

DETERMINATION OF THE ISLAMIC ART ACCURACY BY USING DIGITAL CLOSE RANGE PHOTOGRAMMETRY

Dr. Mostafa Abdel-Bary EBRAHIM
Lecturer at Civil Engineering Department
Faculty of Engineering
Assiut University
Assiut, Egypt.
Ebrahim@acc.aun.eun.eg

KEY WORDS : Digital Photogrammetry, Accuracy, Islamic Art, Close-Range, Photogrammetry, Orthoimage

ABSTRACT

Islamic art is perhaps the most accessible manifestation of a complex civilization that often seems enigmatic to outsiders. One of the most important element in Islamic art is a preference for covering surfaces with patterns composed of geometric or vegetal elements.

An accuracy investigation has been done to obtain the accuracy of the Islamic painting on the mosques' ceilings and domes. To carry out this investigation, ten photos have been taken from different camera stations for the ceiling of Abdel-Raheem El-Kenawi's mosque by using a non-metric camera. New comparison techniques have been used to find out the relation between the points' coordinates in order to obtain the accuracy of the Islamic painting. Then a numerical comparison between the symmetrical points has been done and other geometric comparison techniques have been applied to verify the results of the numerical comparison.

The results showed that such Islamic art is accurate in dimension and shape. The numerical results have been tabulated and the geometric results have been done in images form.

1. INTRODUCTION

1.1 The Islamic Art

Art is the mirror of a culture and its world view. There is no case to which this statement more directly applies than to the art of the Islamic world. Not only does its art reflect its culture values, but even more importantly, the way in which its adherents, the Muslims, view the spiritual realm, the universe, life, and the relationship of the parts to the whole. (Elisabeth Siddiqui, 2000)

Islamic art is perhaps the most accessible manifestation of a complex civilization that often seems enigmatic to outsiders. Through its brilliant use of color and its superb balance between design and form, Islamic art creates an immediate visual impact. Its strong aesthetic appeal transcends distances in time and space, as well as differences in language, culture, and creed. Islamic art not only invites a closer look but also beckons the viewer to learn more.

The term Islamic art may be confusing to some. It not only describes the art created specifically in the service of Islam, but it also characterizes secular art produced in lands under Islamic rule or influence, whatever the artist's or the patron's religious affiliation. The term suggests an art unified in style and purpose, and indeed there are certain common features that distinguish the arts of all Islamic lands. Although this is a highly dynamic art, which is often marked by strong regional characteristics as well as by significant influences from other cultures, it retains an overall coherence that is remarkable given its vast geographic and temporal boundaries. Of paramount concern to the development of this singular art is Islam itself, which fostered the creation of a distinctive visual culture with its own unique artistic language. (Linda Komaroff, 1999)

One of the most important elements of the Islamic art is a preference for covering surfaces with patterns composed of geometric or vegetal elements. Complex geometric designs, as well as intricate patterns of vegetal ornament (such as the arabesque), create the impression of unending repetition, which is believed by some to be an inducement to contemplate the infinite nature of God. This type of nonrepresentational decoration may have been developed to such a high degree in Islamic art because of the absence of figural imagery, at least within a religious context.

In Islamic cultures the so-called decorative arts provide the primary means of artistic expression, in contrast to Western art, in which painting and sculpture are preeminent. Illuminated manuscripts, woven textiles and carpets, inlaid metalwork, blown glass, glazed ceramics, and carved wood and stone all absorbed the creative energies of artists, becoming highly developed art forms. These works include small-scale objects of daily use, such as delicate glass beakers, as well as more monumental architectural decoration, for example, glazed tile panels from building façades. Such objects were meticulously fabricated and carefully embellished, often with rare and costly materials, suggesting that the people for whom they were made sought to surround themselves with beauty. (Linda Komaroff, 1999)

Decoration is a major unifying factor in Islamic architecture and design. Decoration has linked buildings and objects from all over the Islamic world - from Spain to China to Indonesia. Islamic art is an art not so much of form as of decorative themes that occur both in architecture and in the applied arts, independently of material, scale and technique. There is never one type of decoration for one type of building or object; on the contrary, there are decorative principles that are pan-Islamic and applicable to all types of buildings and objects at all time. (Islamic Arts and Architecture Organization (a), 1998)

The effect of the Islamic decoration is extraordinary and its function quite unmistakable. The Islamic decoration goes hand in hand with the non-directional plan, the tendency to an infinite repetition of individual units(bays, arches, columns, passages, courtyard, doorways, cupolas) and the continues merging of spaces without any specific direction or any specific center or focus. And if a definite spatial limit is reached, such as a terminal wall, the surface that should stop the progress of anyone moving through the building will be decorated with patterns that repeat themselves, leading on visually beyond the given limit of the wall, surface, vault or dome. (Islamic Arts and Architecture Organization (b), 1998)

1.2 The Accuracy

The accuracy is an important element in the world of measurements. So, it has been defined in several text books and articles. As example, Edward M and Gordon Gracie, 1981 defined the accuracy as the degree of conformity or closeness of a measurement to the true value. They state that accuracy includes not only the effects of random errors but also any bias due to uncorrected systematic errors. If there is no bias, the standard deviation can be used as a measure of accuracy.

Buckner R.B., 1983 defined accuracy as the degree of conformity with a standard (“the truth”). He mentioned that the accuracy relates to the quality of a result, and is distinguished from precision, which relates to the quality of the operation by which the result is obtained.

Kenneth E. and Donald J., 1995 defined the accuracy as the degree to which information on a map or in a digital database matches true or accepted values. Accuracy is an issue pertaining to the quality of data and number of errors contained in a dataset or map.

Buckner R.B., 2000 wrote that the accuracy has only one meaning: conformity with the truth. The truth in measurement science is defined by one or more of the following:

- * An adopted physical or other standard (on distance, weight, volume, time, etc.).
- * Geometric laws.
- * A system decided as correct by some recognized authority.

In theory of errors of measurements the term accuracy is traditionally used for a concept that measures the closeness of derived estimated or predicated data to reality. (Ebrahim, 1992)

The accuracy can be evaluated by using one of the following two methods (Hottier, 1976) :

- 1- Check measurements
- 2- The accuracy predictor

In the first method, the photogrammetric results are compared with the results obtained from a more accurate measuring procedure. The accuracy predictor is a theoretical way to evaluate a system using its main parameters.

Fraser,1990 agree with Hottier, 1976 for the first method and mentioned that “If check points are available in the object space, the root-mean square (RMS) errors of photogrammetrically determined target point co-ordinates can be used as an accuracy measure”.

Photogrammetrist very often estimate the accuracy of a method by controlled experiments, where the photogrammetrically determined co-ordinates are compared with so called given co-ordinates that have an accuracy that considerably higher than that of the method to be checked (Ebrahim, 1992).

2. THE TEST FIELD

2.1 Its Natural

A part of the ceiling of Abdel-Raheem El-Kenawi's mosque has been chosen as a test field for this investigation. Its flat ceiling and its domes has a very beautiful decoration which has been painted by the Islamic artists. The test field consists of one panel of the whole ceiling which contains a dome centered in its flat ceiling. The diameter of the dome is about five meter and the dimension of the flat ceiling is about 8 x 8 meters. It surrounded by a system of regular columns which carry a sold part decorated with a beautiful painting and calligraphy. Above the sold part, there are a row of windows covered with regular Islamic pattern . Theses windows separates by painted posts which carry the flat ceiling and the dome. Figure (1) shows part of the panel.



Figure (1) Part of the panel

2.2 Its History

The mosque was built in 1948 by the constructor Aal-Zarea from Gerga city. An extension for the mosque has been done in 1989. This extension is a copy of the main part of the mosque. Beside the main part, lies the shrine of Abdel-Raheem El-Keenawi which directly connected to the main part.

2.3 Its Location

The mosque lies in the main square of Kena city which far from Cairo by 518 Km to south. The main entrance is in the western side and the shrine of Abdel-Raheem El-Kenawi lies in the eastern side. The test field panel lies in the southern side of the mosque.

3. THE USED CAMERA

A non-metric camera, YASHICA Zoomtec 90 Super, has been used in this investigation. The focal length of the camera has been fixed to 38 mm. A self calibration for the camera has been done by the used photogrammetric software through the processing of the project. As this camera is a non-metric camera, a separated camera has been defined for each photo in the used software. Roll film (FUJI 100 ASA) was used with this camera with 24 by 36 image format. The photos have been scanned via a flatbed scanner "MUSTEK ScanExpress 600 SEP".

4. THE EXPERIMENTAL WORK

4.1 The Study Procedure

1. Gather up data about the test field
2. Take ten photos of the test field with the used camera.
3. Scan the photos by a flatbed scanner.
4. Set up the camera in the used photogrammetric software.
5. Mark all the points on all images.
6. Process with the photos.
7. Compare results in analytical and geometrical forms.

4.2 Number Of Photos And Their Positions

Ten photos for the test field have been taken from different camera positions which arranged to get a complete coverage of the test field and to verify a good angle of intersection of the market points. Figure (2) shows the camera positions regarding to the test field. Figure (3) shows one of the original used images.

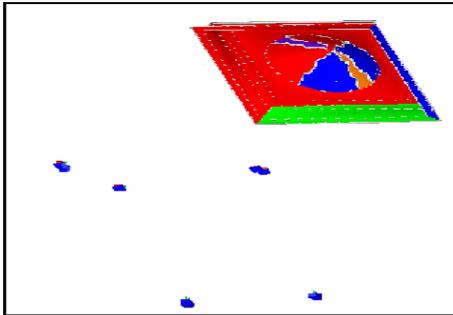


Figure (2) The camera positions



Figure (3) An original Image

4.3 Image Enhancement

No Image enhancement has been used for the different images to assure that the images in all cases are the same and has no changes in contrast, brightness, tone adjustment, ... etc., which may effect in the image geometry.

4.3 The Used Photogrammetric Technique

A common photogrammetric software has been used to obtain the photogrammetric solution (external and internal orientation elements). 371 points have been marked on all photos on the flat ceiling and the dome to obtain the 3-D coordinates of the marked points and the computer model of the dome and the flat ceiling of the mosque. A self calibration for each defined camera has been done through the processing of the project. The points have been marked in a certain points on the painting edges. 16 different levels have been chosen in the dome for the purposes of the comparison techniques. A coordinates system has been chosen in order to put the model in a symmetrical position regarding to the x and y axes in order to make the comparison easier for obtaining the accuracy of the painting.

The handling of the images happened in the common iterative way through the used photogrammetric software :

- Approximate marking of the points.
- Shifting to the exact position in a zoomed window.
- First processing
- Moving of single points according to their residual vectors.
- Second processing.
- If necessary repeating of the last steps.

The resulting points' co-ordinates have been written to ASCII file and prepared and formatted for further analytical comparison processing. An orthoimage, produced by the used photogrammetric software, has been obtained for the test field for further geometric comparison.

4.4 Results And Comparison

The results of this investigation are in the form of 3-D co-ordinates and an orthoimage of the test field. In this investigation, there are not any given co-ordinates (co-ordinates that obtained from a more accurate procedure) or any theoretical way to evaluate a system using its main parameters. So, the standard deviation of the obtained co-ordinates will be the accuracy measurement tool.

The co-ordinates system has been chosen as follows : x and y axes are in the ceiling plan and z axis is the vertical direction which is perpendicular to the ceiling plan.

The evaluation of the different methods was done in two independent ways :

- Analytical comparison of the measured points 3-D co-ordinates in X, Y, and Z.
- Geometric comparison of the painting shapes in 2-D co-ordinates (X, Y).

For the analytical comparison and the geometric comparison the average errors = $\text{sum}(\text{abs}(\text{diff}))/n$ and the standard deviation = $\text{sqr}(\text{sum}(\text{diff}*\text{diff})/(n-1))$ (where diff is the difference in co-ordinate values and n is the number of points) have been computed. These methods lead to significant values for the accuracy of the evaluated methods.

The position of the dome axis has been calculated from the center of each level (Xo, Yo) and the standard deviation of the position of the axis (σX_o , σY_o) is obtained. Also the radius of each level (R) has been calculated from different points co-ordinates and the standard deviation of the radius (σR) has been obtained for the various radiuses and tabulated as in table (1).

Level No.	Xo	Yo	Zo	R	σR	σZ
1	3.205	3.265	0.000	2.546	0.038	0.000
2	3.214	3.255	-0.086	2.423	0.018	0.017
3	3.215	3.256	-0.168	2.306	0.018	0.023
4	3.217	3.257	-0.205	2.249	0.019	0.024
5	3.216	3.257	-0.319	2.068	0.017	0.027
6	3.215	3.258	-0.398	1.961	0.018	0.027
7	3.217	3.256	-0.445	1.879	0.018	0.030
8	3.214	3.257	-0.504	1.781	0.018	0.030
9	3.216	3.262	-0.641	1.561	0.021	0.028
10	3.220	3.263	-0.719	1.416	0.017	0.033
11	3.225	3.260	-0.775	1.328	0.036	0.038
12	3.223	3.259	-0.915	1.090	0.032	0.040
13	3.225	3.254	-1.038	0.893	0.035	0.039
14	3.220	3.254	-1.156	0.682	0.037	0.030
15	3.222	3.255	-1.210	0.568	0.033	0.030
16	3.228	3.255	-1.302	0.314	0.033	0.021

All values are in meter

Table (1) The dome axis' position and the radius according to each level

From table (1), the average co-ordinates of the dome axis position are : $X_o = 3.218$ m and $Y_o = 3.258$ m and the standard deviations of the dome axis position are : $\sigma X_o = 0.0056$ m and $\sigma Y_o = 0.0033$ m

A curve fitting according to the Least Squares Error has been applied to find out the best formula for the profile of the vertical cross section of the dome by using the radius at each level as X and the levels as Y. The results of the curve fitting shows that the parabolic formula is the best formula for the profile. The formula that fits the results is :

$$Y = 0.08785 X^2 - 0.3078 X - 1.3732$$

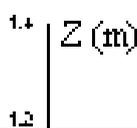
The circles radius at each level according to the values that calculated from the formula have been compared and tabulated in Table (2). Also Figure (4) shows the curve fitting results.

Level No.	X	Y	Calculated Y	Error
1	2.546	0.000	-0.020	0.020
2	2.423	-0.086	-0.111	0.025
3	2.306	-0.168	-0.196	0.028
4	2.249	-0.205	-0.236	0.031
5	2.068	-0.319	-0.361	0.042
6	1.961	-0.398	-0.412	0.034
7	1.879	-0.445	-0.484	0.039
8	1.781	-0.504	-0.546	0.042
9	1.561	-0.641	-0.679	0.038
10	1.416	-0.719	-0.761	0.042
11	1.328	-0.775	-0.809	0.034
12	1.090	-0.915	-0.933	0.018
13	0.893	-1.038	-1.028	-0.010
14	0.682	-1.156	-1.122	-0.034
15	0.568	-1.210	-1.170	-0.040
16	0.314	-1.302	-1.268	-0.034

All values are in meter

Table (2) The curve fitting accuracy

The average error of the curve fitting = 0.032 m and the standard deviation of the curve fitting = 0.034 m



An orthoimage related to the flat ceiling plan as a reference plan has been obtain directly from the used photogrammetric software as shown in figure (5). This image has been divided into four quadrant for purposes of the geometric comparison. Each quadrant has been enhanced through an image enhancement software to prepare the images for the comparison. The upper-left quadrant is remain as it is, the upper-right quadrant has been flipped horizontally, the lower-left quadrant has been flipped vertically and the lower-right quadrant has been flipped vertically and horizontally. Figure (6) shows the various quadrates.



Figure (5) An orthoimage of the test field



Figure (6) The orthoimage four quadrate

In the enhanced image which illustrated in figure (6), 28 points have been chosen and their co-ordinates have been measured in each quadrant. The image co-ordinates have been transformed from pixels to meter by multiplying each co-ordinate by the transformation factor. This factor is equal to 0.01056 which has been calculate from the distance between two points in the original orthoimage by pixel and its equivalent length by meter. The lengths between each point and the others (378 lengths) in each quadrant have been calculated. The lengths range is between .144 and 3.274 meter. A comparison between the calculated lengths in the various quadrant has been done. This comparison shows that the average standard deviation of the lengths is .0353 meter. For purposes of the geometric comparison, two models

have been chosen from the painting shapes. These models have been copied from each quadrant in the enhanced image and arranged as shown in figure (7).

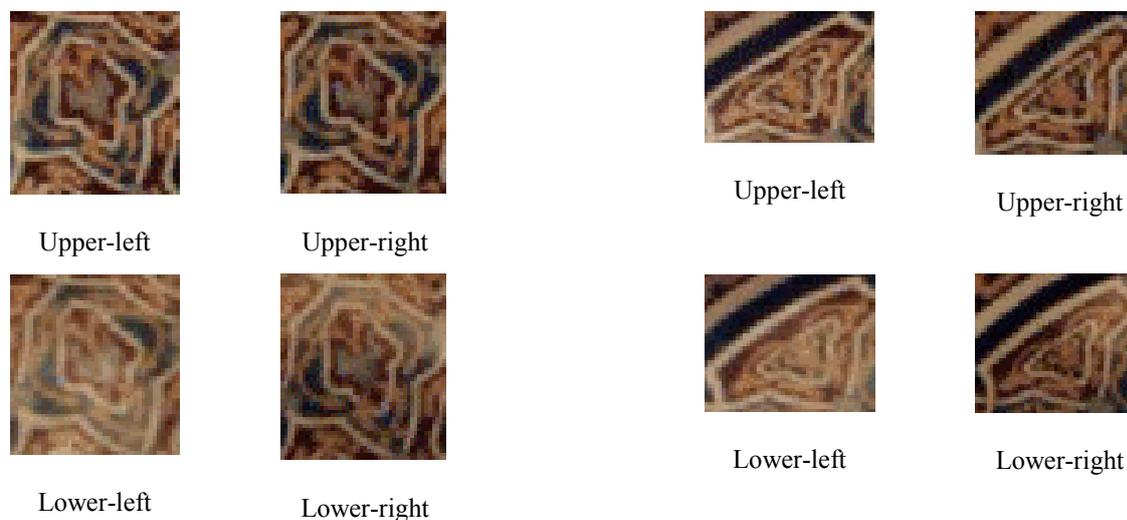


Figure (7) Four quadrant symmetrical shapes samples

4.5 Analysis

Two kinds of results have been obtained, numerical results (3-D co-ordinates) and geometrical results (orthoimage 2D-co-ordinates). As a general look in the results tabulated in table (1), it is noted that the dome axis co-ordinates is almost the same between the levels 2 through 9 and changed some thing in the other levels. That means the painting base as a construction may be warped in these levels which made the center of each circle in its level has a small shift from its original position.

The standard deviations of the dome axis position are 5.6 mm in X direction and 3.3 mm in Y direction. These standard deviation considered as a high accuracy. The used points were in a symmetrical system around the dome axis. If the painting is not accurate, the average of each two symmetrical points will not lies in the dome axis. This means that the painting is very accurate, so it produce a very accurate position of the dome axis.

The standard deviation of the Z direction is about 3.5 cm. This value may affected by the construction itself and by the accuracy of the used photogrammetric software. According to Hanke and Ebrahim, 1997, the relative accuracy obtain from the used photogrammetric software is about 1/3000 by using a non-metric camera. In our case the relative accuracy is 1/3036 for the dome axis position (X, Y). It is known that in the photogrammetric works, the weakest accuracy come always in the camera axis direction and this is what we have in Z direction.

Looking in the results of the dome profile, the accuracy is about 3.4 cm for the curve fitting. The painting has a big influence in this accuracy because the values of the level have been obtained from the painting levels (Y in the formula). If the painting is not accurate, the levels would not be close to the formula values, taken into consideration that Y values is in camera direction.

In the geometric comparison, the results shows that the shapes of the painting is almost the same in dimension and position. This can be noted from the four quadrant of the orthoimage that obtained from the photogrammetric software. Also, the accuracy of the distances is 3.53 cm and this can be considered as a good accuracy taking into consideration the painting base construction and the accuracy of the used photogrammetric software.

From Figure (7) we can noted that the symmetrical sample models is very accurate in their shapes and colors. That means the Islamic art is very accurate even in its fine details.

5. CONCLUSION

The Islamic art accuracy has been studied using the digital close range photogrammetric technique. One Islamic art element has been chosen as an Islamic art guide. This element is the painting of the mosques' ceilings. The photogrammetric technique has been applied and the results have been compared. The comparison results shows that the standard deviation of the dome axis are $\sigma X_o = 0.0056$ m and $\sigma Y_o = 0.0033$ m which calculated from symmetrical points around the dome axis. This values considered as a high accuracy. The other comparisons shows that the standard deviation of the dome profile and the lengths are about 3.5 cm. This value considered as a good accuracy if we took into consideration the another two factors that effecting in this values (the painting base as a construction and the accuracy of the used photogrammetric technique) and the effect of the third direction (Z). The geometric comparison shows that the Islamic art is very accurate in dimension and shapes.

From this investigation, we can conclude that the Islamic art is very accurate in shape and dimension as obtained from the numerical and geometrical results that obtained from the digital close range photogrammetric technique.

6. REFERENCES

- 1- Buckner R.B., "Surveying Measurements and their Analysis", Landmark Enterprises, 1983.
<http://www.flatsurv.com/accuprec.htm>
- 2- Buckner R. B., "The nature of measurement :Part IV - Precision and Accuracy", Professional Surveyors Publishing Co. 2000,
http://www.profsurv.com/ps_scripts/article.idc?id=168
3. Ebrahim, M.A-B, "Using Close Range Photogrammetry for Some Engineering Applications", M.Sc. thesis, Assiut university, Egypt, March 1992.
- 4- Elisabeth Siddiqui, "Islamic Art", An article in the Muslim Students Association of Colorado University Home Page, 2000.
<http://www.colostate.edu/Orgs/MSA/docs/islart.html>
- 5- Fraser, C.S., "Film unflatness effects in analytical non-metric photogrammetry", ACSM-ASPRS Annual convention, Vol. 5, 1990.
- 6- Hanke, K. And Ebrahim, M. A-B., "A Low Cost 3D-Measurement Tool for Architectural and Archaeological Applications", CIPA International Symposium, Vol. XXXII, Part 5C1B, Göteborg, Sweden, 1997.
- 7- Hottier Ph., "Accuracy of Close Range Analytical Restitution : Practical experimental and Prediction", Photogrammetric Engineering and Remote sensing, 42(3), 1976
- 8- Islamic Arts and Architecture Organization (a), "The concept of decoration in Islamic architecture", An article in its home page, 1998
<http://www.islamicart.com/pages/archtcre/decorate.htm>
- 9- Islamic Arts and Architecture Organization (b), "Overview of Islamic architecture", An article in its home page, 1998
<http://www.islamicart.com/pages/archtcre/overview.htm>
- 10- Kenneth E. Foote and Donald J. Huebner, "Error, Accuracy, and Precision", 1995
<http://wwwhost.cc.utexas.edu/ftp/pub/gcraft/notes/error/error.html>
- 11- Linda Komaroff, "Introduction", An article in the LACMA Islamic Art webpage, 1999
http://www.lacma.org/islamic_art/intro.htm