Close Range Photogrammetric Technique for Documentation of NAQSH-I RUSTAM

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ABSTRACT

Naqsh-i Rustam is a name of an ancient place which is located in the south of IRAN 80 kilometre far from Shiraz. It includes five graves, four rock-carvings, epigraphs, and a building so called Kabeh-i Zartosht. Graves are caves on the mountain located 40 meters higher than ground. The mountain is a stony mountain and was cut to develop walls with columns. On walls and columns are friezes and figures of monarchs with their servants. In addition, on walls are epigraphs about monarchs' life. Width of each wall is about 15 meters. The rock-carvings also was cut on the mountain which explain story about the SAŞANIAN dynasty's fights with their enemies. Besides, there are some epigraphs on the mountain about SASANIAN dynasty. The building of Kabeh-i Zartosht was build of cubic stones and it has a cubic shape. There are three epigraphs on three walls of the building with three languages of SASANIAN, MOBADAN, and GREEK.

The paper outlines a close range photogrammetric project for documenting the described place precisely. The project involves to provide digital maps from epigraphs and rock drawing with scale of 1:5, from building with scale of 1:25 and from grave with scale of 1:50. In addition, a virtual reality model of the place has to be developed.

According to the aims of the project, a pre analyse was fulfilled for defining a main coordinate system for the place, and different sub-coordinate systems for epigraphs, grave, rock-carving and building. Sub-coordinate systems can be transferred to the main coordinate system. Each object was photographed by a film based camera with 6x6 cm frame size. The stereo photograph method was used in this project and more than 900 stereo photographs were taken from objects. More than 400 control points were located on the objects. Control points were positioned by surveying intersection method with accuracy less than 0.1 mm. Because a high precision close range photogrammetry was required, according to the pre-analyses the control points were distributed on the objects such as that any six control points were in a stereo photograph. This method of photography reduced interferes of lens and camera distortion and increased the precision. In addition, every stereo photograph had 80% coverage.

All 3D models were developed on a ZEISS P33 stereo plotter. Mentioned accuracy of P33 by the manufacturer is between 7 to 5 μ and we accepted this accuracy. The pre-analyse was also fulfilled based on this accuracy. Results verified the method of photography and processing was reliable.

There were problems with the P33 when the models were oriented. It seems the P33 was designed for aerial photogrammetry according to conventional method, but close range photogrammetry employed special methods according to its aims. These special methods were not evaluated in P33; therefore, P33 was not able to develop some special models. Besides, author has experience with other analytical and digital stereo plotters which all of them had the same problems.

This paper will discuss all problems and evaluate employed methods and obtained results.

1 INTRODUCTION

The heritage organisation of IRAN had a request for documentation of Kabeh-i Zartosht, the rock-carving of the triumph of the first Shapur, and the grave of the first Dariush, and some epigraphs on walls of building and rock-carving at the Naqsh-i Rustam by using close range photogrammetry method. The project involves to provide digital maps from epigraphs and rock-carving with scale of 1:5, from building with scale of 1:25 and from grave with scale of 1:50. In addition, a virtual reality model of the place has to be developed.

Kabeh-i Zartosht (Figure 1) is a cubic shape building which was made of blocks of stones. Size of blocks was about 1x.5x.4 m which they extracted and cut from the mountain. The area of this building is about 400 square m and its height is about 25 m. Three epigraphs in three languages of SASANIAN, MOBADAN, and GREEK were carved on three walls of building. There are a number of rectangle holes on walls with size of 25x40 cm and their depth are about 25 cm. The holes are regularly placed on walls. It seems these holes were designed for place of some rock drawings and signs. Each of walls of left, right, and back side of building have six windows. The front wall has the main and only gate which includes a rock drawing on the door way.

Figure 1: Kabeh-i Zartosht form left side view.

On the left, right, and back walls of the building are three epigraphs with three languages of SASANIAN, MOBADAN, and GREEK (Figure 2) were noted about the first Shapur, a king of the SASANIAN dynasty. These epigraphs include more than 1500 characters and worlds. The size of each character was about 1x2 cm.

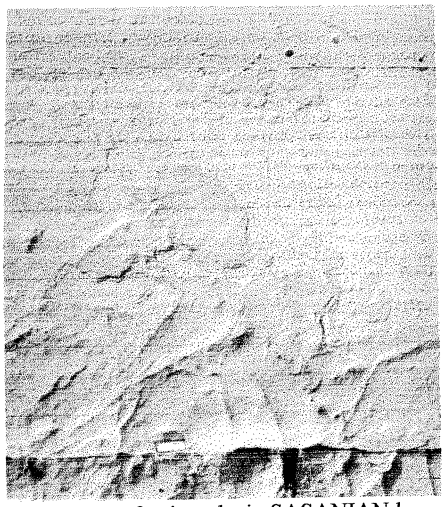

Figure 2: A part of epigraphs in SASANIAN language.

The rock-carving is a drawing on the mountain (Figure 3). The triumph of the first Shapur was commemorated by this rock-carving showing him on horse-bake and his Roman opponent (Valerian Roman empire) kneeling before him. The king is on a dignity cloth with crown and fully arm, he raised his right hand as sign of exemption the empire. King was followed by a servant and at the front of the king was another Roman who was offering the Roman flag to him.

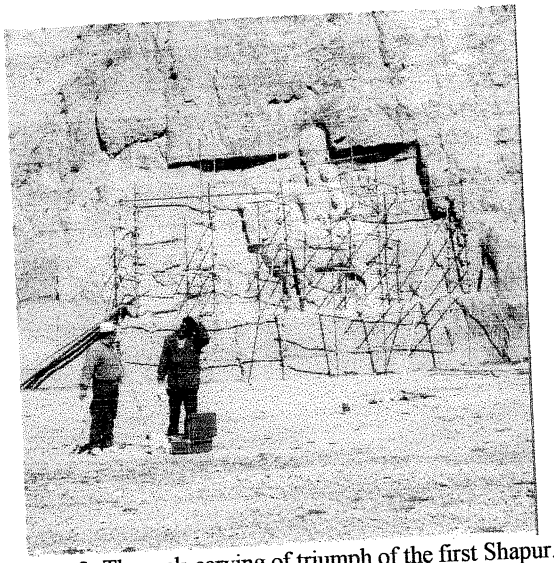

Figure 3: The rock-carving of triumph of the first Shapur.

This drawing is very live and infuses that event into spectators. The size of the rock-carving is about 12x9 m. Its height from ground is about 3 m. the depth of the drawing in some parts is more than 40 cm; for example, the depth of forelock, muzzle, and belly of horse is more than 40 cm.

The grave is in a cave at the height of 25 m on the mountain (Figure 4). The mountain was cut to develop a wall and columns of a palace. On the wall, there are friezes and figures of kings with their servants. The height of the wall is 40 m and its width is about 15 m.

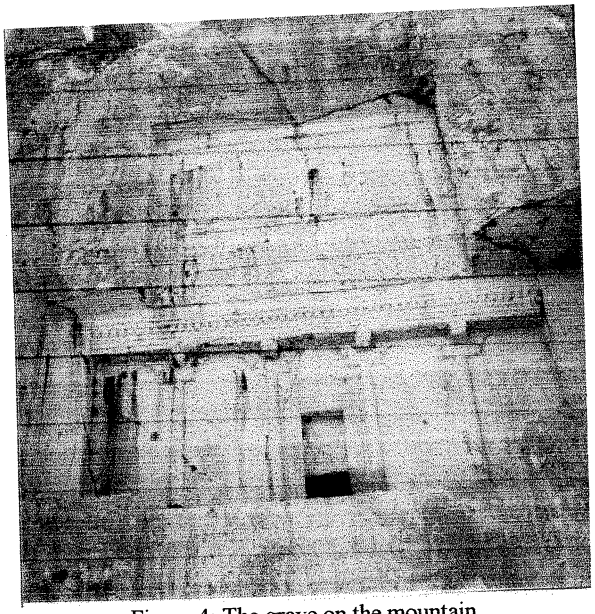

Figure 4: The grave on the mountain.

This paper will discuss strategy of photography according to structure and particular geometric shapes of objects for achieving aims of the project. Indeed, there were a number of issues and problems which interfere the process of project. This paper will evaluate these problem and will explain methods of overcoming these issues. Next section will discuss the strategy and methodology of the project. Problems and issues will be evaluated at the third section. Conclusion and results will be given at the fourth section.

2 Methodology

This section will explain methodology of project for achieving aims. Atkinson (1996) explains close range photogrammetry and its application broadly. Despite aerial photogrammetry, image acquisition in close range photogrammetry quite different and in most cases, images are highly convergence. The main aim of this project was to produce maps from those objects; therefore, method of image acquiring and photography should be support this aim. Stereo photography is a best and simplest method for map compiling from photographs. Consequently, stereo photography method was used in this project and it was tried to acquire non-oblique photographs. Indeed, camera axis was normal to the object all the times; however, there were some exceptions.
A HASSELBLAD 553EL/M was used in this project. However, this camera supplied with a 100 mm ZEISS lens which is a high quality lens with minimum distortions, it was tried any stereo photograph had at least 80% coverage for compensating depth error. For

making a strong geometry between photographs and objects, more than 400 control points were distributed on objects. Distribution of control points was designed based on any 6 control points were acquired by a stereo photograph. This strategy increases the reliability of the project and decreases effects of any errors on the processing. Surveying intersection was used for measuring the control points. For measuring control points, a SOKKISHA electronic tacheometer model SET 10 was employed and RMS of control points was about 0.1 mm.
As mentioned, most of photographs were tilt free and more than 500 stereo photographs were covered all objects. Camera was set up in distance of 1.35 m far from epigraphs, 2.3 m far from rock-drawing, 4.5 m far from the building, and 8 m far from the gave. All stereo photographs were compiled to map by using a P33 ZEISS analytical stereo plotters. A triangulation has been applied on the extracted data for compensation errors and unified a coordinate system.

3..Problems and Issues

The main problem in this project was related to the photogrammetric system which was designed for conventional photogrammetry. Indeed, most of analytical photogrammetric systems were designed for conventional photogrammetry so were digital photogrammetric systems. Despite aerial photogrammetry, close range photogrammetry is always used for precise and reliable measurement which employs a reliable mathematical modeling. The mathematical modeling can not be supported by these kinds of photogrammetric systems. Only a few close range photogrammetric systems employ this mathematical modeling.

As mentioned early, in this project was tried to acquire stereo photographs and follow conventional photogrammetric method. Therefore, stereo photography method was considered to employ in this project; however, some photographs were highly convergence on three axis. In addition, it was considered all photographs which were taken from an object to had unique scale. Unfortunately, these rules could not perfectly observed because shape of objects and their places made a natural obstacle to reach them. Consequently, some photographs, as mentioned, were highly convergence and different scales. the mentioned strategy was considered based on the experience of author in this field.

Because there were some limitation in analytical stereo plotters for compiling map from unconventional photographs, this strategy were decided. However, some references were explained analytical stereo plotters are able to cope with these issues such as Slama (1980), still they have problems with very special photographs. it should be considered that analytical stereo plotters are very more flexible than digital photogrammetric systems when working whit these kinds of photographs.

Another problem related to the size of film and volume of project. the size of film was 5x5 cm. According to the strategy and pre-analysing, more than 600 stereo photographs were covered to all objets, and it was tried each stereo photographs included at least 6 control points. Processing of this volume of photographs needs to consider a special strategy for overcoming any processing errors and increase the reliability of processing. Increasing control points and area of coverage on the stereo photographs grantees the strategy of project, but increases the processing time.

4..Conclusion and Results

This section will explain results and will conclude with the remarks. As mentioned more than 600 stereo photographs were covered objects and more than 400 control points were distributed on the objects. All control points were measured by using intersection surveying method and RMS of their coordinates was about 0.1 mm. About 500 stereo photographs had a normal condition with object and the rest had a highly convergence. All of processes were done by a ZEISS STEREO PLOTTER model P33.

At the first characters and letters of epigraphs were compiled. These characters had special shapes which manually extraction and digitisation was very tedious and needed patiently working for hours. More than 150,000 points were extracted and digitised for compiling these characters in the computer. Besides, three independent groups were working for editing of these characters. Figures 5,6,7 show the final output of these characters.

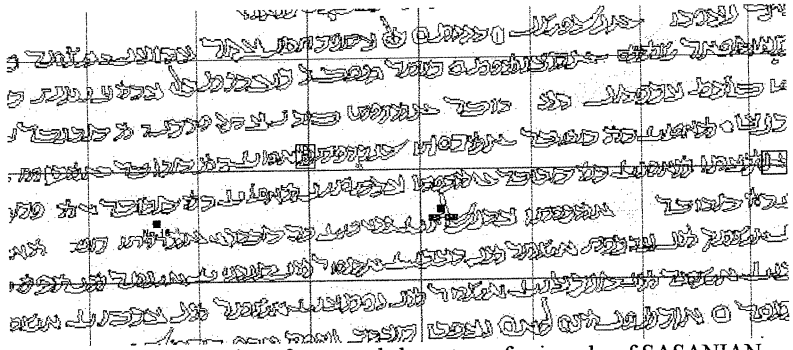

Figure 5: Demonstration of extracted characters of epigraphs of SASANIAN.

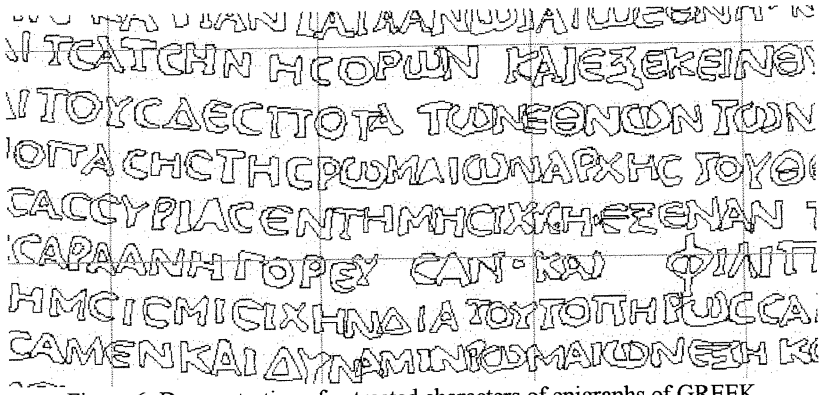

Figure 6: Demonstration of extracted characters of epigraphs of GREEK.

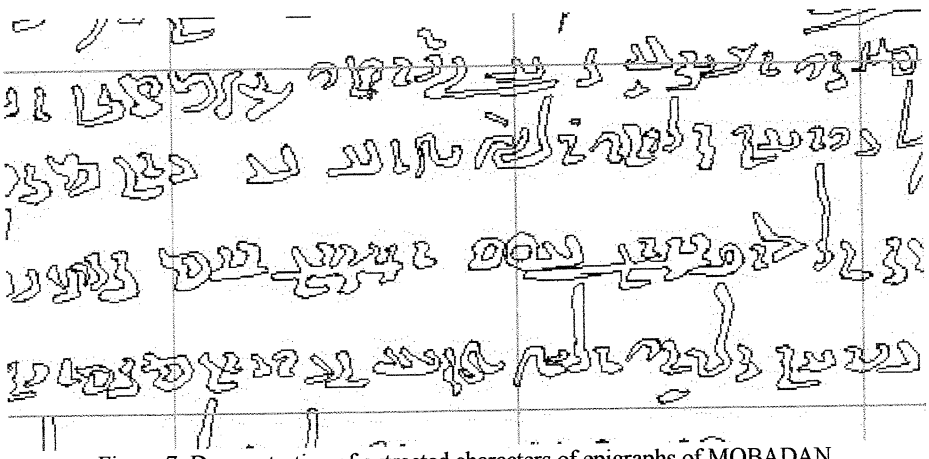

Figure 7: Demonstration of extracted characters of epigraphs of MOBADAN.

All of the photographs were taken from the building had a high tilts in three axis. Compiled maps from these photographs were need a post processing before final output. Figure 8 shows a wall of building. Rock-drawing was a huge rock-carving and more than 350 stereo photographs were covered this drawing. All photographs were processed and compiled in the computer. Figure 9 shows a part of Valerian's face which it seems painted by an artist.

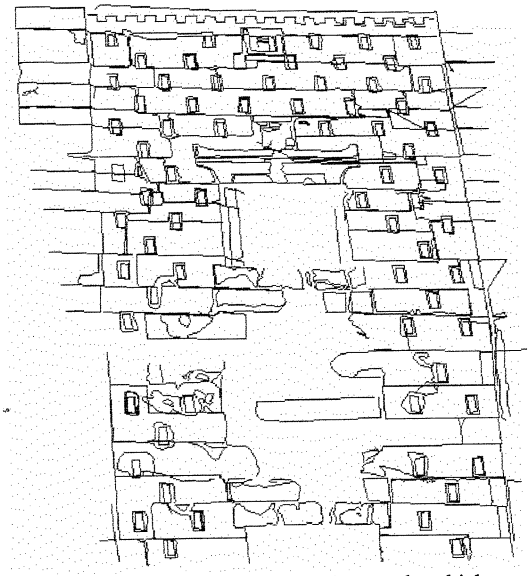

Figure 8: Demonstration of main gate of Kabeh-i Zartosht which compiled by P33.

Figure 9: Demonstration of compiled Valerian's face.

The project is still successfully continuing and there are a lot of work for compiling the grave.

References

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