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The Role of Photogrammetry in the Conservation of Jarash

Introduction

Photogrammetry is the basic method of topographic map production. Due to its major role in reducing the time-effort of plotting, it has been used since 1950 to replace direct survey. Photogrammetry uses different kinds of stereoplotters for plotting maps, plans and orthophotos.

Terrestrial photogrammetry is one of the non topographic applications of photogrammetry dealing with terrestrial photos for the survey of historical monuments and archaeological sites. It is considered as one of the best measuring technique used in this field.

The recording of historical monuments produces photogrammetric documentation of the "as-found" condition. Detailed measured drawings can be generated and plotted prior to restoration or renovation of a historical monument. The most frequent scales of plotting are:

* plotting scale 1/100 for relative plotting (preliminary studies for restoration);
* plotting scale 1/50 for accurate plotting (classification, documentation, evolution study and conservation of sites).

RJGC Capabilities and Equipment Used

The equipment used for this work were:

1- P31 WILD camera: wide angle F = 10cm, the diapositives of such camera can be used for orientation and measurements (see camera P31, FIG. 1).

2- T3 theodolite for angle measurements of traverse and ground control points on the site, for the determination of a topometric layer of all images equipped with ground control points. Generally a camera combined with a theodelite "phototheodelite" is used, but an independent camera of I.G.N. with a long exposiure time was used in this case.

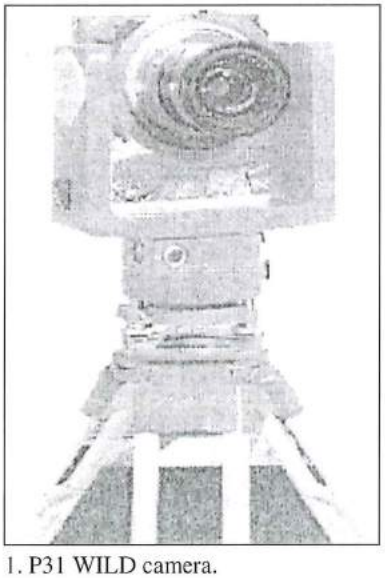
3- BC2 analytical stereoplotter with a suitable software (INP, ATI, PMO) for aerotriangulation and plotting (contours and digital data).

4- RJGC profile equipment (see TABLE 1).

Terrestrial Photogrammetry and the Site of Jarash

Why Terrestrial Photogrammetry?

1- Taking the photographs is relatively easy since they are independent of the structure, the site and the condition of the object to be photographed.



1. P31 WILD camera.

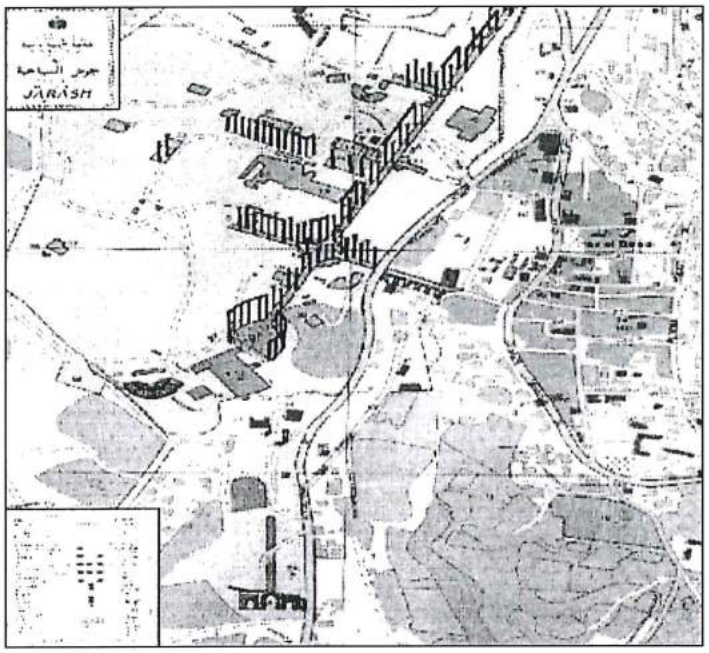
TABLE 1. List of equipment.

EQUIPMENT			
AERIAL PHOTOGRAPHY CAMERA AND LABS EQUIPMENT		FIELD SURVEY EDM's	
RC30 Wild Camera System	1	Tellorometer (AGA, CA1000)	13
ASCOT Aerial Survey Control Tool	1	Geodimeter (DI10, 3S, 300)	9
PHOTO LABS (B/W ,Miligan/ COLOR, Durst)		TOTAL STATIONS	
GPS RECEIVERS		Wild TC1610	4
Ashtech ZXII	5	Wild T2000	2
PHOTOGRAMMETRY		THEODOLITS	
Analytic Stereoplotter / BC2	1	Wild T16	10
Wild B8S	2	Wild T2	10
Wild A8	2	Wild T3	21
Wild AG1	4	DKM3	1
Wild A10	2	LEVELS	
Wild RecE4	1	Wild NA2, N3, Nic2, N2	19
Wild Pug4	1	GENERAL PURPOSES	
TA10 Plotting Table	2	PC's 386/486 Pentium	20
Printers (dot-matrix, lazerjet, color)	3	Plotters (Versatic, Optronix, Tektr.)	3
PC's + (TCP / IP + LAN + HUB)	11	Electrostatic Plotter	2
REPROGRAPHY		Scanner B/W	1
Klimsch Repro Camera	1	Digitizing Tables	5
Developing Machines (B/W And Color)	2	Silicon Graphics	2
CARTOGRAPHY		ARCInfo	5
Desk Top publisher	3	Dipex, Pericolor	2

2- Low cost of photographs, savings of both time and finances are considered more than in architectural surveys when the camera and stereoplotters are available.
3- With a complete process — for faithful reproduction of the monument — going from terrestrial photographs survey, triangulation, until the final output there is a possibility to get data and output quickly for any studied site.
4- Taking photographs and plotting are two operations quite separate in time. Plotting for documentary purposes can be carried out at any moment (even years after).
5- The possibility to measure complicated object (no matter how complex the shape and the form) and it is not necessary to touch or to set foot on it.
6- The amount of information contained in terrestrial metric photographs and the conditions of exposure are recorded objectively in full detail.

Why Jarash?

1- Jarash is situated some 50km north of 'Ammān, making communications with the centre easy during the experimental stages.
2- The ancient city of Jarash is an important and attractive site in archaeological terms with a remarkable unbroken chain of human occupation, considered as one of the best preserved examples in the world of a Roman provincial city.
3- Jarash was a member of the Decapolis. Its engineering was so advanced that large parts of the city—including our concerend monument—still survive today.
4- This pilot project highlights a major sight as well as new techniques for the concerned institutions in this pilot project which are: RJGC "Royal Jordanian Geographic Centre"; IGN "Institut Geographique National" (France); JADIS "Jordan Archaeological Database and Information System" (Department of Antiquities); JIIAS "Jordanian-Italian Institute of Archaeological Science /Amman".
5- The chosen monument (the **Eastern Baths**) is an easy-to-access feature close to the down town (FIG. 2). It is an ideal monument for the study. In the middle of the eighth century AD, the city was hit by an earthquake that affected many of its buildings, one of which was this monument.
6- An attempt to conserve some monuments that are 2000 years old using the photogrammetric methods, taking into consideration the massive effects of human activities and festivals around the site, affected also by the urban expansion services and infrastructure of the new city.
6- The "Eastern Baths" is the only preserved monument in the centre of the new city, and there is a danger that the walls could be ravaged by traffic going around close to them or that the monument would be otherwise affected by the new city.



2. Tourist map of Jarash.

Requirements

Requirements for terrestrial photographs:

Reconnaissance (preliminary study)

Some factors have to be taken into consideration when we perform terrestrial photography, this is a kind of preliminary study of the site:

1- Location of the monument in the site .
2- Position in space (vertical, horizontal elevations) of the monument.
3- The relief (weak, deep).
4- The complexity of the monument and the light direction.

The simple case is an architectural element flat with vertical elevations. We get a photographic image when we orientate the axis of view perpendicular to the plan of that element.

5- Photographic scale of 1/100 and a plotting scale of 1/50 were adopted, the reconnaissance showed that 7 strips of 24 photos were required to allow the plotting of the whole of the 2 elevations.

Our study was restricted to four models with clear fiducial marks and points covering the west elevation.

Other Factors

1- Camera calibration certificate, principal distance = 99.21mm.
2- Well distributed and accurate ground control points (traverses, computation), related to the Jordanian national system of coordinates with premarked control

points on the elevations themselves. For the western elevation, 8 control points were trisected to control the 4 models. Artificial targets were fixed on the corners and in the common overlap to increase the accuracy.

3- Photoscale and plotting scale related to the more adequate existing stereoplotter and plotting table for plotting results issued from these photographs.

Requirements for PMO Program of Plotting (Initialization Parameters):

1- Preperation and input of CA- file for calibration data by INP program.
2- Choice of terrestrial photo as type of photgraphs.
3- Computation and introduction of photo base (22mm).
4- Introduction of distance camera-object(10m).
5- Camera height (terrain unit) = distance camera-object + dH (10m+4m = 14m).
6- Ground height = dH of the object = 4m.

Methodology and Execution

1- Initialization: details about input photo, calibration data, ground control data is introduced.
2- Orientation (inner, outer) py parallax for 6 standard points of each model , RMS py = 1.3 microns for photo coordinates (TABLE 2). The tolerance in precision can be of the order of 4% of the principal distance, and what we had achieved was about RMS xy = 3mm, RMS z = 5mm (outer orientation on ground control points).
3- Plotting (scale and accuracy). The scale of the photo is the ratio (principal distance/distance camera object).

In general the final output scale is 1/50 or 1/100 allows to show all existing structural defects. TA10 plotting table was used to plot the west elevation, example of output is to be found in FIG. 3.

Planimetric details: lines in black and slopes in red.

Altimetric contours: index in red and normal in black in digital files. All breaks in masonry as well as individual stones, fractures, gaps, cement surfaces were represented, either by lines or by plotting both sides with slopes and dashed lines.

Results and Remarks

1- Field survey: full ground control points with premarked points and some natural details on the monument itself had been selected, observed and computed with an accuracy of RMS xyz = 1mm.
2- RMS xy for models = 1mm targeting could increase the accuracy of identification and plotting.
3- Plotting PMO with the following specifications:
   - projection XZ plan instead of XY plan;
   - rotation for the axis system;
   -diapositive with emulsion up and overlap out.
4- The monument (walls) form an attractive feature of the site, the top of the monument has remained in a ruined condition, with falling masonry presenting a hasard, and some gaps/fractures in the fabric. It is important to strengthen it against further deterioration, for remedial measures, very large scale plotting for the west monument at (1/20) scale instead of 1/50 scale is needed to highlight the fractures, gaps, cement surfaces and individual stones.

Conclusion and Recommendations

1- Good representation of architectural objects of Jarash by photogrammetric survey. These representations are useful for architectural, archeaological and art-history experts and indicate the advantage of the photogrammetric survey in terms of accuracy, economy and homogeneity.
2- The complex reality of the monument in a manner adapted to the needs of different users and objectives of the photogrammetric results. Thus the participation of different concerned users in the analysis of the photogrammetric results.
3- Appropriate training should be provided to develop a deep analysis of the site with the participation of all

TABLE 2. The inner and outer orientation protocols.

Orientation Protocol
Model name :J35J34

OUTER ORIENTATION

Residuals on Photo Coord.(Micr.) and Ground Coord.(Metres) ORI-1.0

Pt.No.	DXL	DYL	DXR	DYR	PY	DXG	DYG	DZG
0111	.0	1.3	.1	-.9	2.1			
0222	.1	-1.7	-.1	1.3	3.0			
0333	.0	.0	.0	-.6	1.5			
0444	.0	.2	-.0	.3	.1			
0555	.1	-.5	-.0	.4	.9			
0666	.0	1.6	.1	-1.5	3.1			
36	-.0	.2	-.0	-.2	.4	.004	-.005	-.005
38	.0	.4	.0	-.3	.9	-.009	-.011	.014
40	.0	.3	.0	-.2	.5	.009	.016	-.004
39	.0	.3	.0	.0	.3	-.004	.000	-.006
RMS :					1.3	.007	.010	.008

Orientation Elements and their Std.deviations ORI-2.0

Photo No	XG	YG	ZG	Azimut	Nadird	Kappa
J335	480.68	517.36	701.75	126.408	107.384	.074
	.07	.07	.13	.279	.504	.249
J334	479.20	512.91	701.93	114.983	107.130	-.075
	.07	.07	.13	.278	.508	.240

ORIENTATION PROTOCOL
Model number :J35J34

INNER ORIENTATION

Left Photo: J335

Fid. Coords. and Residuals in Microns

Pt.No.	XT	DX	YT	DY
1	-57500.	-1.	-1.	0.
2	57500.	-4.	-3.	3.
3	-4.	4.	57499.	0.
4	-0.	3.	-27497.	-4.

DXG = 538.6 SFX = 1.00008 KAPA = -.21279
DYG = -55840.2 SFY = 1.00006 ALFA = .00000

Right Photo: J334

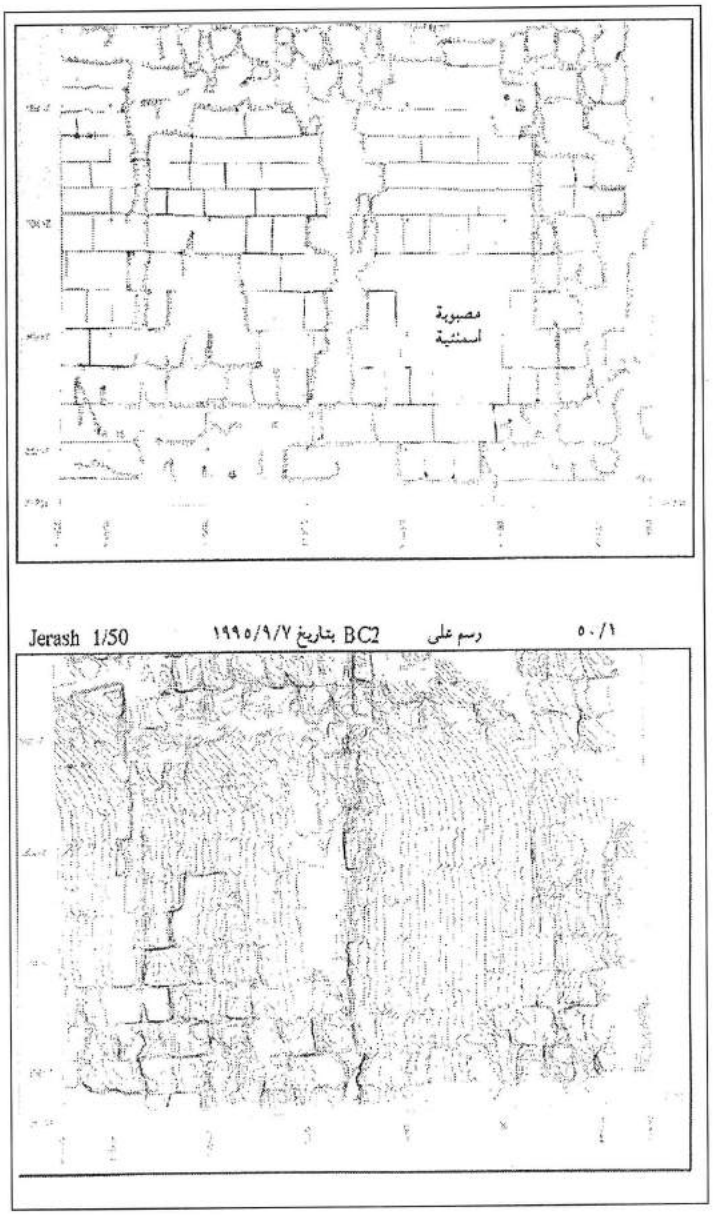
Fid. Coords. and Residuals in Microns

Pt.No.	XT	DX	YT	DY
1	-57507.	6.	1.	-1.
2	57505.	0.	0.	-1.
3	0.	-9.	2.	-2.
4	0.	0.	57498.	11.
5	-2.	2.	-27495.	-8.

DXG = 703.8 SFX = 1.00015 KAPA = .78162
DYG = -55391.9 SFY = 1.00015 ALFA = .00000

concered institutions, giving priority to those concerned with the safeguarding and restoring the architectural heritage.

4- The major role of photogrammetric methods applied to architecture is for recording measurments and conservation of historical sites. The models can be used to reproduce specifically—true to scale and safety—any detail of interest at any time.



3. Examples of the final output.

5- The analytical approach is suitable in studying the structure and stability of the monument through multitemporal digital models.

6- The study of elevations from a structural point of view has led to a conclusion about the mode of repair and restoration taking into consideration th critical areas of falling stones risk. I think that permanent marks to all models could be helpfull to get photogrammetric plots related to each other.

New Aspects of Development

New techniques and methods are recently used or proposed:

1- Close range photogrammetry for historical site (nacelle + photo.camera + lifts) and remote sensing technique for cultural heritage (multispectral images) for the entire city documentation.

2- Employment of an airborn thermal scanner, coupled with the photogrammtric camera and GPS reciever antenna (IR + Visible images) by the CENTRO ESCAVI "Centro Ricerche Archeologich e Scavi di Torino". RJGC is ready to cooperate with international institution concerned by similar archaeological studies for monuments in Jordan in coordination with the Department of Antiquities.

3- Rolleimetric camera 6x6 for orthophotos of surveyed building or site with automatic exposure medium format camera.

4- Digital plotting could be used also when photos are well controlled by means of DPW "digital photogrammetric workstations".

All Jarash photos will be scanned by DSW "Digital Scanning Workstations" and processed to create a data base of all terrestrial models of the site to get digital orthos and other applications.

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