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THE EFFECT OF VARIES CAMERA CALIBRATION FIELDS ON CAMERA PARAMETERS

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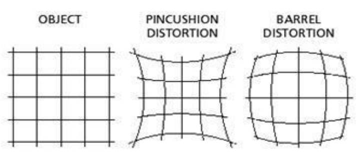
Graphical abstract



Abstract

All photogrammetric applications need good camera parameters for mapping purpose, such as an Unmanned Aerial Vehicle (UAV) that encompassed with camera devices. Simple camera calibration is commonly used in many experiments in order to obtain the camera parameter's value. In aerial mapping, interior camera parameters value of close-range camera calibration is used to correct the image error. However, the changes of the interior calibration parameters used need to be considered at different heights of mapping. Therefore, this research aims to contribute by analyzing of camera parameters' changes from three heights using calibration field, and one camera calibration in the laboratory as commonly used. Camera distance heights of 15 metre, 25 metre, 55 metre, and 1.4 metre camera distance in the laboratory. The results show the changes in camera parameter's value. Hence, value of camera calibration parameters of a camera is considered different and can change depend on the distance (height) of calibration.

Keywords: Camera parameter, camera calibration, calibration field

Abstrak

Kebanyakan aplikasi fotogrametri memerlukan parameter kamera yang terbaik bagi tujuan pemetaan, seperti pesawat tanpa pemandu yang dilengkapi dengan alat kamera. Kalibrasi kamera yang ringkas kebiasaannya digunakan dalam kebanyakan eksperimen untuk memperolehi nilai parameter kamera. Di dalam pemetaan udara, nilai parameter dalaman kamera daripada kalibrasi kamera jarak dekat digunakan untuk membetulkan kesalahan pada imej. Walaubagaimanapun, perubahan nilai parameter dalaman kalibrasi yang digunakan perlu dipertimbangkan pada ketinggian pemetaan yang berbeza. Justeru, fokus kajian ini melibatkan analisa perubahan parameter kamera daripada tiga ketinggian menggunakan padang kalibrasi dan satu kalibrasi kamera di dalam makmal sebagaimana kebiasaan dilakukan. Ketinggian jarak kamera adalah 15 meter, 25 meter, 55 meter dan 1.4 meter jarak kamera di dalam makmal. Hasil kajian menunjukkan berlaku perubahan pada nilai kalibrasi kamera. Oleh itu, nilai parameter kalibrasi pada kamera adalah berbeza dan boleh berubah bergantung kepada jarak (ketinggian) kalibrasi.

Kata kunci: Parameter kamera, kalibrasi kamera, padang kalibrasi

1.0 INTRODUCTION

Camera calibration is the first step in many machine visions and photogrammetric applications involved [1]. Lens distortion is the major factors of the camera calibration [2]. Accurate camera calibration procedures are a necessary requirement for the extraction of accurate and reliable three-dimensional (3D) metric information from the image [3]. Digital cameras currently used in UAV mapping and receiving great interest from the aerial surveying communities due to the low cost equipment [4]. Unfortunately, most of digital cameras uses in civilians UAV are non-metric devices. Therefore, if they are to be used in precision mapping applications, it is crucial that they are repeatedly calibrated to assess current interior orientation parameters [5]. A lot of techniques and some studies concerning calibration have been presented in recent decades [6]. There are an extensive body of literatures on the calibration of digital cameras such as [7, 8] to general investigations [9, 10, 11], low- cost digital cameras [12, 13, 14], behavior of Interior Orientation parameters [14, 15] and accuracy aspects [16]. In order to recall and reiterate salient and occasionally overlooked principles of camera calibration, camera calibration with 1.4, 15, 25, and 55 metre camera distances need to analyze, and determine the trend of the camera parameter's value change.

2.0 CAMERA CALIBRATION

Camera calibration methods involve the estimation of parameter values that provide the ability to accurately infer information about the real world from a single image [15]. The camera is considered calibrated if the principal distance, principal point offset and lens distortion parameters are determine [3]. Camera calibration methods are divided into traditional calibration and self-calibration methods. The traditional approaches take advantage of a calibration pattern with precisely known structure. The parameters of the camera model are determined by conjugate points in the image space [17,18,19]. The self-calibration method utilizes correspondences between small numbers of points in two or more views of a moving camera [20]. According to (4), there are two types of distortion: [1] radial distortion, which is symmetric from the principle point (pincushion and barrel distortion), and [2] tangential or decentering distortions. Figure 1 below shows types of radial lens distortion.

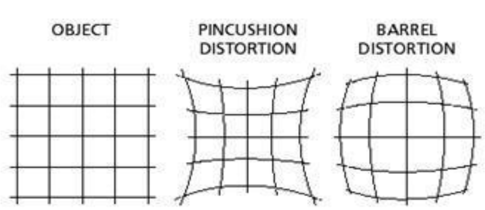


Figure 1 Radial lens distortion

2.1 Calibration Technique

The calibration procedure use in this experiment is slightly different as the other camera calibration procedure used in a number of photogrammetry applications, such as [7,9] and aerial photogrammetry in Unmanned Aerial Vehicle (UAV) application such as [21,22]. The studies used to calibrate the camera using UAV as a camera platform in outdoor space such as those done by [25] and [26].[25] used to calibrate the camera at 50 meter UAV flying height and the calibration method made by [25] at building area. They only tested the calibration at a single camera distance. So, this study was done using long interval camera distance at three camera distance, evaluate the change of camera distance at each camera distances and compare to 1.4 meter camera distance in the laboratory.

2.2 Calibration Fields

The calibration field used in this experiment are 36 black wooden panel targets at each camera distance calibration in the field. The black targets are 400 millimetre × 400 millimetre dimension size and nailed to fix target to the ground with white circular papers. The diameter of white circular paper targets size used are different according to camera distances which are 35 millimetre for 15 metre camera distance, 60 millimetre for 25 metre camera distance, and 130 millimetre for 55 meter camera distance. The sizes of white paper targets are based on 10 pixel size from camera at each camera distances as the detection of the Australis software can detect the target automatically. Black plain wooden panel with white circular targets are digitize using computer software [23], This design of the target is easy to process by using Australis software. The specification of this calibration frame suitable to calibrate in a long distance as done by [24], but it depends on the processing work to point the target. The calibration frames use in this research is different from the normal calibration. The concept of this experiment is to identify the trend of camera parameter's value within various camera distances. So, three types of flat calibration fields are made as show in Figure 2 below.

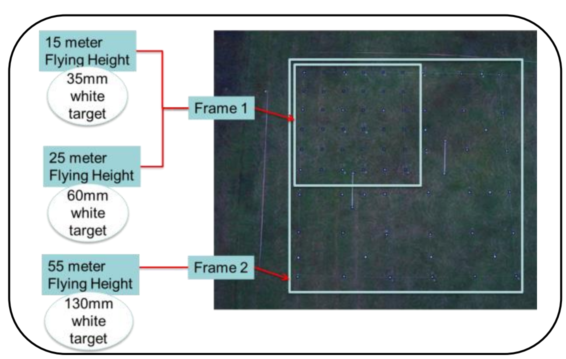


Figure 2 Three flat calibration fields

Three flying height are used to capture the calibration fields. The difference of three flying heights are the dimension size of flat calibration, the size of white circular targets which are 35, 60, 130 millimeter according to UAV camera flying heights and the camera distances at 15, 25, and 55 meter. 36 calibration targets are used at all camera distances. The same camera mode with fix zoom aperture is used at three camera distances.

3.0 DIGITAL CAMERA AND PROCESSING

Digital camera used is Sony NEX 6. The size of a pixel of the camera is 0.004804 millimeter. Camera Sony NEX 6 is a non-metric camera and suitable for UAV mapping purpose. Figure 3 below shows the digital camera used. Figure 4 shows Australis (version 6.01) software that used in this experiment. Australis software is common software used by photogrammetry user and it also can get an accurate measurement and suitable for long range object distances.

Figure 3 Digital camera Sony NEX 6

Figure 4 Australis software logo

The experiment is done at Universiti Teknologi Malaysia (UTM) football field. The wide size area is needed to occupy 36 calibration targets for 30×30 meter and 50×50 meter dimension size. Figure 5 and Figure 6 shows the technique used to represent 15, 25, and 55 meter camera distance calibration on calibration fields using the UAV. The technique is same as close-range calibration technique, but using eight images at a long camera distance.

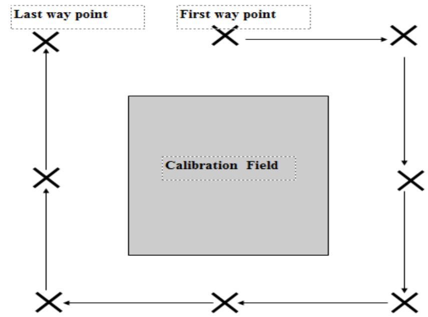


Figure 5 UAV way points

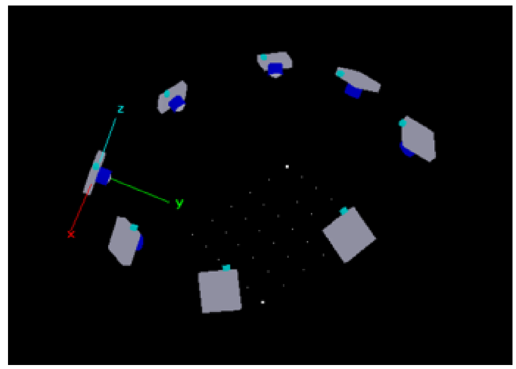


Figure 6 Camera position in Astralis software

The laboratory calibration frame is also used in this experiment using 1.5 × 1 meter of portable calibration frame as shown in Figure 7. The camera and technique of capturing image are same as 15, 25, and 55 metre camera distance calibration. 1.4 metre camera distance calibration is made to compare to UAV platform camera distance calibration at long distances.

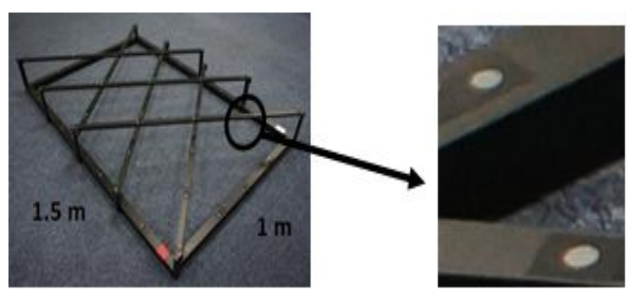


Figure 7 Calibration frame with rectro-target

The target markers used in the portable calibration frame are retro-target point with 10 cm diameter size each of them [Figure 7]. The retro-targets markers are highly reflective target which are specially made for precise automated digitizing using computer software [24]. This kind of target is easy to process by using Australis software that is used in this experiment.

4.0 RESULT AND ANALYSIS

Five observations were set up at each camera distance. There are four camera distances for in this camera calibration including laboratory calibration at 1.4 meter. The white circular target of 35, 60, and 130 millimeter diameter still can be digitized in Australis software processing. It shows that 15, 25, and 55 meter camera distance calibration using the UAV flying platform can be done. One-factor ANOVA (Analysis of Variance) are made through all the camera distances. Table 1 shows the ANOVA statistical test value for all camera parameters for 1.4, 15, 25, and 55 meter camera distance calibration.

Table 1 Calibration ANOVA statistical test values of each parameter over 1.4, 15, 25, and 55 metre camera distances

Parameter	c	xp	yp	k1	k2
Fcalc	2.7	53.02	17.74	344.33	150.81
p-value	0.0806	1.56E-08	2.42E-05	9.71E-15	6.09E-12
Parameter	**k3**	**p1**	**p2**	**b1**	**b2**
Fcalc	34.54	20.1	17.04	14.88	0.65
p-value	3.21E-07	1.12E-05	3.09E-05	0.0001	0.5932

F-critical value used in Table 1 is 3.24 as refer to the t-distribution table. The F-critical value is referred to Numerator degree of freedom which is 3, Denominator degree of freedom which is 16, and total of degree of freedom which is 19. On the other hand, the alpha (a) is 0.05 as it is set by the tester based of 95% confidence level.

H_O: Camera parameters for different camera distance calibration are similar

H_A: Camera parameters for different camera distance calibration are different

Table 1 above showed Fcalc are bigger than F-critical for xp, yp, k1, k2, k3, p1, p2, and b1 (Ho False). While P-value are smaller or same than alpha (a=0.05) for xp, yp, k1, k2, k3, p1, p2, and b1 (Ho was rejected and HA was accepted). It can be said that 1.4, 15, 25, and 55 meter camera distance calibration using camera SONY NEX6 got changed and different camera parameters of xp, yp, k1, k2, k3, p1, p2, and b1. Through the ANOVA statistical analysis, only camera parameter xp, yp, k1, k2, k3, p1, p2, and b1 got changed and different value in five observations for long interval range at 1.4, 15, 25, and 55 meter camera distance calibration. The xp, yp, k1, k2, k3, p1, p2, and b1 camera calibration parameter trends were shown in Figure 8, 9, 10 and 11 below to identify the way of the values changed.

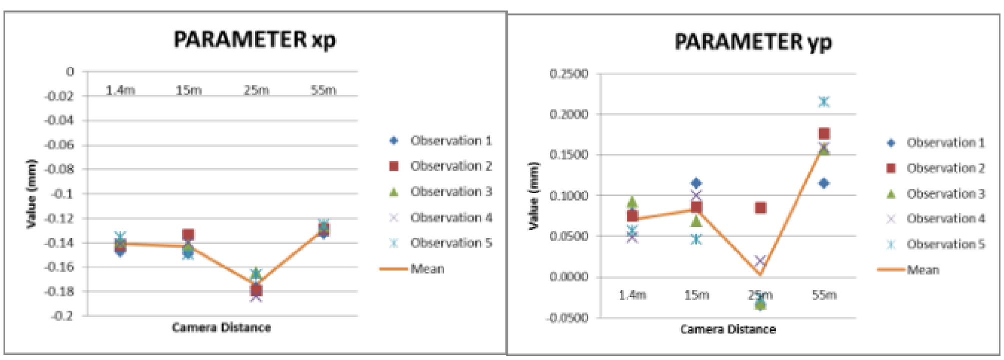


Figure 8 Trends of xp and yp parameters value

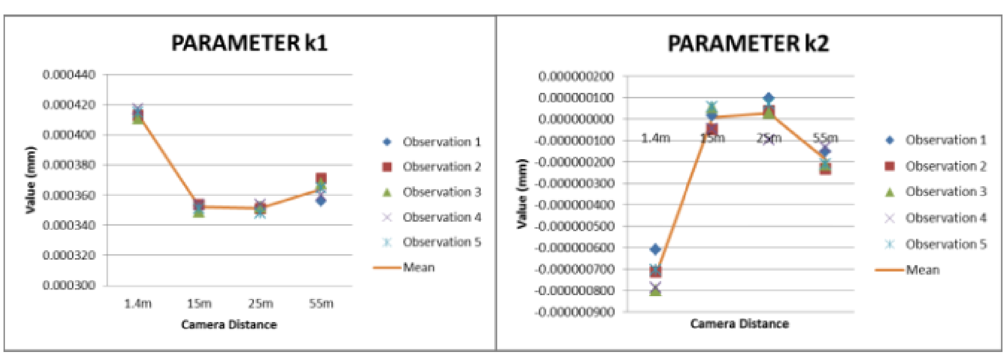


Figure 9 Trends of k1 and k2 parameters value

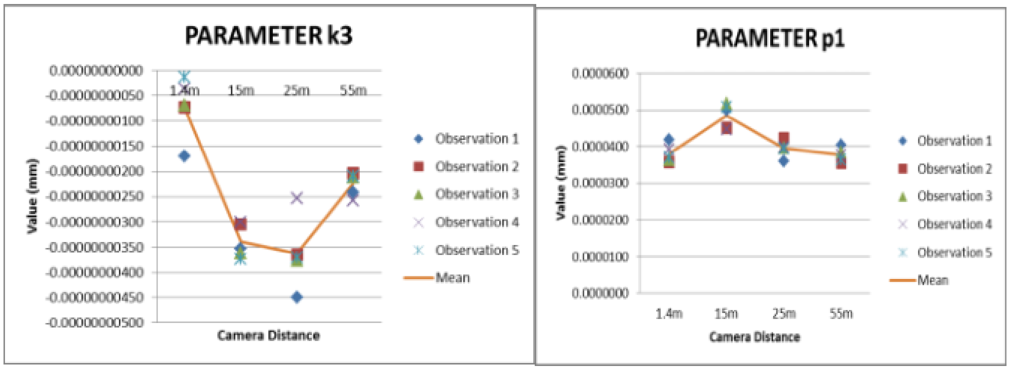


Figure 10 Trends of k3 and p1 parameters value

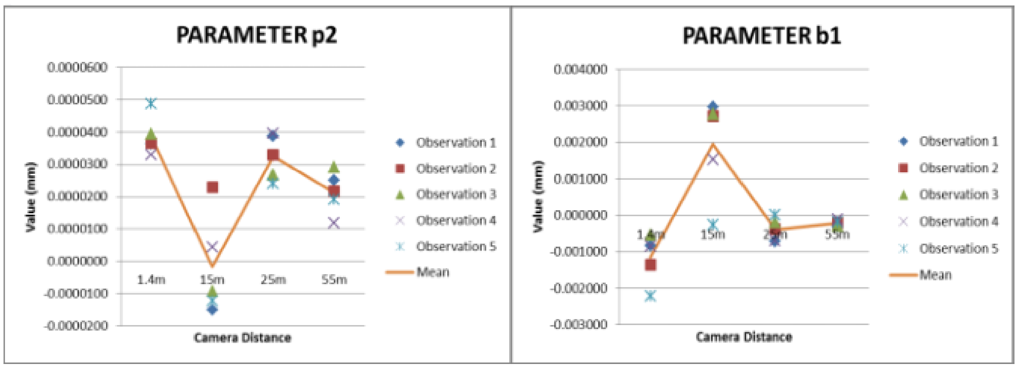


Figure 11 Trends of p2 and b1 parameters value

Figure 8 above shows that the 25 meter camera distance calibration showed the lowest mean value for both parameter xp, and yp. While the other camera distances show increasing mean value across 1.4, 15, and 55 meter camera distance calibration. The camera parameter mean value of xp, and yp got the same trend. Figure 9 showed that the 1.4 meter camera distance calibration showed lowest and highest mean values for both camera parameter k1 and k2. The camera parameter of k1 showed slightly decreasing mean value at 15meter to 25 meter, and increasing mean value at 55 meter camera distance calibration. On the other hand, the camera parameter of k2 showed slightly increasing mean value at 15meter to 25 meter, and decreasing mean value at 55 meter camera distance calibration. Figure 10 above showed that the 1.4 meter camera distance calibration showed highest mean values for camera parameter k3. The camera parameter showed slightly decreasing mean value at 15meter to 25 meter, and increasing value at 55 meter camera distance calibration. The camera parameter mean value of k1, and k3 has the same trend. Figure 10 showed camera parameter p1 mean values tabulated quite same mean value except for 15 meter camera distance calibration. Overall the mean values of five observations from 1.4, 15, 25, and 55 meter camera distance calibration are slightly flat trend even though ANOVA statistical analysis resulting have changed and different camera parameters values. Figure 11 showed that the 15 meter camera distance calibration showed lowest and highest mean values for both camera parameter p2 and b1. The camera parameter of p2 showed slightly decreasing mean value at 1.4 meter to 25 meter, and decreasing mean value at 55 meter camera distance calibration. On the other hand, the camera parameter of b1 showed slightly increasing mean value at 1.4 meter to 25 meter, and increasing mean value at 55 meter camera distance calibration. Across 1.4, 15, 25, and 55 meter camera distance calibration, there have group of parameter got same trend. For instance, parameter xp, yp, k1, and k3 got decrease mean values initially and increase back at the higher camera distance calibration. For parameter k2, and p1, the mean values were increase mean values initially and decrease back at the higher camera distance calibration. Another two parameters like p2 and b1 got change its value at unique trend than others.

5.0 CONCLUSION AND FUTURE STUDY

Through the result and analysis, the camera distance calibration at 15, 25 and 55 meters also work as practiced in laboratory calibration. The study indicates that every camera calibration can be dissembled by the camera distance of the camera captured in calibration field. There are only camera parameters of xp, yp, k1, k2, k3, p1, p2, and b1 got changed and have its own trend of changing within different camera distances. Longer camera distances and many camera distance interval need to study further for more interesting research.

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