Applicability research of smart camera for the application of Unmanned Aerial Vehicle(UAV)

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ABSTRACT

As the commonly used low-end digital cameras are not made for measurement, we need to know accurate inside orientation elements in order to perform three-dimensional measurement using them. To this end, we must go through camera calibration(Jaehong Oh, etc,. 2006).
However, The rapid development of digital camera technology made it possible for non-metric digital camera sensors to reach tens of millions pixels. With this opportunity, we began to easily acquire images with non-metric digital cameras and use digital cameras for a variety of purposes in the field of photogrammetry that was carried out only with metric cameras.
This research deals with applicability of smart camera for the Unmanned Aerial Vehicle(UAV) application.

KEYWORDS: Camera calibration, UAV, Distortion

INTRODUCTION

A smart camera is having a dedicated processor and a lot of sensor(GPS, Accelerometer, 3Axis-magnetic, light, gyroscope, gravity, rotation, etc) in each unit. and, it can collect lens distortion and image stabilization, etc.
The existing camera was not able to perform prompt image processing without having dedicated processor. In addition, as the high-resolution digital image got accessible, the technology of digital camera ranging from computer vision to such specialized area as digital photogrammetry has been applied in many ways. (Hwan-hee Yoo etc, 2003). When it comes to digital photogrammetry, in particular the frequency of high-resolution non-metric camera usage has constantly increased (Jeong Su etc, 2005). However, most commercial digital camera is not designed for digital photogrammetry, what is important is when using it for measurement, is the lens Calibration. (Seong-su Jeong etc, 2008). Camera calibration is required in order that lens Calibration.

Nowaday, various smart camera is developed and on sale, automatic lens distortion is equipped with the smart camera. Especially the camera in existence had only camera firmware, in the case of Samsung NX smart camera, set to offer different information according to each lens through lens firmware and the 16mm lens set to provide revised image. The research is to evaluate the recently issued camera that provides high-resolution image among different sensors built in smart camera to suggest applicability of the smart camera image on photogrammetry. samsung NX smart camera was used and the operation with TLS and GPS were performed for the evaluation. Before that, Camera calibration were proceeded by priority for lens calibration, and in this process, calculation result according to correction factor of lens distortion were compared and analyzed to evaluate relative accuracy of smart camera. Also, UAV with a built-in smart camera raised the quality of secured date by manufacturing dust-proof to minimize vibration transferred from UAV for accurate image obtention.

The purpose of the thesis is to evaluate applicability of the image by UAV with a built-in smart camera to examine generation of DEM according to the correction of camera distortion. A pair of the secured image goes through triangulation process for geometric correction. This process is dividedly proceeded with the case of concerning camera calibration date, and the case without concerning. Accuracy evaluation on each case is also undertaken. At this time differences in the result according to camera calibration data, and orthoimage is created through orthometric correction process utilizing DEM by TLS technique, and its accuracy is estimated by check point. It is also evaluated by comparing between TLS and DEM.

Method (Experimental configuration)

Before equipping with UAV, the distortion correction process by smart camera is as follow. First, evaluate correction factor of smart camera's lens distortion through camera calibration, and then, image is secured through UAV by smart camera, the image provided in such way is triangulated by the precise Ground Control Points(GCPs) according to distortion correction, each 6 exterior orientation parameters(X_0 , Y_0, Z_0, ω, ϕ, κ) of each camera is also determined. Accuracy evaluation is performed through various analysis and the secured image. At the and, the triangulated images turn into orthoimage going through orthometric correction. The orthoimage is expressed the coordinate of actual object.

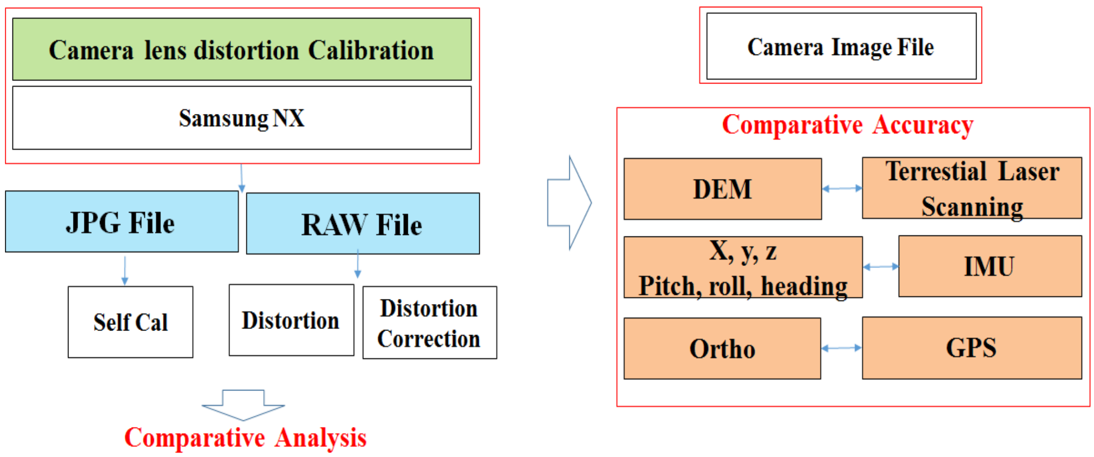

Figure 1. Flow Chart

The UAV function used in the research is same as Table 1.

Category	Specification
Model	X8+
UAV	Multicopter
Autopilot	Pixhawk v2.4.5 / ArduCopter 3.2
GPS	3DR u-blox GPS with Compass
Ground Station Radio	3DR Data Radio (433 MHz)
Motors	SunnySKY V2216-12 KV800Ⅱ
Propellers	8 (APC Propelleer 11X4.7 SF(4), SFP(4))
Size and weight	Size: 35cm X 51cm X 20cm, Weight: 2.56kg
Flight time	12 ~ 15 minute
Take off/landing	auto / manual
Payload	800g

Table 1. Specification of UAV

A dustproof device was manufactured to prevent jello effect and wobbling effect caused by high frequency vibration when smart camera is equipped with UAV (Figure 2). Dustproof device was used in the research. Flight times (within 10 minutes), flying speeds(4m/s,) and flight altitude(25m) are also set.

Figure 2. A dustproof device designed in order to reduce high frequency vibration from UAV(X-8 Copter)

Field experiment was proceeded in the schoolyard of Pukyong National University located to Busan Metropolitan City, in the southeast (Figure 3).

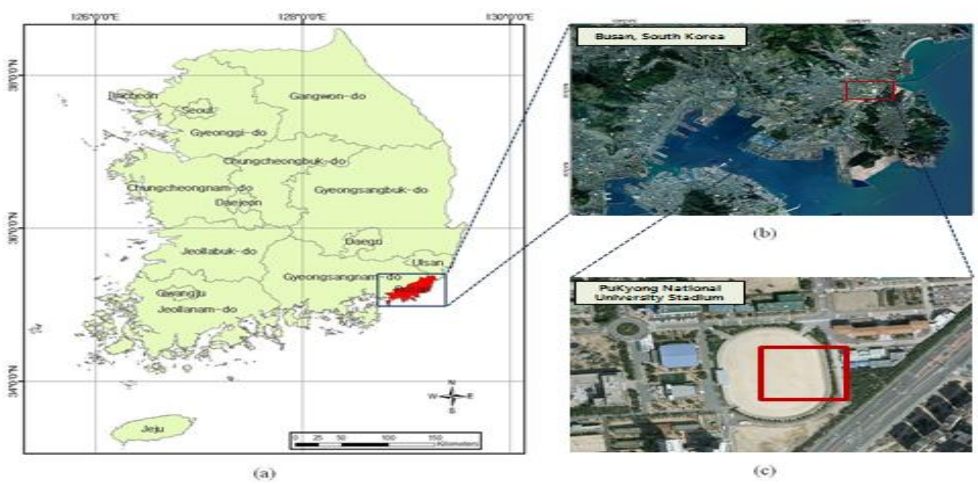

Figure 3. Field Experiment Area

UAV(X8+), Smart camera (Samsung NX), GPS receiver 3D laser scanner were used. Figure 4. shows the arrangement of equipment for the research and flight path

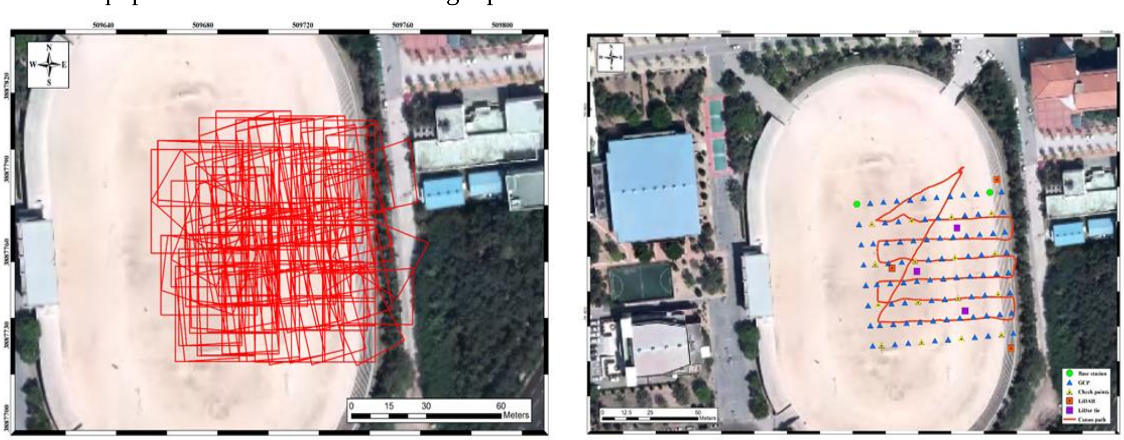

Figure 4. Flight path and Equipment point

RESULTS

Camera Calibration

Different camera models have been formulated and used in photogrammetry, but generally sensor orientation and calibration is performed with a perspective geometrical model by means of the bundle adjustment(Brown, 1971).
The camera used in this research was Samsung NX Camera which showed less lens distortion on the image by self-correction according to the result of camera calibration. And the image through camera calibration, lens distortion similar to the self-corrected image was found when correcting not the already-corrected image(jpg) in securing, but an original file(raw), however it was also known that without any correction, there was also as many as 20 times of lens distortion (Figure. 5)

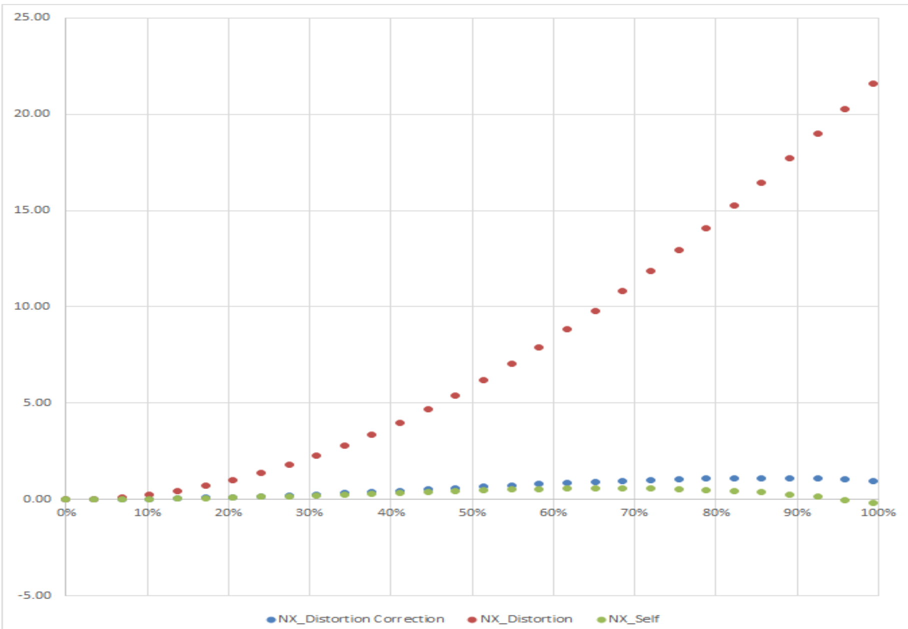

Figure 5. Radial Lens Distortion

Comparative Accuracy

ϕ, θ, ψ estimated directly through result of accelerometer and magnetometer built in UAV or provided by gyroscope in smart camera were compared to ω, ϕ, κ(rotation element of each image) estimated in the triangulation process with ERDAS Imagine Photogrammetry project manager. ω, ϕ, κ had different reference coordinate from ϕ, θ, ψ to compare both element ω, ϕ, κ transformed into θ, ϕ, ψ (Bäumker and Heimes, 2001).

As a result, roll and pitch angle's Stdev upon Sensor revealed within about 2.5, heading angle's Stdev was found over 5 deg. Roll and pitch angle's Stdev on the Sensor in UAV was within 2 deg, heading angle's stdev was within about 1 deg In other words, sensor in Smart Camera is less accurate than Sensor in UAV. In addition, in DTM case, with image block, using each image and TLS DTM, utilized every area involved in each orthoimage that is finally made, and created both image-based DTM (0.2m grid) and TLS DTM in the different representative and flat area. The orthoimage regarding this area and image-based DTM created by automatic terrain extraction is the same as Figure 6.

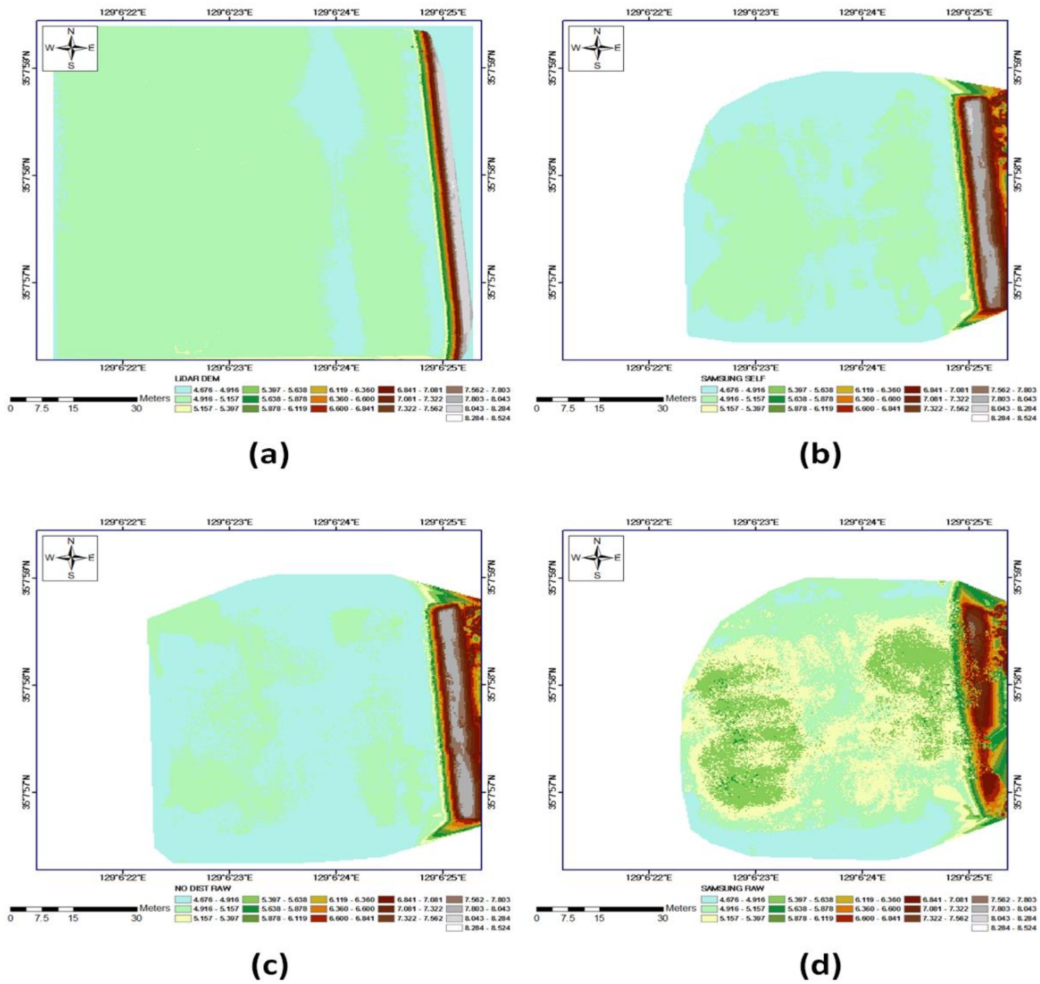

Figure 6 (a) TLS DTM, (b) Camera Self, (c) Camera Raw Distortion correction (d) Camera Raw defult

And also, compared the differences between TLS DTM about the same area above and image-based DTM (Table 2).

Unit : m		Samsung NX		
		JPG5)	Raw6)	
		Self2)	No Dist3)	Raw4)
DTM Staticstic	Min	4.721	4.730	4.630
	Max	5.046	5.037	5.791
	Mean	4.927	4.901	5.264
	Stdev	0.038	0.033	0.164
Residual by TLS1) Staticstic	Min	-0.158	-0.126	-0.895
	Max	0.177	0.162	0.296
	Mean	**-0.021**	**0.006**	**-0.357**
	Median	-0.022	0.003	-0.350
	Mode	-0.019	-0.004	-0.327
	Stdev	**0.038**	**0.032**	**0.165**

Table 2. Extraction DTM and Difference each DTM and TLS DTM Statics

1 : Terestrial lidar system
2： Manufacture IO for self corrected lens distortion on Smartcamera
3 : Calibrated IO for Smartcamera Raw file
4 : Manufacture IO for Smartcamera Raw file
5 : Samsung defalut setting
6 : Samsung Raw file only remove chromatic and vignette by adobe lens creator

DISCUSSION

This research was proceeded based on the certain camera(Samsung NX) among smart camera which is expected to have difficulty in application for all sort of the camera. However it is also indicated to secure corrected image with ease through self-correction equipped with the camera as technology improved in contrast with the existing non-metric camera required calibration process to have space information.

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