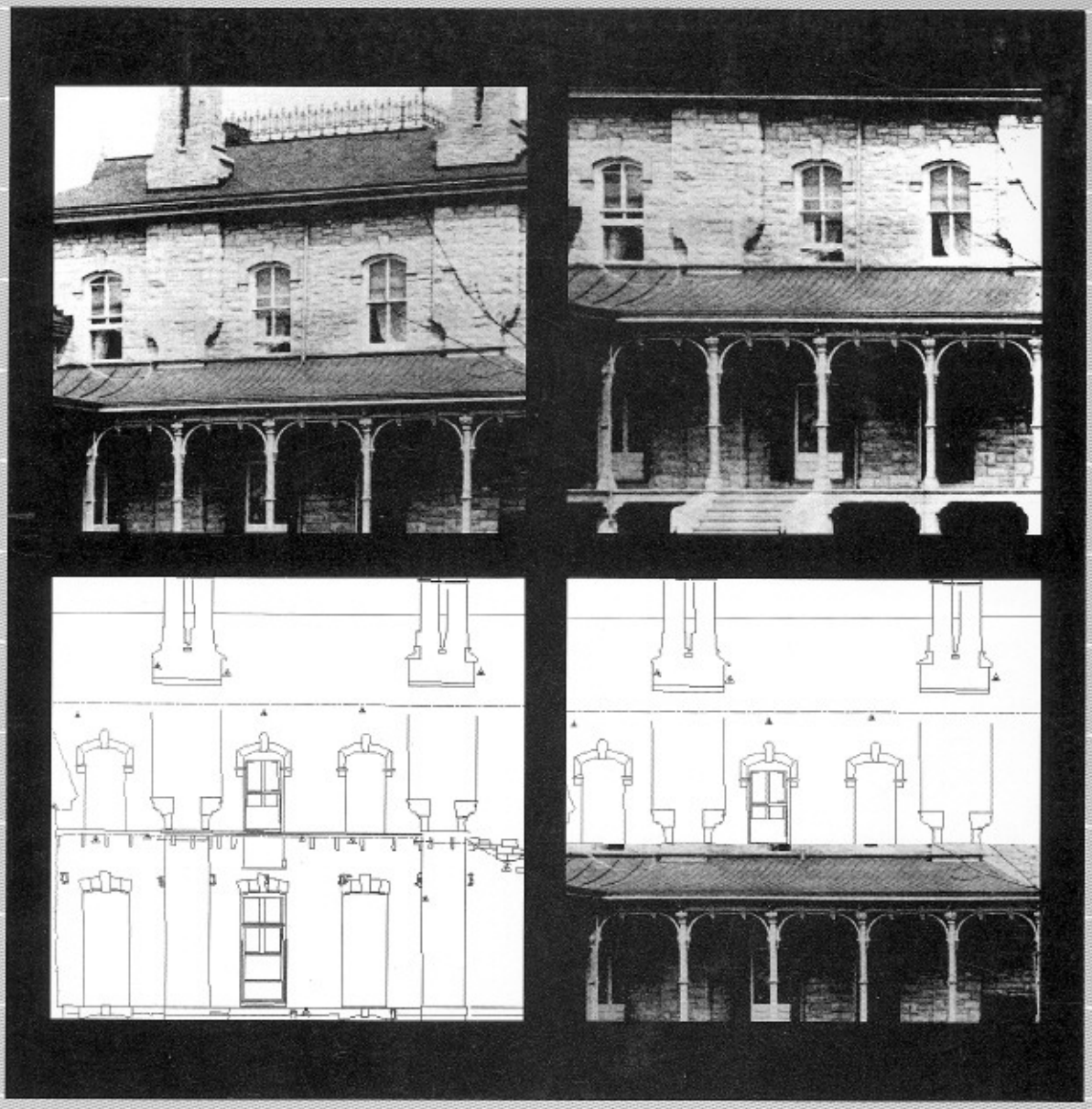

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The Association for Preservation Technology APT Association pour la préservation et ses techniques

Experiences in Rapid, Economical Surveys of Monuments at the Escuela de Estudios Arabes

ANTONIO ALMAGRO

Objective documentation of architecture is achievable through a combination of simple techniques.

Introduction

About eight years ago, I set up a photogrammetry laboratory to record architectural heritage for the Spanish Ministry of Culture; it was equipped with traditional photogrammetry instruments: large format metric cameras (Zeiss UMK and SMK) as well as analogical (Zeiss Topocart D) and analytical high precision plotters (Wild Aviolyt BC2). While the high-precision results were excellent, they were achieved at great cost. Later, in researching Islamic architecture on a limited budget, I used photogrammetry in company with simpler, less expensive techniques. CAD applications for personal computers enabled us to depict plans and perspectives and develop a data bank. We created software to converge on AutoCad and used portable instruments and simple data taking.

Methods

We acquired a theodolite with a distance meter and electronic data recorder and prepared software to calculate 3-D point coordinates. We could then use topographical measurements to establish reference systems; the data are also drawn with CAD. A wide-angle, half-format

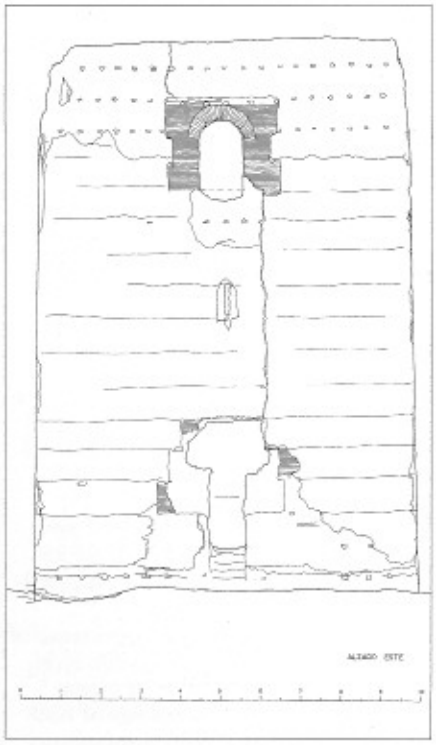

Fig. 1. Tower of Romilla, Granada, 14th century. This elevation was surveyed with rectified photography controlled with the topographic measurement of a few points.

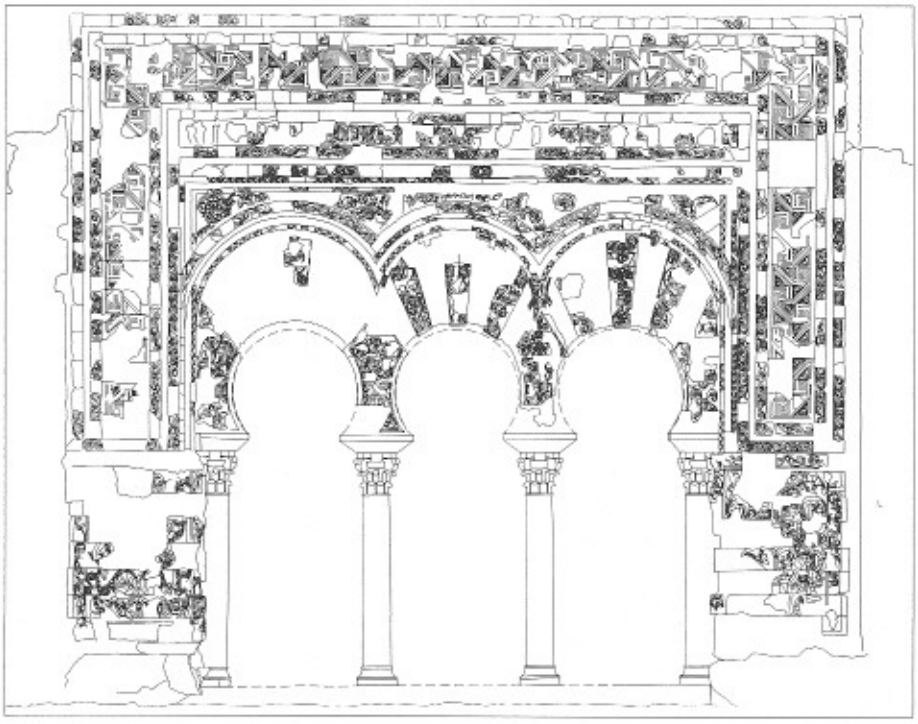

Fig. 2. Facade of Yafar's Palace, Madinat al-Zahra, Cordoba, 10th century. A handful of photographs and only one distance were used to draw this elevation.

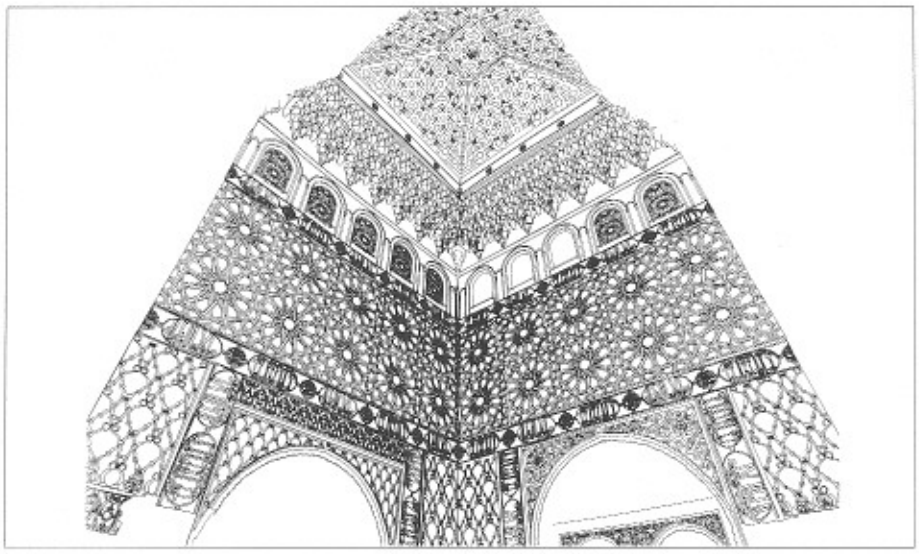

Fig. 3. A conic perspective of the interior of the Alcazar Genil, Grenada, 14th century, made from photogrammetric three-dimensional plotting in AutoCad.

Fig. 4. Perspective of the decorated chamber of the Egyptian temple of Debod, Madrid, an example of a three-dimensional model produced from photogrammetry managed with CAD.

Hasselblad SWC camera with a negative size of 55mm x 55mm and a focal length of 38mm allowed us to experiment with photographic images set to scale and controlled from points measured with a theodolite. Later, we used photographic enlargements set on a digitizer and calibrated through the CAD program and experimented with vectorizing digitized images through the CadOverlay program, which allowed combination of the raster image and the vector drawing.

This provided acceptable accuracy for flat or low-relief images when the photograph was taken with the flat surface of the image parallel to the plane of the object; if this was not possible, we used stereo photogrammetry for the efficient, continuous drawing of complex forms such as those found in Islamic decoration. We purchased a low-cost, small-format analytical stereo plotter, an Adam MPS2. New software was needed to transform the files to .DXF graphic transfer files: these files were then converted into AutoCad .DWG files and edited. Nonmetric photographs taken with the Hasselblad camera determined accuracy. Lack of camera calibration produced only minor errors, even when the camera axis was tilted. A semi-metric Rollei 6006 camera with two lenses of 40mm and 80mm focal length improved accuracy.

Simplification in Data Taking

Surveying with measurements of complete control points generally requires a theodolite, considerable time, and trained personnel. Topographical measurement is necessary for large, complex buildings. Sometimes stereo pairs have to be taken; however, basic building inventory or first analysis and diagnosis could be accomplished by inexperienced personnel using the software and CAD's capability to set directions and projection planes.

For structures that can be registered with one pair of photographs, a level can be set to the camera so that the plane of the negative is vertical, and a reference system is established with respect to the image plane of the left-hand camera. A measurement or a length-reference on the object can be used to obtain the remaining information necessary for plotting. A spirit level, such as the Cullman or the round Hasselblad, gives a precision of +/- 30′, which for a 10m object may mean an error of about 9cm in leveling at the extremes. This error may be corrected with a slight rotation of the drawing. The planimetric error is insignificant. We have carried out a number of restitutions of facades and decorative elements using pairs of photographs, some taken with the Hasselblad camera and one horizontal measurement.

The reference system might also be fixed using photographic elements, such as a plumb line or spirit level; the rotations of the left-hand camera must be calculated in the plotter. The values of the rotations

may then be used to calculate absolute orientation. For example, photographs and measurements of archaeological objects in Bibracte (Burgundy) and Ulaca (Avila) taken by neophyte photographers, were of acceptable accuracy.

For small objects or those where the camera must remain set due to low light or awkward angles, we prepared a precision track, such as those used by robots, with a carriage on bearings on which the camera was fixed; this ensures controlled movement with the optical axis constantly parallel. The carriage held a spirit level; marks on the track measured the base exactly, so that the length on the object could be eliminated.

Recently we explored bundle adjustment to improve precision with semi-metric cameras, reducing the number of control measurements and aiming to use non-metric cameras for calibration. This method required a wider knowledge of photogrammetry, but it is important if there is a lack previously calibrated cameras or if control-point measurement is difficult. For example, it was possible to measure control points in only a small area of the Castle of San Romualdo in San Fernando, near Cadiz; the bundle adjustment allowed us to take about twenty photographs from flat roofs surrounding the building and to obtain control points for plotting elevations and terraces.

With only a three-person team and modest financial and technical resources, we were able to demonstrate that a limited investment could improve the quality of our recording considerably—and also the knowledge of our cultural heritage.

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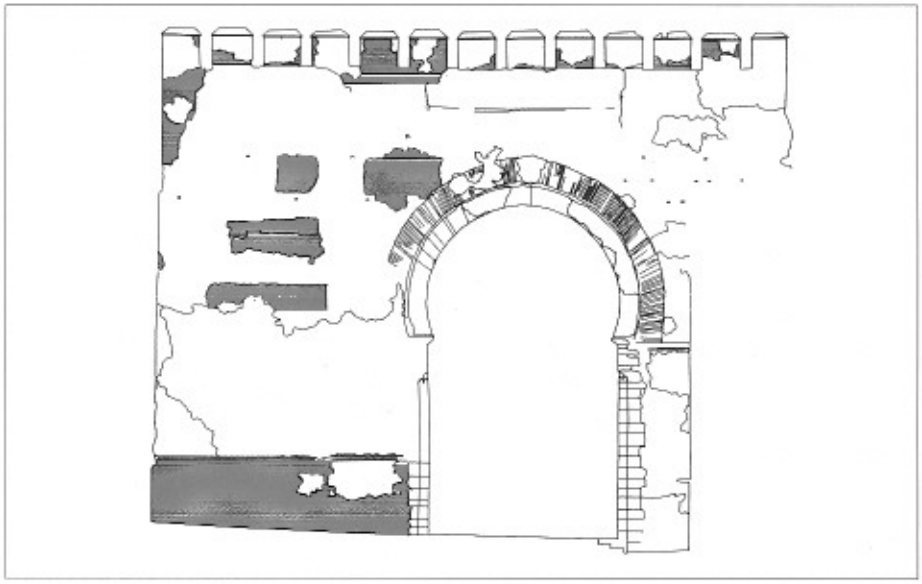

Fig. 5. The Elvira gate in Granada, 14th century, an example of a survey performed before the restoration.

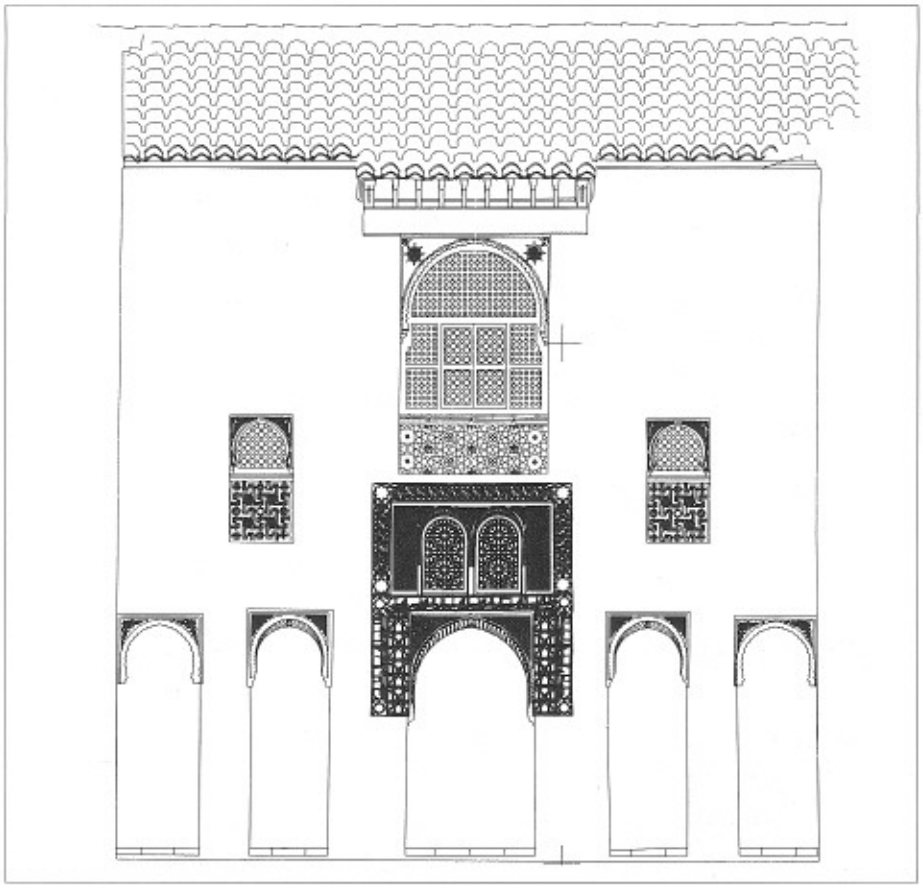

Fig. 6. Interior courtyard of an Islamic house, Granada, 14th century, documentation after restoration for research purposes.