

## OBTAINING FAÇADE PLAN OF A HISTORICAL BUILDING WITH ORTHORECTIFICATION OF SINGLE IMAGES GATHERED BY MOBILE PHONE AND DIGITAL CAMERA

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### ABSTRACT:

Turkeys National Cadastres Istanbul Branch Office Building is one of the most impressive buildings of Historical Peninsula. It is located in the Sultan Ahmet Square, in Istanbul. In the near vicinity of this building, there are several historical buildings, like the Hagia Sophia, which is registered as a World Heritage by UNESCO and Sultan Ahmet Mosque known as Blue Mosque. The building consists of two parts. First part was built in 1881 and still used for storing of the Ottoman Archive. Second part was built in 1910 by the Architect Vedat Mehmet Efendi and merged with the first part. The area of the façade of the building is 850m<sup>2</sup>. In this application, digital images of this office building have been taken from different sources such as mobile phone and digital camera. Then these images were rectified using Pictran, Photomodeler and PhoTopol. The aim of this study is to compare the image sources regarding the capability of using them for various purposes and the capacity and usability of the software's regarding manpower, obtained results and transfer to other visualization tools.

### 1. INTRODUCTION

The Anatolian Plate, where has been a place of call of different Civilizations throughout the history, shelters so many Heritages from its east to west. Many of these monuments both from the pre-historical times, from the Seljuqi or Byzantine and Ottoman periods have been preserved. Anatolian civilizations left their marks on the development of science, culture and art and as a result, many scientists, engineers, artists and architects were born. Although a big part of this national treasury has been preserved and documented very well, detailed documentation and preservation studies are still being carried on in every part of the country with the association of government and non-government organizations. Developments in computer and digital camera technologies caused to use new tools, which can be used for saving the cultural heritage and nature easily. Photogrammetry is the most convenient tool for documentation of historical heritage. Accurate coordinate values are produced by this method faster than any other technique. Due to limitless information contained by the photograph, they might be used to understand the current status of the historical monuments. 3D models are becoming the most popular visualization techniques for the cultural heritage.

Most of the terrestrial photogrammetric applications are related with architectural photogrammetry. This technique is generally used to obtain the plan of historical buildings. Photogrammetry is known as the best technology where the time consuming classical methods cannot reach the required accuracy. Architectural photogrammetry is not only used for obtaining the facade plan of historical buildings but also used for non-historical buildings and commercial objects.

In this project, rectified images of the facade of Sultan Ahmed Cadastre Office were produced by means of digital terrestrial photogrammetric technique. The objective of this project is to prepare rectified images of the building and compare the results of the used mobile phone camera and digital camera. Also it is aimed to compare the usability of the softwares.

### 2. STUDY AREA

Turkeys National Cadastres Istanbul Branch Office Building is one of the most impressing historical buildings of Istanbul which takes place at the most visited touristic region of Istanbul

called Historical Peninsula. The building consists of two parts. First part was built in 1881 and still being used for storing of the Ottoman archives. The building has been used for the cadastre works since it has been built. In 1910, the second part of the building was built by the Architect Mehmet Vedat Efendi and merged with the first part.

The building has been renewed and texture of the front façade was cleaned with a special solution. The front façade of the building is 850 m<sup>2</sup>. There are 20cm to 30cm depth differences on the façade and the is symmetric with respect to the middle section.



**Figure 1:** The pre-cleaned situation of the front façade

### 3. MEHODS USED

For documentation of the cultural heritage, Photogrammetry plays very important role. Photogrammetry is the most economical and effective technique to obtain true 3D coordinates, which is required for documentation of historical monuments. Close range Photogrammetry, is the most convenient technique for documentation among the others. Many of the applications of terrestrial photogrammetry are focused on architectural photogrammetry.

### 3.1. Plane Rectification

As an alternative to the classical hand held measurements or stereophotogrammetry, rectified images have an increasing usage ratio in less time and low-cost comparatively to the other techniques. Although it has been called photo mosaic, photomontage or photo drawing in different sources, the most appropriate term is “rectified images”. It is generally preferred in obtaining architectural or archeological site plans since it has provide the adequate accuracy, which is about ±5cm, required for these kind of jobs.

Rectification process is a projection of a tilted image to a tilt-free surface with a scale. Approximately 30cm depth differences on the surface can be taught as acceptable in a projective transformation of a building facade.

This product provides much more advantage to the end user in comparison with a classical line map since it shows more detail. On the other hand, it does not provide the accuracy as stereophotogrammetry or orthophoto does.

There are three main error sources that have to be taken care of in rectification process;

1. Scale and shifting errors due to the depth differences on the surface.
2. Variable scale due to the not being parallel of the image plane to the facade.
3. Lens distortions.

Shifting can be decreased by increasing the focal length, but this process decrease the advantage of rectification since the covered area decreases. Another method is to scale the surfaces in different pieces and mosaic them after rectification.

### 3.2. Basics of Plane Rectification

The base of rectification is an 8-parameter transformation.

$$x'' = \frac{a \cdot x' + b \cdot y' + c}{g' \cdot x' + h \cdot y' + 1} \quad y'' = \frac{d \cdot x' + e \cdot y' + f}{g' \cdot x' + h \cdot y' + 1}$$

Known:  $x'', y''$  Object coordinate system  
 $x', y'$  Measured image coordinates

Unknown: a, b, c, d, e, f, g, h

There are two equations for each point. Therefore at least 4 points in both coordinate systems (4\*2=8 equations) are required. If this prerequisite is fulfilled, the equation system is solvable (8 equations, 8 unknowns) and transformation parameters a, b, c, d, e, f, g, h can be determined from those 8 equations.

If more than 4 points are available, a least square adjustment is applied. In this case it is possible to calculate rectification accuracy.

### 3.3. Application

In this study; photographs of the building were taken by a digital camera and by a mobile phone for rectification. Olympus μ1000 Digital Camera which is 10 mega pixels and Sony Ericson W610i mobile phone which is 2 mega pixels were used. Both the digital camera and mobile phone were calibrated in the ITU Photogrammetry Division Laboratory test field. The calibrated focal length of the camera is 7.2885 mm and the calibrated focal length of the mobile phone is 4.7330 mm.



Figure 2: Sony Ericsson W610i



Figure 3: Olympus μ 1000 Digital Camera

13 control points were mounted on the building and measured by Pentax PTS total station and their coordinates were calculated according the equations of intersection method. A local coordinate system was defined and coordinate were calculated. Obtained coordinates of the control points is given in Table 1. Rectification processes were carried out using Pictran, Photomodeler and PhoTopol digital photogrammetric softwares.

Control Point	X (m)	Y (m)	H (m)
33	160,57	116,82	114,57
1	138,95	115,14	115,24
7	181,82	115,4	114,93
9	156,15	115,19	115,14
2	160,81	110,98	114,95
34	177,56	104,17	115,18
35	181,19	104,11	114,81
36	183,42	104,12	114,78
32	158,68	103,01	114,13
10	137,42	102,51	114,71
21	145,69	102,53	115,41

Table 1. Obtained Coordinates of the Control Points

#### 4. RESULTS AND CONCLUSION

As it is aimed to make a comparison between a mobile phone camera and a digital camera and images were taken by these two data sources were rectified.



**Figure 4:** Original image taken by Olympus  $\mu$  1000 Digital Camera



**Figure 5:** Rectified image by Pictran Software



**Figure 6:** Original image taken by Sony Ericsson Mobile Phone Camera



**Figure 7:** Rectified image by Pictran Software

In order to compare these two data sets, 5 control points' coordinates were measured again after rectification and compared with the measured values and standard deviations are calculated according to formula below:

Since the image scales differs, these obtained results were normalized.

According to the final RMS values, it is possible to say that a 2 mega pixel mobile phone camera is capable to provide adequate accuracy for rapid and simple survey projects which is about  $\pm 5\text{cm}$ .

Image	Image Distance; image scale	mx	my	mxy	Normalized mxy=%D
Mobile Phone	30m; 1/6300	1.8 cm	2.3 cm	3 cm	%0.1cm
Digital Camera	50m; 1/7000	1.8 cm	3 cm;	3.6 cm	%0.072cm

**Table 2.** Accuracy of the obtained results

The second aim of this study is to compare the image sources regarding the capability of using them for various purposes and the capacity and usability of the software's regarding manpower, obtained results and transfer to other visualization tools by means of rectification of single images.

The softwares used during the application have different algorithms for rectification processes. With measured 4 points; Pictran makes Affine Transformation. More than 4 points Least Square Adjustment process is carried out so the accuracy control of the rectification process can be controlled. On the other hand, PhoTopol uses 2 Dimensional Collinear Transformation for rectification. Since the source code of the Photomodeler program we have used at this study is user concealed, any information regarding the process algorithm is not accessible.

Developments in computer and digital camera technologies are growing day by day. Mobile phones, which have been used just for communication for long time, now became a very important and quick picture taking devices. Moreover, the image resolution is becoming better and better. The idea of use of these cameras for basic photogrammetric projects is not far away anymore. In this case study, the capability of a 2 mega pixel mobile phone camera for rectification process was researched by comparing a digital camera and quite acceptable results were obtained.

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**Pictran User Manual**