STUDY OF CHARACTER OF LENS DISTORTION AND METHOD CORRECTING LENS DISTORTION

Kim Hong Il Email: Kim17103@scientifictext.ru

Kim Hong Il – Master of geography, Lecturer,

DEPARTMENT OF GEODETIC INFORMATIONAL ENGINEERING, FACULTY OF RESOURCE PROBING,

KIM CHAEK UNIVERSITY OF TECHNOLOGY,

PYONGYANG, DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

Abstract: *the lens distortion correction is very important problem in the field of technological engineering processing image obtained by camera. This becomes a more important problem in photogrammetry. All of the photographs obtained by the camera have a distortion of the lens. If we do not correct the distortion, result of photogrammetry is not accuracy. Therefore, Correction of lens distortion is generally the first step to proceed in photogrammetry. There are various methods for correcting the distortion of the lens. There are polynomial methods, advantageous methods, in many methods and All of these methods are correction methods for the general shape of the lens. Therefore, in this paper we have analyzed the lens distortion characteristics in the photogrammetry, and performed the distortion correction by the polynomial method based on this analysis. It has been experimentally confirmed that the correction method proposed in the introduction is superior.*

Keywords: *lens distortion, distortion correct, distortion style, polynomial correction.*

ИССЛЕДОВАНИЕ ХАРАКТЕРА ИСКАЖЕНИЯ ЛИНЗЫ И МЕТОДА КОРРЕКЦИИ ИСКАЖЕНИЯ ЛИНЗЫ

Ким Хон Ир

Ким Хон Ир – кандидат географических наук, преподаватель,

кафедра геодезической информационной техники, факультет зондирования ресурсов,

политехнический университет им. Ким Чака

г. Пхеньян, Корейская Народно-Демократическая Республика

Аннотация: *коррекция искажения линзы является очень важной задачей в области обработки изображений технологической инженерии, полученных камерой. Это становится более важной проблемой фотограмметрии. Все фотографии, полученные камерой, имеют искажение линзы. Если мы не исправим искажения, результат фотограмметрии не будет точным. Поэтому коррекция искажения линзы обычно является первым шагом в фотограмметрии. Существуют различные методы коррекции искажений линзы. Есть полиномиальные методы, предпочтительные методы и все эти методы являются методами коррекции для общей формы линзы. Поэтому в данной статье мы проанализировали характеристики искажения линзы в фотограмметрии и выполнили коррекцию искажений полиномиальным методом, основанным на этом анализе. Экспериментально подтверждено, что предложенный во введении метод коррекции является лучшим.*

Ключевые слова: *искажение линзы, коррекция искажения, форма искажения, коррекция полинома.*

УДК 528.74

Introduction

In general, many camera lenses, especially zoom lenses have clear distortion. Recently, a lot of research projects have been conducted to correct lens distortion.

Harri Ojanen was assumed that many inexpensive camera lenses suffer from very clear distortion and analyzed its forms [3]. He was described that even with such a lens near perfect images can be obtained by using a correction algorithm based on a simple mathematical model and without any special measuring tools.

Enrico Calore was described that Improper camera orientation produces convergent vertical lines (keystone distortion) and skewed horizon lines (horizon distortion) in digital pictures [2]. He was shown here that, after accurate calibration, the camera on-board accelerometer can be used to automatically generate an alternative perspective view from a virtual camera, leading to images with residual keystone and horizon distortions that are essentially imperceptible at visual inspection. And he described the uncertainty on the position of each pixel in the corrected image with respect to the accelerometer noise.

Dapeng Gao was proposed A method for computing a complete camera lens distortion model [4]. With a view of a planar pattern, an iterative procedure was established to estimate the ideal homography under radial, tangential and prism distortions, by specially selected parameters of both radial and tangential distortions. The ideal image points which represent the correct positions of distorted image points can be computed with the approximate ideal homography.

Carlos Ricolfe-Viala [5] was suggested the method of lens distortion correction to correct without model. This method was more sensitive to local deformations and allows the image to be corrected in accordance with its distortion.

Yucel Altunbasak was assumed methods for estimating motion in video sequences that are based on the optical flow equation (OFE) were that the scene illumination is uniform and that the imaging optics are ideal. This paper extended the models upon which the OFE methods are based to include irregular, time-varying illumination models and models for imperfect optics that introduce vignetting, gamma, and geometric warping, such as are likely to be found with inexpensive PC cameras. It was described that the resulting optimization framework estimates the motion parameters, illumination parameters, and camera parameters simultaneously and in some cases these models can lead to nonlinear equations which must be solved iteratively.

The lens distortion correction methods such as the lens distortion non-metric method and the self-calibration method are all generally performed considering the general characteristics of the lens. In other words, correction was carried out assuming that the barrel distortion or pincushion one of the lens are uniformly distorted from the center of the lens. However, the photographs obtained by the digital camera do not change in agreement. From this point of view, it is assumed that the lens distortion does not change uniformly, and the distortion correction method is described.

1. Lens distortion form and Characteristic analysis

In general, the lens distortion is largely divided into barrel distortion and pincushion distortion [Fig. 1]. If the general distortion correction is performed without considering the structural characteristics of the camera, the distortion of the shape shown in Fig. 1 can be corrected.

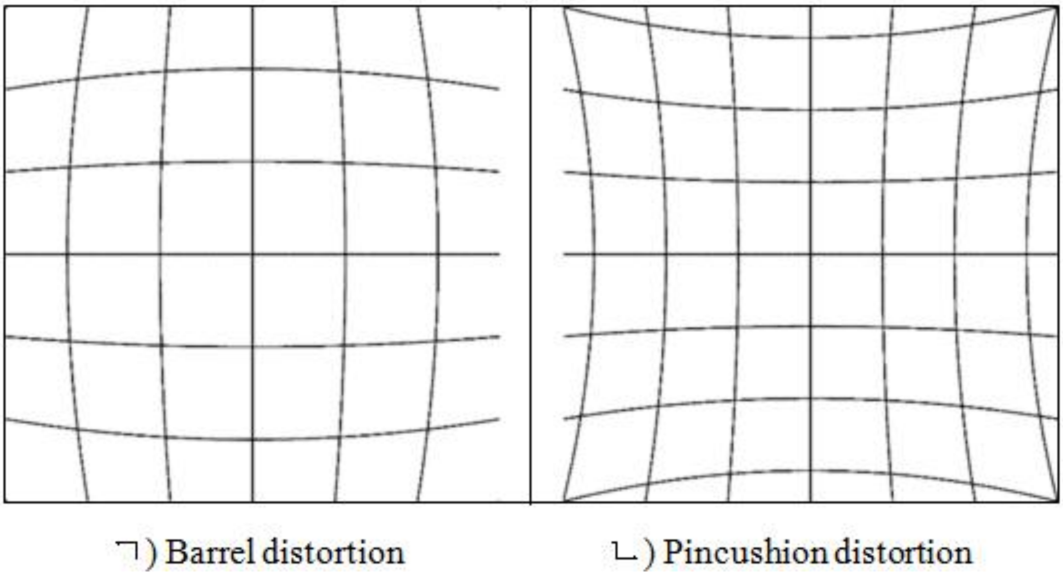

Fig. 1. Lens distortion

In this paper, we assumed tha t the lens distortion does not occur uniformly from the center of the photograph, and have analyzed the characteristics of the photograph. For this purpose, the center of the lens is centered on the origin and the quadrant is set as shown in Fig. 2.

A quadrilateral network with a spacing of 2 Cm was installed for the distortion characteristic. The picture of the quadrilateral net is shown in Fig. 3.

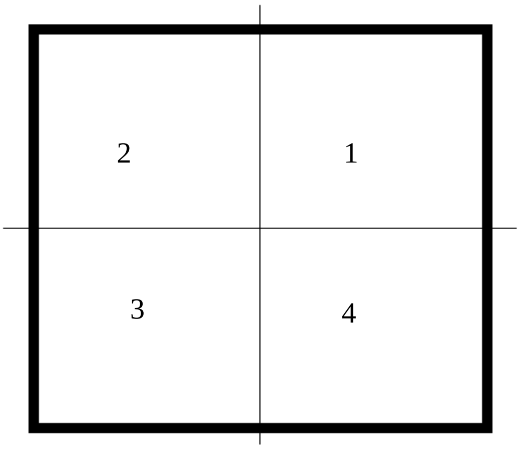

Fig. 2. Quadrant set in photograph

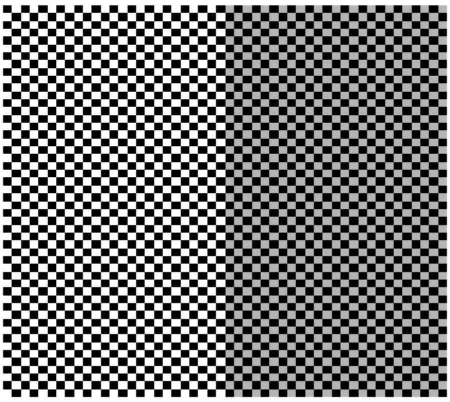

Fig. 3. Checkerboard

The photographs taken for the quadrilateral net are as follows(Fig. 4).

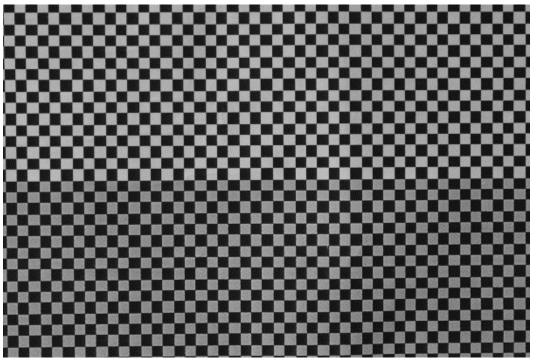

Fig. 4. Image of distortion

Figure 5 shows the distortion curve for the feature points.

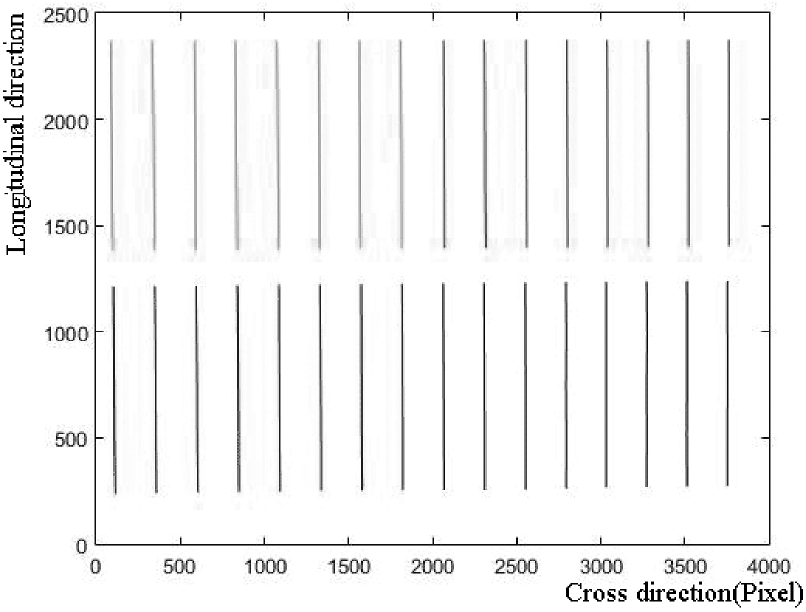

Fig. 5. Distortion curve for the feature points

Figure 6 shows the characteristic of lens radius.

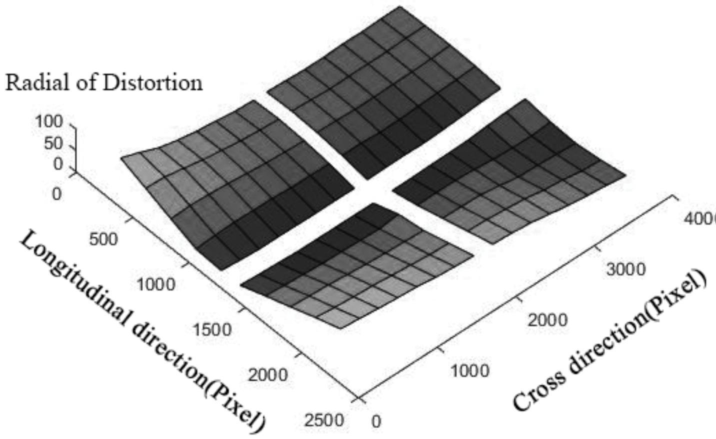

Fig. 6. Characteristic of lens distortion radius

2. Method of lens distortion correction

As can be seen in Figures 5 and 6, the photographs taken by the camera have some lens distortion and the distortion is different for each quadrant.

The distortion is greater in the second and fourth quadrants than in the first and second quadrants, moving away from the center of the lens.

Therefore, calibration should be done differently for each quadrant.

In general, the lens distortion correction is performed by a polynomial method.

If the distortion correction value is Δu, Δv, the relationship between the distortion value and the actual value is as follows.

$$\begin{cases} u = u' + \Delta u \\ v = v' + \Delta v \end{cases} \qquad (1)$$

Where u', v' – distortion value in photograph(Pixel)

u, v – actual value in photograph(Pixel)

Distortion correction value is as follows.

$$\begin{cases} \Delta u = q_u(k_1 r_d^2 + k_2 r_d^4 + \cdots) + p_1(q_u^2 + q_v^2) + 2p_2 q_u q_v + s_1 r_d^2 \\ \Delta v = q_v(k_1 r_d^2 + k_2 r_d^4 + \cdots) + p_2(q_u^2 + q_v^2) + 2p_1 q_u q_v + s_2 r_d^2 \end{cases} \qquad (2)$$

Where $q_u = u' - u_0,\ q_v = v' - v_0,\ r_d^2 = q_u^2 + q_v^2$

$o = (u_0, \quad v_0)$ – coordinate of central point in photograph

k_1, k_2, k_3 – modelling coefficient of radial distortion

p_1, p_2, p_3 – modelling coefficient of line distortion

s_1, s_2, s_3 – modelling coefficient of prism distortion

3. Analysis of experimental results

Using the equations (1) and (2), we determined coefficient of distortion correction according to the quadrants and corrected the distortion by using the coefficient of distortion correction.

The distortion correction coefficients according to the quadrants is as follows (Table 1).

Table 1. Distortion correction factor

Quadrant	k_1	k_2	p_1	p_2	s_1	s_2
1	8.617×10^{-10}	4.747×10^{-16}	2.017×10^{-6}	8.912×10^{-7}	-6.904×10^{-6}	4.142×10^{-6}
2	1.337×10^{-9}	-1.254×10^{-16}	-3.863×10^{-6}	-2.834×10^{-6}	-5.434×10^{-6}	4.517×10^{-6}
3	-1.018×10^{-8}	1.133×10^{-15}	5.077×10^{-6}	2.897×10^{-6}	8.367×10^{-6}	4.870×10^{-6}
4	-8.197×10^{-9}	1.013×10^{-15}	1.443×10^{-6}	3.379×10^{-7}	2.802×10^{-6}	-4.514×10^{-6}

The distortion correction coefficients for the whole image are as follows (Table 2).

Table 2. Correction of distortion for Whole images

k_1	k_2	p_1	p_2	s_1	s_2
-1.504×10-9	2.349×10-16	-1.596×10-6	-1.579×10-6	-3.368×10-6	5.085×10-7

The least square error for the distortion correction is as follows (Table 3).

Table 3. Least square error for distortion correction

First quadrant (Pixel)	Second quadrant (Pixel)	Third quadrant (Pixel)	Forth quadrant (Pixel)	Whole image (Pixel)
18.389	28.249	22.969	27.673	42.943

As shown in Table 3, the least square error for the distortion correction is smaller in the first and third quadrant than second and forth, and the distortion correction for the quadrants is much smaller than the distortion correction for the whole image.

Conclusions

In the paper, we have analyzed the lens distortion characteristics of a digital camera and proposed a method to improve the accuracy of the distortion correction and verified its effectiveness. It has been experimentally confirmed in the introduction that the distortion correcting method according to the quadrants is superior to the general distortion correcting method for the entire image.

References / Список литературы

1. *Altunbasak Yucel*. A Fast Parametric Motion Estimation Algorithm With Illumination and Lens Distortion Correction, IEEE TRANSACTIONS ON IMAGE PROCESSING. Vol. 12. № 4, APRIL 2003.
2. *Calore Enrico, Frosio Iuri* Accelerometer-based correction of skewed horizon and keystone distortion in digital photography. Image and Vision Computing. 32 (2014). 606–615.
3. *Ojanen Harri* Automatic Correction of Lens Distortion by Using Digital Image Processing, July 10, 1999.
4. *Dapeng Gao*, Computing a complete camera lens distortion model by planar homography. Optics & Laser Technology 49 (2013) 95–107.
5. *Ricolfe-Viala Carlos*. Correcting non-linear lens distortion in cameras without using a model. Optics & Laser Technology. 42 (2010). 628–639.