A GROUND REFERENCE TARGET DETECTION METHOD FOR AUTOMATIC VICARIOUS CALIBRATION OF UAV MULTISPECTRAL IMAGE

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KEY WORDS: Vicarious calibration, UAV image, Spectral reflectance, Target detection

ABSTRACT: Recently, demands of unmanned aerial vehicle (UAV) image has increased in various fields, and sensor technology are rapidly developing. Radiometric correction is needed to transform from pixel's digital number (DN) to spectral reflectance when using spectral information in an application. To obtain spectral reflectance, some sensors for UAVs measure a reference target before taking-off, and measure the irradiance during image acquisition. For sensors without the irradiance, spectral reflectance can be obtained by vicarious radiometric calibration with scenes including ground reference target. Currently, for vicarious calibration, the commercial software is designed to manually specify the area of the ground reference target in the scene. In this study, we propose an automatic method to detect a ground reference target in a scene for vicarious calibration of multispectral UAV image without radiometric calibration parameters. All of reference targets were detected in the experiment condition. Further study is needed to decrease false alarm with similar spectral and morphological characteristics.

1. INTRODUCTION

Various application fields are using UAV images through enhanced aircraft and sensors. Users can acquire imagery at desired area and time without effects of cloud. Accurate preprocessing is essential for quality of data on applications (Rhee and Kim, 2015). Commercial software has been developed for acquiring 3D spatial information such as ortho image and DSM using UAV images.

Recently, multispectral or hyperspectral imaging sensors are used to acquire spectral information of targets in various application fields such sensors can be installed on the UAV with compact size (Mathews, 2015). The radiometric correction is very important preprocessing procedure to get accurate spectral information from images (Tu et al., 2018). Most of commercial software are using a vicarious correction method to get spectral reflectance from digital number (DN) of UAV images. DN is transformed to radiance using pre-measured coefficients. Then radiance is converted to reflectance using reference ground targets (Iqbal et al., 2018). To get accurate spectral reflectance, some sensors measure the irradiance during image acquisition because solar irradiance changes by atmosphere during the flight. However, most of cameras do not provide accurate radiometric correction coefficients and irradiance. Thus, they have limitations in obtaining accurate reflectance images. Therefore, a radiometric correction method is needed to obtain reflectance images from general UAV images even though some commercial software support radiometric correction for certain multispectral sensors.

The vicarious radiometric correction method is used for acquiring reflectance images which do not provide radiometric correction coefficients and a reflectance conversion method. It is also known as the empirical line, which derives the DN to reflectance conversion coefficient through linear regression analysis between DN and reflectance for each band (Wang and Myint, 2015). The spectral reflectance can be acquired from ground reference targets which have pre-measured reflectance values in most case. The user must manually define the location of the pixels corresponding to the reference targets from images. Therefore, this procedure needs to be improved in terms of accuracy and efficiency of image processing.

In this study, we suggest an automated method of detecting ground reference targets to improve the accuracy and efficiency of the reflectance image acquisition process from UAV multispectral images. The sets of reference tarp were installed on the ground and UAV image was acquired. In order to detect the reference tarp in images, we used two parameters explaining spectral variation and morphology.

2. DATA AND METHODS

2.1 Data Acquisition

The reference targets were installed on the grass which is a soccer field in Jeonju city, Korea (Figure 1). The reference targets were specially dyed tarps those have reflectance of 3%, 5%, 11%, 22%, 33%, 44% and 55% within 400 nm to 1000 nm wavelength region. The size of tarps is 1.2 m for each. Figure 2 shows spectral reflectance curves of each tarp which were measured with a FieldSpec-3 spectro-radiometer, ASD Inc., USA.

Figure 1. The reference targets with 3%, 5%, 11%, 22%, 33%, 44% and 55%.

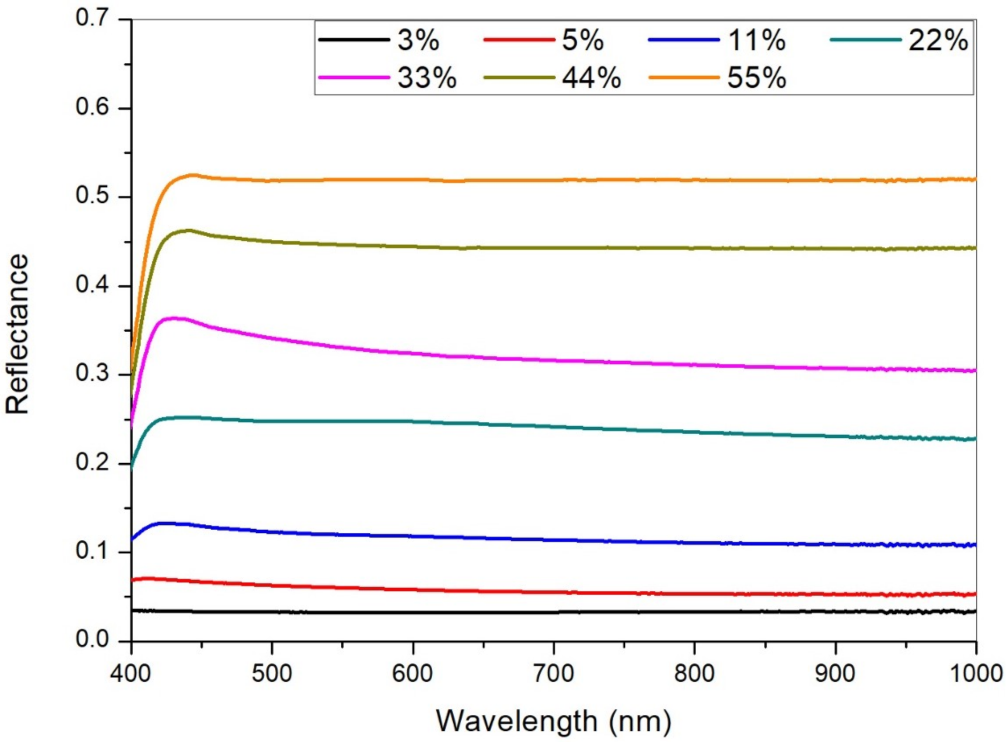


Figure 2. Spectral reflectance curves of the reference targets.

The A5100 camera, SONY was used to get a multispectral image which was installed on a quad-copter UAV. The camera has 3 bands (RGB), 8 bits radiometric resolution, 6000 by 4000 pixels and 20 mm focal length. The image was acquired at 100 m altitude with 2 cm spatial resolution on 5 July 2018 (Figure 3).

Figure 3. A multispectral image acquired using A5100 camera on a quad-copter at 100 m altitude.

2.2 Target Detection Methods

The method was composed with 4 steps to detect the reference targets (Figure 4). In the first homogeneity was calculated using coefficient of variance within moving window which had size with half of reference targets. The reference targets have high homogeneity than natural targets. The coefficient of variance is defined as ratio of standard deviation to mean where we defined under 0.2 as a threshold to extract candidates of targets. The second step was extraction of objects using the Canny filter as a high-pass filter which was used to extract edge of objects with similar and high homogeneity. The third was measurement of area and shape. The reference targets have specified size and shape that we used square targets with 1.2 m by 1.2 m size. Candidates of the targets could be narrow down using area and shape from objects with high homogeneity. The last step was measurement of DN variation among bands to extract target finally. The reference targets have similar reflectance through VNIR region that reference targets could be selected from other candidates.

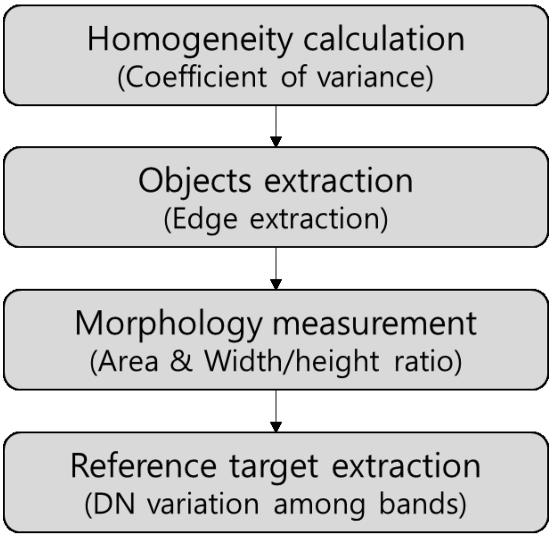
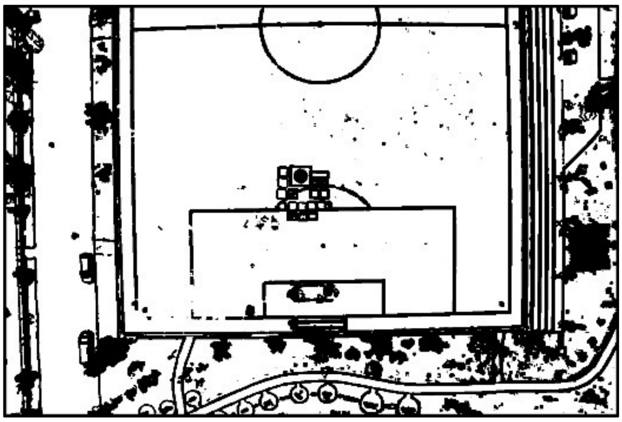


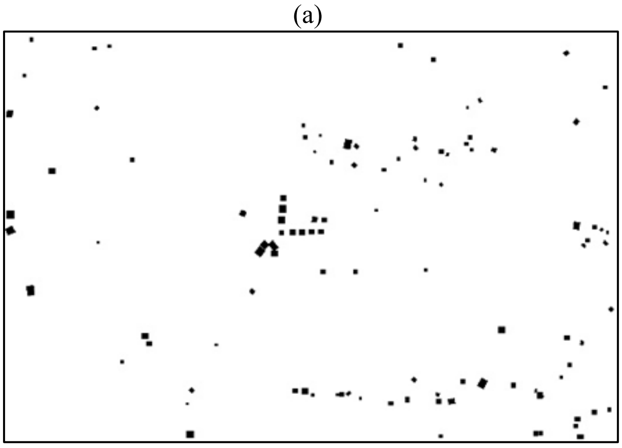
Figure 4. A processing procedure for reference target detection.

3. RESULTS AND DISCUSSION

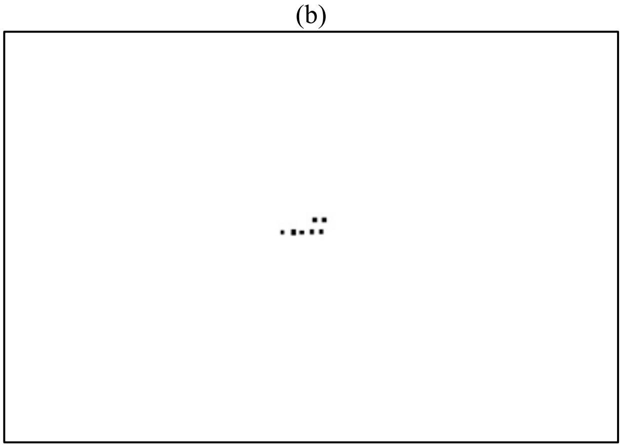
The reference targets were detected through the procedure. Figure 5 (a) shows extracted objects using homogeneity. Most region of image was extracted to objects because imaging area was composed with homogeneous materials such as grass, blocks and concrete. Figure 5 (b) shows candidates of reference targets those were extracted using morphological parameters (area and shape) from the objects. Many of them includes false alarms with similar area and shape with the reference targets. An additional parameter was needed to decrease false alarm. Figure 5 (c) shows extracted reference targets using DN variation among bands from the candidates. The reference targets have specific reflectance for each band, is a good indicator to detect target. However, other artificial materials also have smoothly changed reflectance among different bands such as asphalt and concrete. We used homogeneity and morphology to filter out artificial features except the reference targets. Figure 6 is an overlay of detected targets and the image as final result of the procedure. Detected targets are smaller than actual size of reference targets because there are blurring effects at near of edge.



(a)



(b)



(c)

Figure 5. Extracted candidates through the suggested reference target detection procedure. (a) extracted objects with high homogeneity, (b) extracted candidates using area and shape (reverse color), (c) detected reference targets using DN variation among bands (reverse color).

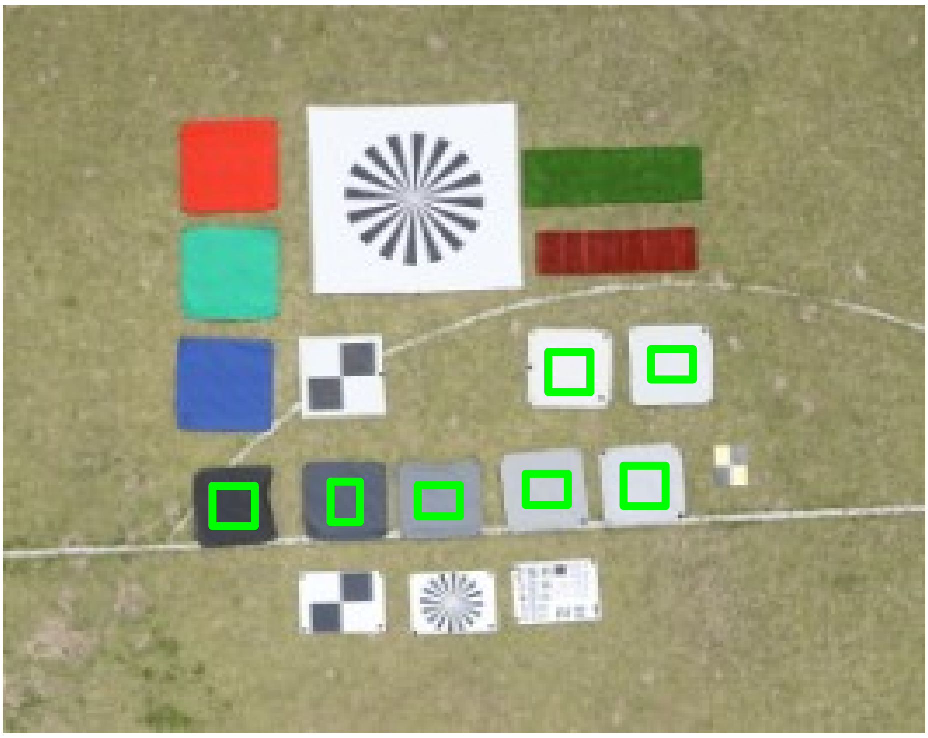


Figure 6. Detected targets on the image used.

False alarms were remained in the target detection result (Figure 7). We tried to remove false alarms using spectral characteristics and morphology. However, some targets do not distinguish using proposed method because they have high homogeneity, constant DN and similar morphology with reference targets. Therefore, further study is needed to decrease remaining false alarms. The take off location might be a term for false alarm removal with an assumption that reference targets are generally installed near take off location.

Figure 7. Remaining false alarms in the target detection result those have similar spectral characteristics and morphology with reference targets.

4. CONCLUSION

In this study, we suggested an automated method to detect reference targets in the UAV multispectral image. The method is composed of homogeneity calculation, objects extraction, morphology measurement and reference target extraction. The reference targets were detected well in monotonous area such as a soccer field although there were some remained false alarm in the parking lot. Further study is needed to remove false alarms in general cases although the proposed method might be acceptable for agricultural application.

ACKNOWLEDGEMENTS

This study was carried out with the support of "Cooperative Research Program for Agriculture Science & Technology Development (PJ01350003)" Rural Development Administration, Republic of Korea.

REFERENCES

Iqbal, F., A. Lucieer and K. Barry, 2018. Simplified radiometric calibration for UAS-mounted multispectral sensor, European Journal of Remote Sensing, 51 (1), pp. 301-313.

Mathews, A.J., 2015. A Practical UAV Remote Sensing Methodology to Generate Multispectral Orthophotos for Vineyards: Estimation of Spectral Reflectance Using Compact Digital Cameras. International Journal of Applied Geospatial Research, 6 (4), pp. 65-87.

Rhee, S. and T. Kim, 2015. Automated DSM extraction from UAV images and Performance Analysis, International Conference on Unmanned Aerial Vehicles in Geomatics. In: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Toronto, Volume XL-1/W4, pp. 351-354.

Tu, Y., S. Phinn, K. Johansen and A. Robson, 2018. Assessing Radiometric Correction Approaches for Multi-Spectral UAS Imagery for Horticultural Applications, Remote Sensing, 10 (1684), pp. 1-22.

Wang, C. and S.W. Myint, 2015. A Simplified Empirical Line Method of Radiometric Calibration for Small Unmanned Aircraft Systems-Based Remote Sensing, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 8 (5), pp. 1876-1885.