AUTOMATIC EXTRACTION OF SHADOW REGIONS IN HIGH-RESOLUTION ADS40 IMAGES - *By Robust Approach of Feature Spaces Analysis*

B. Babu MADHAVAN*, Kikuo TACHIBANA, Tadashi SASAGAWA, Hiroyuki OKADA and Yasuke SHIMOZUMA

Geographic Information Systems Institute, PASCO Corporation, , Tokyo, Japan

Email: mb_pasco.co.jp

KEY WORDS: Vision, Urban, detection, extraction, recognition, feature detection, automation.

ABSTRACT:

Due to high object density and high proportion of shadow-covered areas, it is usually quite difficult to extract information in urban high-resolution airborne images from Leica Geosystems' airborne multispectral line sensor, ADS40. The shadows of various extent cause problem in image matching for elevation extraction, and obstruct road extraction. Further, the occluded and shadow areas pose problem to the interpretability of orthophotos. This paper describes strategy of robust feature space analysis and multilevel thresholding adopted to extract shadow regions in ADS40 images automatically without the aid of Digital Surface models (DSM) or any other accessory data.

In this work, low-level computer vision tasks for shadow extraction, elimination, and enhancement of texture information in the shadow regions in high-resolution ADS 40 digital aerial images were presented. A general nonparametric technique was implemented for the ADS 40 data points in the joint spatial- range domain for the analysis of a complex multimodal feature space and to delineate arbitrarily shaped clusters in it. The filtered image was segmented and then subjected to a bimodal thresholding to extract automatically shadow regions. Using an adaptive contrast enhancement approach, texture in the shadow regions was enhanced. All shadow regions caused by buildings, trees and other smaller objects in the urban areas were robustly extracted.

1. INTRODUCTION

While shadow detection and analysis in high-resolution digital air-photos is difficult, the development of techniques to extract, eliminate and enhance are still continuing. It is usually quite difficult to extract information in urban high-resolution airborne imageries due to high object density and especially high proportion of the shadow-covered areas. Images from multi-lines scanner technology based Airborne Digital Sensors such as ADS40 from Leica Geosystems have more shadow areas especially in urban region. So, it becomes difficult to extract the information in the shadow-covered area.

2. PREVIOUS METHODS

Shadows were detected through simple thresholding (Nagao et al. 1979), by using correspondence between shadow edges and the geometric edges (Lowe and Binford, 1981), shadow simulation by using digital terrain models (DTM) (Stevens et al 1995); using digital surface models (DSM) and sun angle parameters (Xu and Li 2001, Nakajima et al 2002), DSM and digital building models (DBM) (Rau et al., 2000); and by colour histogram matching (Gerke et al., 2001). Thus in most of the previous attempts, DSM, DBM, sensor parameters, sun elevation and zenith angle parameters are required to extract shadow regions. But the present approach has not considered any of these key factors.

*Corresponding author

3. PRESENT APPROACH

The present work utilized the mean-shift analysis (Fukunaka and Hosteler, 1975; Cheng, 1995; Comanicu and Meer, 2002) filtering and segmentation for shadow region extraction from high-resolution air-photos. The lowest mean lightness parameter added to the segmented image finally will automatically extract the shadow regions. Since shadow regions are the darkest regions, applying the lowest mean lightness value to threshold the segmented image will extract shadow regions. Panchromatic (PAN-grey level) was used as input. ADS 40 NIR image covering a part of northern part of Tokyo (figure 1) was tested and significant results obtained.

Figure 1. ADS 40 NIR image with shadow regions

The lowest lightness value can be attributed to the darkest shadow regions (especially in NIR images), and shadow regions will be extracted by using Boolean operation. By image arithmetic operator, the extracted shadow regions were eliminated from the original image and texture of the shadow regions was separated. The texture information under shadow regions was enhanced by using the adaptive contrast enhancement (ACE) techniques suggested by Stark (2000).

4. EXPERIMENTAL RESULTS

The filtered and segmented ADS40 image is shown in figure 2. All the obtained segmented images were thresholded by using the mean lightness thresholding that separated shadow regions and non-shadow regions (figure 3). From the figure 3, it was observed that all the dark pixels are not shadow regions as some of them represent water bodies (A in figure 3), dark coloured roofs (B in figure 3), newly paved tar roads and similar objects. Figure 4 shows the texture information in the shadow regions. The adaptive contrast enhancement helped to enhance the shadow regions and finally an integration of the shadow texture regions with the shadow-removed image resulted in a shadow-free image (figure 4).

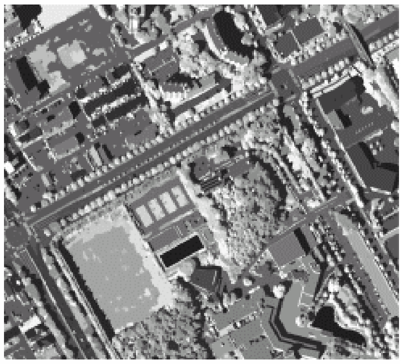

Figure 2. Filtered image

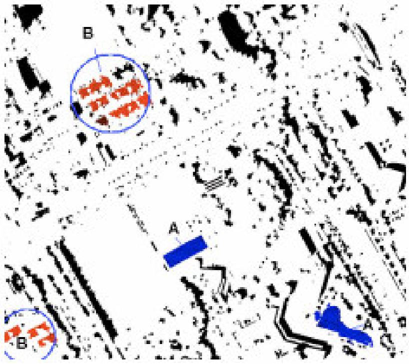

Figure 3. Extracted Shadow regions and false positive regions (*circled areas* A- water bodies; B-dark coloured roofs)

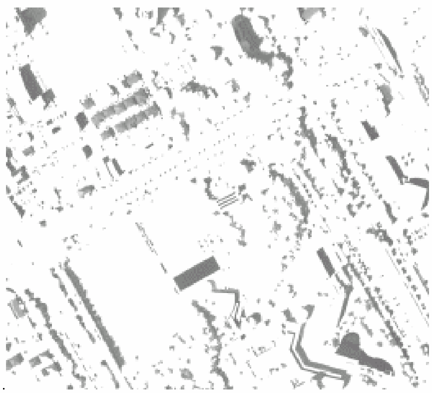

Figure 4. Texture information under shadow regions

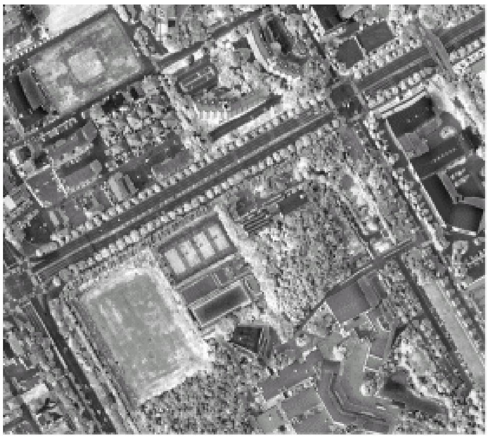

Figure 5. Shadow free image

5.CONCLUSION

The present shadow detection, extraction and enhancement methods do not require a DSM or DBM, sensor parameters, sun elevation and zenith angle parameters in contrast to the previous techniques. The mean-shift filtering technique was unexploited in the remote sensing image analysis. Further the application of the filtering to shadow extraction also new to photogrammetry. As a future work it is planned to apply the method to colour images and also to improve the segmentation algorithm to remove false positives.

REFERENCES

Cheng, Y., 1995. Mean Shift, Mode seeking, and clustering. *IEEE Trans. Pattern Anal. Machine Intell.* 24, Vol.17 790-799.

Comanicu, D., and Meer. P., 2002. Mean shift: A robust approach toward feature space analysis. *IEEE Trans. Pattern Anal. Machine Intell.* 24, 603-619.

Fukunaka, K, and Hosteler, L. D., 1975. The Estimation of Gradient of a Density Function, with Applications in Pattern Recognition, IEEE Trans. Information Theory, Vol. 21, pp. 32-40.

Gerke, M., Heipke, C., and Straub, B. -M., 2001. Building Extraction From Aerial Imagery Using a Generic Scene Model and Invariant Geometric Moments. Proc. IEEE/ISPRS Workshop on Remote Sensing and Data Fusion over Urban Areas, ISBN 0-7803-7059-7, pp.85-89.

Lowe, D. G., and Binford, T. O., 1981. The interpretation of geometric structure from image boundaries, Proc. DARPA Image understanding Workshop, pp. 39-46.

Nagao, M., Matsuyama, T., and Ikeda, Y., 1979. Region extraction and shape analysis in aerial photographs. Computer, Graphics and Image Processing, Vol. 10, No.3, 195-223.

Nakajima, T., Tao, G., and Yasuoka, Y., 2002. Simulated recovery of information in shadow areas on IKONOS image by combing ALS data, Proc. Asian Conference on Remote Sensing http://www.gisdevelopment.com/aars/acrs/2002/vhr/214.pdf

Rau, J. Y., Nai-Yu Chen and Liang-Chien Chen, 2000. Hidden Compensation and Shadow Enhancement for True Orthophoto Generation, Proc. Asian Conference on Remote Sensing. http://www.gisdevelopment.net/aars/acrs/2000/ts4/digi0003pf.htm

Stark, JA, Adaptive Image Contrast Enhancement Using Generalizations of Histogram Equalization, IEEE Transactions on Image Processing (9), No. 5, May 2000, pp. 889-896.

Stevens, M. R., Pyeatt, L. D., Houlton, D. J., and Goss, M. E., 1995. Locating Shadows in Aerial Photographs Using Imprecise Elevation Data, Computer Science Technical Report CS-95-105, Colorado State University, USA.

Xu, F., and Li, S., 2001. Automatic Building Extraction of ALMIMS. *The 3rd International Symposium on Mobile Mapping Technology*, http://gscrlig1.eng.ohio-state.edu/flxu/publications/papers/ buildingextraction_3mmc.pdf