The Effects of JPEG2000 Compression on Automated DSM Generation

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Abstract

The effects of JPEG2000 compression on automated DSM extraction by using the area-based matching are evaluated in this paper. The influences on DSM heights obtained via PCI Geomatics OrthoEngine module are investigated using a single stereo model of 1:5,000 scale aerial photography at image resolution of 20 μm. The experiment design of elevation errors are computed for a range of compression rates from 2:1 to about 100:1, and the DSM which generated from uncompressed image is used as 'ground truth' data for comparison. The experimental results show that the standard deviation ranged from 0.9m to 2.5m with the compression ratio from 2 to 100. It is also observed that there is no significant degradation on DSM accuracy up to the compression ratio of 33.

1. Introduction

The JPEG is the most common applied algorithm in the Photogrammetry for data compression (Mittal & Singh, 1999; Li, et al., 2002). However, in 1997, the JPEG Committee decided that the needs and requirements of imagery applications in today's world point to the need for a new standard. This proposition brought forth the new standard JPEG2000. Fundamental to the automatic generation of DSM (Digital Surface Model) is the process of image matching. This is the process of finding conjugate points in the two images. The two commonly applied schemes include the area and features based (Gooch & Chandler, 2001; Schenk, 1999). Area-based matching matches small areas or patches in each digital image with cross-correlation or least-squares matching techniques. Feature-based matching identifies objects such as the edges of buildings, roads, etc., which are visible in both images (Gooch & Chandler, 2001; Hijazi, 2002). In this paper, the effects of JPEG2000 compression on DSM generation via PCI Geomatics OrthoEngine module are evaluated. The scope of this evaluation is confined to a single stereo model of 1:5,000 scale aerial photography, which has been scanned at resolution of 20 μm. The compression ratios considered ranged from 2:1 to about 100:1.

2. The Experiment

The JasPER 1.5 is used in this study to perform image compression with JPEG2000. The PCI Geomatics OrthoEngine module 8.2.3 is used for automated

DSM generation. Because PCI Geomatics does not support JPEG2000 files in this version, the JPEG2000 files are converted into TIFF format with IrfanView (IrfanView, 2003) first. The density of the point matching is set to 2 pixels, about 0.2m on ground. To evaluate the variation of elevation due to the JPEG2000 compression, the DSM which generated from uncompressed images is used as the 'ground truth' data.

Table 1. DSM correlation success percentage vs. compression ratio.

CR	1.0	2.0	5.0	7.7	11.1	13.3	15.6	20.0	25.0	33.3	50.0	100.0
JP2000	75.1	75.1	77.4	79.1	80.5	82.4	83.3	83.9	85.4	87.4	88.2	89.8
JPEG	75.1	76.5	77.4	77.5	78.7	79.7	80.8	81.4	82.8	82.9	81.0	71.5

Table 1 shows that for JPEG2000, the increase for DSM correlation success percentage is almost linear as compression ratio increases. Similar to JPEG2000, the correlation success percentage is also increasing with the compression ratio up to compression ratio 33.3. It is known that smoothing effects remove high-frequency structures on wavelet-based compression (Schiewe, 1998). One reason for the improvement of match percentage may be the smoothing effect. To prove this assumption, the image is applied with 5x5 mean filters to both the original left and right images, respectively, resulting in a 75% to 85% in the DSM correlation success rate. There are some points exceeded the maximum elevation of study area, about 150m. These points most likely are the man-made features. These points came from the failure of DSM generation algorithm. The reason for this failure is probably a lack of image content (Gooch & Chandler, 2001). For the DSM comparison, searching criterion is set to be 0.1m, about the ground size of a pixel. Consequently, two points from different DSM data sets with the distance less than 0.1m be taken as the 'identical' points.

Table 2. The relative mean errors by compression ratio.

CR	2.0	5.0	7.7	11.1	13.3	15.6	20.0	25.0	33.3	50.0	100.0
Mean_JP2000	-0.0006	0.0013	0.0051	0.0074	0.006	0.0085	0.0061	0.006	0.0086	0.0149	0.0514
Mean_JPEG	0.0058	0.0083	0.0061	0.0086	0.0078	0.0083	0.0112	0.0194	0.0067	0.017	0.029

Table 3. The relative standard deviation of errors by compression ratio.

CR	2.0	5.0	7.7	11.1	13.3	15.6	20.0	25.0	33.3	50.0	100.0
Std_JP2000	0.89	1.01	1.00	1.17	1.32	1.27	1.18	1.32	1.40	1.75	2.48
Std_JPEG	1.26	1.30	1.29	1.34	1.34	1.50	1.62	1.54	1.45	1.84	2.26

The relative mean error and relative standard deviation of errors of DSM from uncompressed images and compressed images are shown as Table 2 and Table 3, respectively. Additionally, the JPEG2000 outperforms JPEG on the accuracy of DSM with same compression ratio. For both of JPEG2000 and JPEG, the gradient of the accuracy degradation are becoming steeper with increasing compression ratios.

3. Concluding Remarks

The experiments show that JPEG2000 compression has a significant influence on the success percentage of automated DSM extraction with an area-based matching methodology. It is also observed that there is no significant degradation of DSM accuracy up to the compression ratio of 33. The standard deviation ranges from 0.9m to 2.5m with the compression ratio from 2 to 100 for JPEG2000 compression.

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