ACADEMIA | Letters

Mobile Photogrammetry for Architectural Documentation: Tips from a Case Study

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Introduction

Photogrammetry is the science and technology of making measurements using photographs (Collier, 2009) or is any measuring technique allowing the modelling of a 3D space using 2D images (Egels & Kasser, 2001). Therefore, architectural mobile (smart-phone) photogrammetry could be defined as a process to produce a 3D geometric model of a building or parts of it from several images taken by conventional mobile cameras. This study is a concise report of practical work that has aimed to provide some suggestions for accurate and precise use of mobile cameras in architectural photogrammetry. For this purpose, in a case study, this paper tried out to find an effective capturing method that could lead to the correct orthoimage production for further indirect measurement and CAD drawings.

Backgrounds

Gruen and akca (2007) reported that mobile phone cameras in comparison to digital still video cameras have great potential for consumer-grade photogrammetric processing. They stated that despite image-to-image varying systematic error patterns in some of them, they still give us an interesting option in terms of accuracy, costs, and flexibility. Sarhan Satchet (2011) showed that whenever mobile phone camera resolution increases the Root Mean Square Error (RMSE) computed by the comparison between the calculated value and the measured value

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of the object space coordinate will dwindle. Other experimental findings by Fawzy (2015) revealed that the mobile phone camera is efficient and can be given good results in comparison with high-resolution cameras in digital close-range photogrammetry. He also emphasized that whenever the mobile phone camera resolution increases, the photogrammetric coordinates are increased. The calibration tests for 17 mobile phone cameras by Takahashi and Chikatsu (2009) confirmed the accuracy of mobile phone cameras and suggested that they can take the place of consumer-grade digital cameras as a useful close-range photogrammetric device. By a 3D survey of a sculpture, Hernán-Pérez et al., (2013) estimated the accuracy of iPhone-based photogrammetry around one centimeter.

Method

In this study, a Samsung Galaxy A720F/DS (16 MP, f/1.9, and 27 mm) is used. The images were captured in 4608×3456 pixels. The AF/AE lock setting was applied to keep the internal and external orientation of the camera constant during the survey. All the images have been captured in March 2021 according to the stereographic principle. Agisoft Metashape Profesional (2019) as a stand-alone automatic lens calibration software was used for close-range photogrammetry. The images were captured in several camera stations and with various angles to the vertical facade of the case study so that their results could be comparable. Some parts of the architectural elements were also measured on-site as checkpoints so that the accuracy of the orthoimage could be validated.

Case Study

Shiraz was one of the historical capitals of Iran and is one of the most populous cities located in the southern part of the country and one of the main political-cultural centers at the north of the Persian Gulf. A significant part of its heritage, back to the early decades of the twentieth century, is disappearing. One of the most important remnants of these heritages is the decorated doorways of aristocratic houses that some remain, but it is feared that they will soon be destroyed without leaving a trace. Thus, a doorway of an old abandoned house along Ferdowsi Street in the northern part of the city was selected for this photogrammetric study.

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Results & Discussion

The camera stations, shooting angles, and the number of images, are three parameters examined in this survey. For this study, no control points were measured in advance as not everyone has access to the Total Station but checkpoints are applied as mentioned earlier. The shooting has been designed in three capturing scenarios.

A) A Convergent bundle, vertically or oblique photography where the mobile camera was at a relatively constant height: In this scenario, 59 photos were captured at a height equal to eye level in a semicircle in front of the façade (Fig. 1). In all the photos, the mobile was vertical. Camera stations and image overlaps shown enough coverage but in some horizontal lines of the scene and few vertical parts around the right pillar, which were at a higher level than the camera station, there are many distortions. Checking of photos taken of these areas shown that in almost all of them, the camera was oblique and was not parallel to the object. Although the distance between camera positions was small enough to result in more than 50% overlaps, the camera distance to the object was not enough to prevent intense distortions.

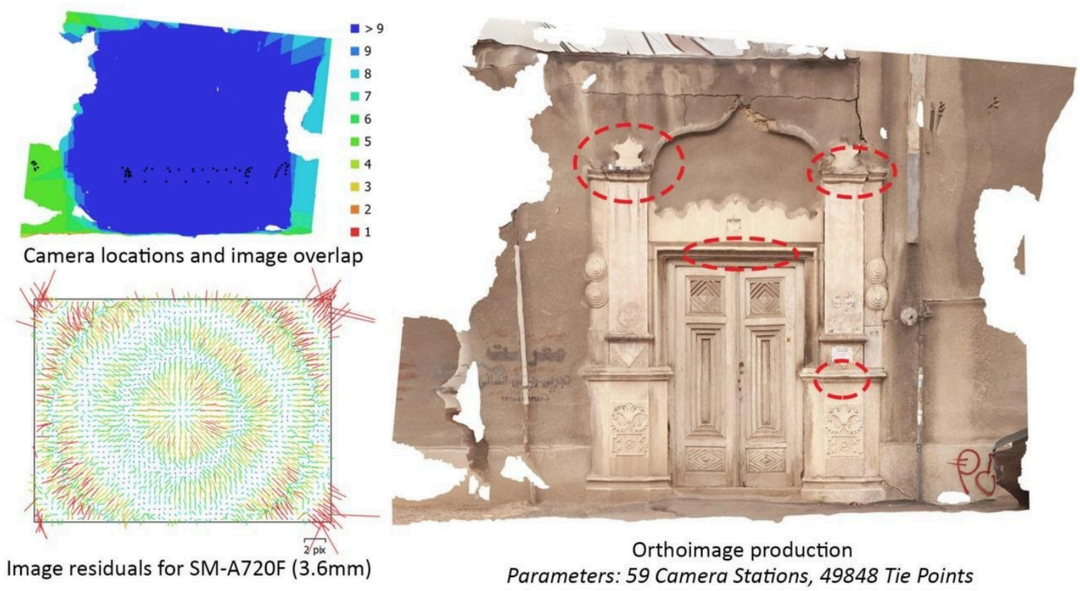

Fig.1. Results of the first capturing scenario (A) in Agisoft Metashape

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B) A stereo pair of images parallel to the building façade: To prevent the above-mentioned errors, in the second scenario, a stereo base (distance between camera positions) alongside the façade was designed so that photos could be captured in parallel without being angled to the façade. In this scenario, only 4 photos alone could cover the whole part of the doorway (Fig. 2). The camera was also vertical in this mode. Although the shooting conditions were more stable, the results showed several distortions in horizontal lines in the upper and lower levels of the scene especially in the bases of the siding pillars.

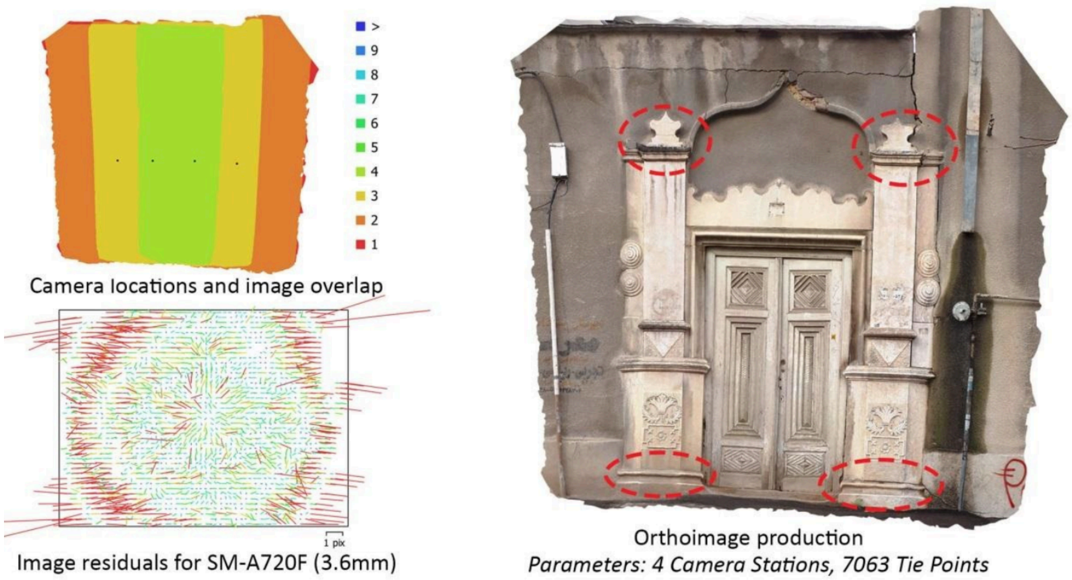

Fig.2. Results of the second capturing scenario (B) in Agisoft Metashape

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C) A stereo multi-image photography in three heights parallel to the building façade: The last scenario consists of 29 photos captured in three levels. Like the previous two scenarios, mobile took photos vertically. The camera calibration parameters are as follows. The nominal focal length was 3.6 mm, cx= -19.1056, cy= 49.9561, k1= 0.194348, k2= -0.969528, k3= 0.822283, p1= -0.000658299 and p2= 0.000481491. The photos have been captured sitting and standing. To maintain the camera parallel to the façade, the mobile was raised for levels higher than the eye to avoid oblique photography. The ratio of stereo base to the camera distance to the object was less than 1:4. Trees prevent this ratio to increase. The final orthoimage production showed no previous distortion. It seems that parallel stereo multi-image shooting at different levels is an efficient and accurate solution for architectural mobile photogrammetry. This capturing method has also reduced the number of required photos by about 50% in comparison to a convergent bundle or oblique photography.

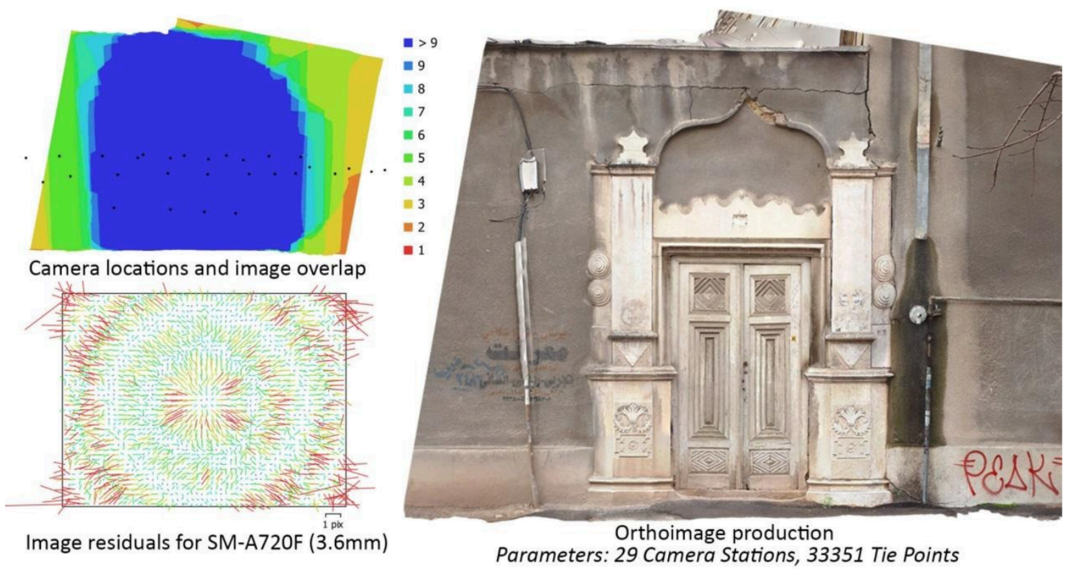

Fig.3. Results of the third capturing scenario (C) in Agisoft Metashape

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This method may also be preferred for architectural photogrammetry as most architectural ornamentations are presented on horizontal or vertical surfaces. Monopods can be used for high-level shootings. Besides, the monopod allows the user to better control the shooting angle and better predict the camera's movement in stereo base. This device could be very useful and practical for photographing decorations, paintings, and ornamentations, especially on the floor and ceiling. The use of a grid in the camera preview screen can be effective in controlling overlaps, and its parallel lines may also be used to ensure that the camera is as parallel as possible according to the object geometry.

To ensure the precision of the orthoimage production through the 3D model, the dimensions of the stone door frame and the width of the stone base ornaments have been measured by a laser distance meter device. The final dimensions extracted from the orthoimage are shown in Figure 4. Comparing these dimensions with the actual dimensions shows only a difference of about 2 mm. Therefore, the capturing method in the third scenario has not only been accurate but also has very high and acceptable precision. This 3D model contains much information for further documentation such as the wooden details, the structure of the gate, and the pathology of its structure. This data can also be used in further conservation and restoration planning.

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Fig.4. Drawing on the final metric orthoimage in AutoCAD

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Conclusion

Mobile (smart-phone) photogrammetry is an inexpensive, affordable, effective, and public tool in documenting architectural heritages, especially details and interior decorations. At least the results of this study show that mobile photogrammetry has not only accuracy but also has acceptable precision of about 2 mm. To achieve reliable results in documenting architectural monuments, the following should be considered:

A) Before Capturing:

- Make sure the mobile camera lens is clean.

- It is recommended to turn off the mobile camera automatic capturing and use program mood instead.

- Make sure of the exposure quality by adjusting the ISO value and etc.

- Do not forget to control the brightness of your mobile screen so that you do not take blurry or bright photos.

B) During Capturing:

- First of all, determine the direction of your movement for planning the best stereo base.

- Depending on the geometry of the object, choose a suitable camera distance for shooting stations.

- Take as many photos as you can parallel to the object. If this is not possible at all, move away from the object. Otherwise, shoot with the minimum camera deflection.

- Do not forget the monopod as a useful device for parallel photography. Act like a scanner.

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