# *DOCUMENTATION OF THE ANCIENT VILLAGE OF KHORANAGH FOR REHABILITATION PURPOSE: A PRELIMINARY REPORT*

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**ABSTRACT**

Surveying cultural heritage involves measurement at different levels. Wide range measurements as those based on topography or photogrammetry can be suitable for large buildings while for complex surfaces or small objects 3D scanning techniques seems more appropriate. In the case presented here, simultaneous presence of different scales in the same survey shows the usefulness of integration of various levels of detail. In a historic site where objects with complex surfaces have to be measured, it is also necessary to measure the structure containing them, where it is important to know other information, as the alignment between walls, or the planarity of the floor, not needing the same level of detail. In these applications a multi-scale survey where the information density is correlated with the importance or formal complexity of the object to be measured, seems to be the ideal solution. In order to obtain such result a possible approach is the fusion of different sensors, as range cameras, satellite imagery, topography and photogrammetry. In this paper, the application of data fusion approach for the documentation of the ancient village of Khoranagh is described.

## 1. INTRODUCTION

Many cultural heritage applications require 3D reconstruction of real world objects and scenes. The motives are numerous:

- To document historic buildings, sites, and objects for reconstruction, restoration and rehabilitation purpose if they are destroyed for example by fire, earthquake, flood, war, or erosion.
- To create education resources for history and culture students and researches.
- To reconstruct historic monuments that no longer exist, or partially exist.
- To visualize scenes from viewpoints that are impossible in the real world due to size or surrounding objects.
- To interact with objects without contact and risk of damage.
- To establish virtual tourism and virtual museum.

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In order to obtain such result a possible approach is the fusion of different sensors, as range cameras, satellite imagery, topography and photogrammetry. In this paper, the application of the aforementioned approach for the documentation of the ancient village of Khoranagh is described.

### 1.1 Historical background

Khoranagh village, situated in Yazd province, is a magnificent architectural complex of clay and mud style with unique characteristics. In ancient times, this village was protected by a fortress constructed around it. The village is surprisingly green in the middle of the Dasht Kavir desert. In five minutes walking distance off the road to the village, a huge ancient citadel catches the eyes. In front of the citadel a Caravan Saray stands.

Figure 1. The unique landscape of Khoranagh

The silence of the desert, the green nature of the village, the remoteness of the place, the ancient history, and its glamorous night sky attracted the Center for International Research and Collaboration (ISMO) to select Khoranagh as the venue for its future scientific workshops and schools.
ISMO was established following an agreement between Abdus Salam International Center for Theoretical Physics (ICTP) and the Ministry of Science, Research and Technology on December 1998. the office started its work on April 1999, with professor Reza Mansouri as the Founding President and was recognized as a center by the Government of Iran on October 2001. The mission of ISMO is promoting Iran's international scientific collaboration and to develop world-class capabilities in knowledge advancement in the country.
ISMO is the authority for the restoration and rehabilitation of the citadel of the Khoranagh village. This is according to an agreement signed on April 2003, between ISMO and the Iranian Heritage Organization. The Village is let to ISMO for 15 years to be used as its venue of the workshops and summer schools of

ISMO. To have a suitable place for its workshops, ISMO envisages its mission further than just renovation of the ancient monuments.

Figure 2. Minister of Science visits documentation site (09/06/2005)

It considers the whole village with its nearly 300 residents, the environment, the school, the mosque, the labor, the social and cultural life, and the economy. ISMO tries to create a center of attention in this ancient forgotten place.

### 1.2 Citadel structure

The citadel is believed to belong to 4000 years ago. It embraces five gates and 80 houses. Six guard towers were used to protect the citadel. The water canal around the citadel was also ditched for protection against invaders. Narrow labyrinth passages connect the houses. In the citadel there are also a mosque with a minaret, a public bath, and water mills. Until 1979 many families lived in the citadel. Today, the citadel has been left deserted.

Figure 3. Citadel facades

The buildings substance of the citadel is very weak and requires maintenance. When performing an inventory or documentation, one should capture the monuments in as detailed a way as possible in the form of construction plans and maps. Furthermore, the arrangement of the settlements and the spatial content should be recorded. It is clear that these are only understood if one includes the social information of the population and its living conditions.

Figure 4. Inhabitants of the area

While documentation contributes to decision making for rehabilitation purpose, it is also necessary to include the development possibilities of the region and of the population.

## 2. SCOPE OF THE DOCUMENTATION PROJECT

The most important step at the beginning of the preservation work is to prepare a detailed documentation and recording of the cultural and natural heritage because without precise documentation of the historic structure and its surrounding environment, it would be very difficult to carry out a suitable restoration project.
Documentation of the cultural heritage serves as a tool to make information accessible to those who cannot investigate the site itself. Different reasons can be found for the necessity of this information transfer:

- The object is not accessible to interested people
- The object is too large or too complicated to be overlooked and it would be too time consuming to execute an own investigation
- The object is visible only for a short period of time at its original location
- The object is too far for people to afford visiting it.
- The object is in danger of deterioration or destruction

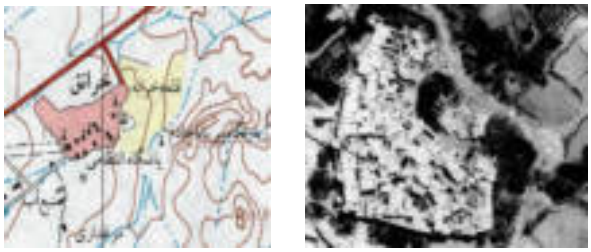
In general, most documentation applications specify a number of requirements such as:

- High geometric accuracy
- Capturing all details
- Photo-realism
- Automation
- Low cost
- Portability
- Flexibility in applications
- Efficiency in model size

### 2.1 What already exists

A survey was made to collect all available sources for spatial information of Khoranagh. The following set of data was achieved: Small scale topographic maps, satellite image, aerial photo and architectural sketch drawings.

Figure 5. Satellite image of Khoranagh area



a b

Figure 6. a) Topographic map b) Aerial photo

**2.2 Documentation process: Fusion of data**

Due to the complexity of the site, a variety of instruments and techniques was employed for the documentation purpose:

- The basic shape and large regularly-shaped details are reconstructed from high-resolution digital images. This is based on advanced photogrammetry that takes advantage of properties found in heritage structures.

Figure 7. Metric photography

- Fine geometric details, like sculpted and irregularly shaped surfaces, are obtained by laser scans. This is combined and integrated with the basic model created in the first step.
- Visual details on the geometric model are obtained from image texture and reflectance models.
- Landscape and far away scenes are completed with image-based rendering or panoramas. This serves mainly to present the monument ion its natural setting.

Figure 8. Terrestrial laser scanning

Fusion of various data captured from different techniques will satisfy most requirements except that, at least for now, the cost is not as low as a fully photogrammetric system. The fusion is performed using following sources of information:

1. *Geometric Information:* This kind of data consists of the characteristic elements of the village such as walls, towers, gates, corridors, passages, the mosque, the bath, the individual buildings and the peripheral objects.
2. *Thematic Information:* The geometric information is completed by the thematic information which is stored in a GIS for storage and manipulating. GIS can be used to automate what people did with maps and to facilitate analysis that would be difficult or impossible to do manually. This concerns information referring to the citadel as a whole such as its political status, its name, its topographic position, as well as specific folklore features and handicraft activities of the inhabitants. The information about infrastructure, water supply and sewage and many others are also recorded. Both tangible and intangible cultural heritage should be documented.

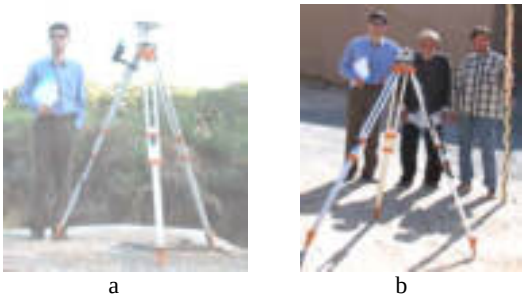


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Figure 9. a) GPS operation b) Precise leveling

3. *Geodetic Survey:* Control network was established using GPS, precise leveling, tacheometry using laser-equipped total station and traverse.

Figure 10. Techeometry

4. *Remote sensing:* Satellite imageries are used to qualitatively tracking archaeological sites and to detect changes.
5. *Photogrammetry:* The following requirements were considered in the design of the geometry of the camera stations and the camera orientations:
    - Multi-image photography had to be acquired to provide optimal imagery for surface generation by multi-image matching.

Figure 11. Establishing control points on old photographs

    - Cameras had to be oriented with the image plane parallel to the principal surfaces to provide optimal data for the generation of rectified and ortho photos.
    - Oblique and rotated photography were required to strengthen the geometry of the photogrammetric triangulation.
    - Multiple diagonal photography was needed at both convex and concave building corners to provide links between surfaces in rectangular orientation.
    - Photography from different elevations had to be captured to obtain texture and detail for facades.
6. *Terrestrial Laser Scanning.*

In comparison of laser scanning technique and close range photogrammetry, one can summarize the advantages of laser scanning as follows:

- Laser scanning provides direct and immediate access to the scan data making it possible to visually inspect the point cloud in-situ and identify possible problem areas in the data sets in the field.
- The point cloud is obtained without any additional processing. Post processing is similar to that of the photogrammetry.
- Only one set up is required for each surface.

Close range photogrammetry on the other hand appeared superior to laser scanning in the following aspects:

- Close range photogrammetry provides discrete user selected points. Vector data, corners, edges and decorative detail can be easier identified and extracted from images than from a point cloud.

Figure 12. Cultural objects

- Photogrammetric point position accuracy is typically higher than that of the laser scanner.
- Cameras are significantly lighter, easier to transport and mechanically more robust than laser scanners.
- Photogrammetric equipment is significantly less expensive than laser scanner.

Today, the integration of close range photogrammetry and laser scanning can be seen as a reliable and accurate method for the documentation of cultural heritage.

Figure 13. Manual inspection and recording of detail

### 2.3 Surface modeling, texture mapping and visualization

Point clouds of surface coordinates are collected from a number of different viewpoints to overcome perspective occlusions. These may be geo-referenced in a Cartesian reference system consistent with the object. This operation is performed with the support of control points. After merging the 3D datasets, a TIN model with meshes is created. The high density of points allows avoidance of the insertion of break lines. Photo-realistic texture mapping is achieved both directly, through the RGB value provided by the laser scanner as an attribute of each point, and with a perspective projection, pixel by pixel, of geo-referenced digital images over DSM of the object. Once the 3D model has been created it is possible to extract structural and architectural outlines, profiles and cross-sections, to visualize contour lines, to calculate volumes and to detect features of interest.

## 3. CONCLUSION

The aim of restoration project is to restore back the original site, buildings and objects using the original material and style and associate with design, texture, colour, workmanship and setting. The restoration project must also be taken to restrain the process of decay and stop further destruction without damaging the character of building or altering the features which have given the building its cultural importance. Fundamental restoration principles such as minimum intervention and minimum loss of existing fabrics must be taken into account.

Figure 14. The restored Caravan Saray

The documenting team consists of a project leader, site manager, architect, archaeologist, surveyor, photogrammetrist, geodesy expert, and computer programmer. Regular technical meeting are held by the manager to discuss any problem encountered on site.

This project is carried out within the regional programme of "Establishment of Persian Heritage Archive" approved as a task group by the international initiative for Recording, Documentation and Information Management (RecorDIM) proposed and directed by the authors.

The guidelines and supports of the International Committee for Architectural Photogrammetry (CIPA) to which the first author is the Iranian national delegate are considered and followed.

This project is a first step towards the establishing scientific village and a venue for international conferences for the Iranian Ministry for Science, Research and Technology. It is thought to be open to various sets of data, thus providing for a multidisciplinary management and analysis tool, to assist in multiple criteria spatial decision making, as well as for monitoring the past and present state and predicting future developments of the valuable but vulnerable ecosystem of Khoranagh village.

This extensive project is currently under operation and the data is being gradually captured and processed. The results of documentation process will be reported in another article.

## REFERENCES

El-Hakim, S.F., Beraldin, J.A. and Picard, M, Detailed 3D Reconstruction of Monuments Using Multiple Techniques, CIPA Workshop, Corfu, Greece, 2002.

ISMO, Khoranagh: Venue for International Meetings, Ministry of Science, Research and Technology, Tehran, Iran, 2004.

Malian, A. and Zolfaghari, M., Non Metric Cameras in Architectural Photogrammetry, IAPRS, ISPRS Congress, Amsterdam, The Netherlands, 2000.

Malian, A. and Zolfaghari, M., Surveying Historical Buildings Using Close Range Photogrammetric Technique, Geomatic Conference, Tehran, Iran, 2001.

Zolfaghari, M. and Malian, A., Gaps and needs in the Documentation of Persian Heritage, RecorDIM Roundtable, CIPA Symposium, Antalya, Turkey, 2003.

Zolfaghari, M. and Malian, A., Documentation of the Documentations of the King of the Kings, IAPRS, ISPRS Congress, Istanbul, Turkey, 2004.

Figure 15. Pulchritudo splendo veritatis