EFFECTS OF JPEG2000 AND SPIHT COMPRESSION ON IMAGE CLASSIFICATION

Zhai Liang [a], *, Tang Xinming[a], Zhang Guo[b], Wu Xiaoliang[c]

[a] Key Laboratory of Geo-Informatics of State Bureau of Surveying and Mapping, Chinese Academy of Surveying and Mapping, China - (zhailiang, tang)@casm.ac.cn
[b] State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan, 430079, China-guozhang@whu.edu.cn
[c] CSIRO Mathematical and Information Sciences, Private Bag 5, Wembley, Australia- Xiaoliang.Wu@csiro.au

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ABSTRACT:

In the field of aerial/satellite remote sensing, the quality of data generated by remote sensing platforms is increasing at a significant rate and researches in image compression focus in two aspects: one is seeking efficient compression algorithms suit for remote sensing image data characters, the other is analyzing use potential of current compression algorithms in remote sensing through studying on reduction degree of reconstructed image. The paper aims at experimentally evaluating the effects of compression on image supervised classification. JPEG 2000, which is a new image coding system that uses state-of-the-art compression techniques based on wavelet technology, was employed for compression test. The testing images including three kinds of terrain － plain, hill and mountain area, were compressed with different compression ratios. All the reconstructed images were classified using MLC of supervised classification. The classified results using the original images were used as the reference (truth). Kappa coefficient was adopted as assessment measure. From the results, it can be found that there could be a decrease in image quality with compression ratio increase. While, when the compression ratio is smaller than 10:1, the deterioration of classification accuracy is not significant for both compression methods. As to different terrain types, both image compression techniques have different effects on them. That is, the effects of JPEG2000 and SPIHT compression on image classification are scene-dependent. Generally speaking, with the same compression ratio, JPEG2000 has better performance than SPIHT, which means that JPEG2000 has little deterioration on image classification accuracy than SPIHT.

1. INTRODUCTION

Digital images usually require a very large number of bits, and many uses of digital images involve large collections of images. It is a critical problem for digital image data transmission and storage in the realm of internet, web browsing, muti-media, communication, medical imaging and remote sensing (Zhai L. *et al* 2006). Image compression is one of key techniques in solving this problem. Image compression exploits redundancy to achieve reduction in the actual amount of data with or without quality information loss according to certain rules through transform and combination. It is redundancy that exists in data that enables compression. As to redundancy, it refers to three types of image redundancy that can be distinguished in the pixel domain: coding redundancy, inter-pixel redundancy and psycho-visual redundancy. Many image compression algorithms have been in practice, such as DPCM, JPEG, JPEG-LS and JPEG2000, etc. Usually image compression can be divided into two main categories. One is lossless compression, the other is lossy compression. Lossless and lossy compression are terms that describe whether or not all original image can be recovered when the compressed one is uncompressed. With lossless compression, every single bit of data that was originally in the image remains after the image is uncompressed (The uncompressed image is also called reconstructed image). All of the information is completely restored. JPEG-LS is a standard providing lossless compression. On the other hand, lossy compression reduces an image by permanently eliminating certain information, especially redundant information. When the image is uncompressed, only a part of the original information is still there (although the user may not notice it). In the remote sensing industry, image compression has become more important due to the availability of high-resolution and hyper-spectral satellite imagery (LAU. W.L. et al 2003). Lossy compression has been widely used in satellite remote sensing, where communication band width and storage capability are limited. Compression size is usually based on compression ratio (CR) and not on compression quality from the consideration of practical applications. It should be borne in mind that the same compression ratio may produce different degrees of quality depending on the type of image (Zabala, A. *et al* 2006). CR is the ratio of size of original image to size of reconstructed image.

Researches in image compression focus in two aspects: one is seeking efficient compression algorithms suit for remote sensing image data characters, the other is analyzing use potential of current compression algorithms in remote sensing through studying on reduction degree of reconstructed image. The latter belongs to the category of image quality assessment. Many image compression algorithms have emerged in the last ten years, while the quality assessment is ignored especially in the realm of application (Zhai L. and Tang X.M., 2007, Zhai L. *et al* 2007). The results of data analysis with supervised and unsupervised classification of original and lossy compressed data indicate potential benefits and problems of this approach to data reduction (Correa A C *et al* 1998).

* Corresponding author.

On this theme, although some attempts (Shen S. S. *et al* 1993, Correa A C *et al* 1998, Zabala, A. *et al* 2006, W.L. LAU. *et al* 2003) have been made to find out the impacts of image compression on image classification process, the scenes with different terrain characters versus the classification accuracy have not been investigated. This paper develops some experiments to illustrate the impact of lossy compression on accuracy of supervised classification results by means of JPEG 2000 standard. Several typical optical remote sensing data scenes with different terrain types are used in this study.

2. METHODS ANALYSIS

2.1 Scenes used

The first step of image compression assessment is to prepare original images which depend on the application (Frank X. J. L. and Zigmantals L. B 1982). And sometimes for certain aims, original images have to be pre-processed. In our experiments, we need images without any pre-process. In this experiment, some aerial images were selected and scanned. Those images are all panchromatic including different types of terrain, and have the same size (600×600).

Entropy is a statistical measure of randomness that can be used to characterize the texture of an image. Table 2 gives the entropy* of testing images, from which we can find that testing images have different texture character. All testing images have rich textures: Mountain has the highest entropy indicating more complex texture, while Plain has the lowest entropy.

Testing image	Entropy
Plain	2.732
Hill	3.166
Mountain	3.233

Table 2. Entropy of testing images

2.2 Image compression

In the realm of remote sensing, transformation method is adopted by the mainstream compression algorithms, such as JPEG, JPEG2000, SPIHT, etc. The compression algorithm employed here is JPEG2000 and SPIHT which are based on discrete wavelet transformation. A series of reconstructed images with compression ratio of 2:1, 4:1, 6:1, 8:1, 10:1, 12:1, 16:1, 20:1 and 30:1 were achieved.

2.3 Classification accuracy

A Maximum Likelihood Classification (MLC) supervised classification was performed in order to obtain an estimate of the effect of compression on image classification. The classifier was run unsupervised on the three original test images. The resultant classification wan assumed to be "ground truth" in the absence of actual ground truth data. Analysis of the reconstructed imagery classification accuracy was performed by comparing each reconstructed image with the original (see figure 3).

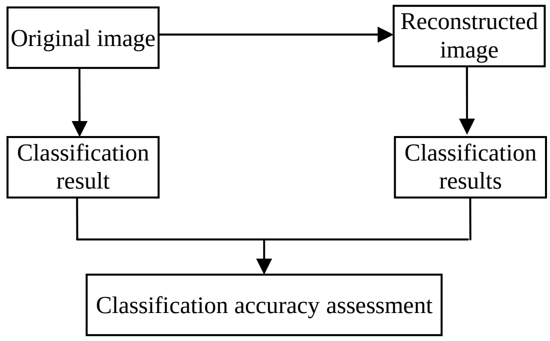

Figure 3 Flow diagram of reconstructed image classification accuracy assessment

3. ANALYSIS OF SUPERVISED CLASSIFICATION RESULTS

For the analysis of supervised classification results, the Kappa coefficient, which is a parameter scaled to a range [0, l], is employed in this study to calculate the actual classification agreement and the chance agreement (LAU W.L. *et al* 2003). A higher coefficient indicates a reliable classification result. A value of 1 means perfect classification. All the results in terms of these two measures were computed and are summarized in table 3 and table 4. Figure 4 and 5 show the relation between compression ratio and the Kappa coefficient.

CR	Kappa coefficient		
	Plain	Hill	Mountain
2:1	0.978	0.973	0.955
4:1	0.894	0.890	0.881
6:1	0.854	0.853	0.834
8:1	0.825	0.823	0.803
10:1	0.824	0.823	0.800
12:1	0.821	0.821	0.790
16:1	0.739	0.738	0.725
20:1	0.644	0.619	0.610
30:1	0.618	0.602	0.595

Table 3. The MLC classification results of original and JPEG 2000 compressed images: Kappa coefficient

CR	Kappa coefficient		
	Plain	Hill	Mountain
2:1	0.972	0.971	0.952
4:1	0.891	0.889	0.879
6:1	0.85	0.843	0.83
8:1	0.822	0.82	0.801
10:1	0.819	0.81	0.78
12:1	0.815	0.801	0.719
16:1	0.73	0.728	0.7
20:1	0.638	0.61	0.601
30:1	0.604	0.59	0.584

Table 4. The MLC classification results of original and SPIHT compressed images: Kappa coefficient

* The entropy here is based on GLCM (Gray-Level Co-occurrence Matrix). More details see (Zhai L. *et al* 2006).

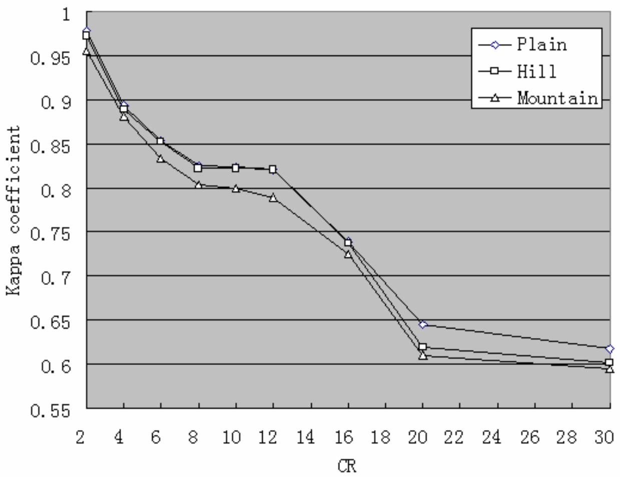

Figure 4. The relation between compression ratio and the Kappa coefficient (JPEG 2000)

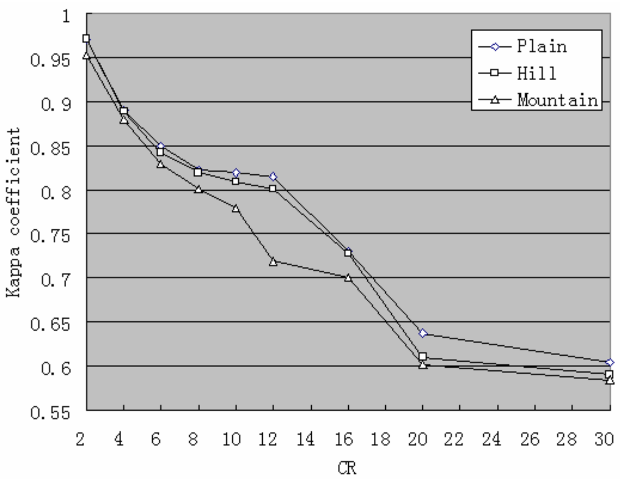

Figure 5. The relation between compression ratio and the Kappa coefficient (SPIHT)

4. DISSCUTION AND CONCLSIONS

Based on the limited testing results obtained in this study, it might be concluded that:

There could be a decrease in image quality with compression ratio increase. As a result, the accuracy of image classification is dramatically deteriorated when image compression ratio is very high.

There could be a decrease in image quality with CR increase. As a result, the accuracy of image classification is dramatically deteriorated when CR is high. However, when CR is around 10:1, the deterioration of classification accuracy is not significant. This scenario indicates that JPEG 2000 and SPIHT have the capability of keeping image classification accuracy at medium CR. But more experiments should be taken to validate this.

As to different terrain types, image compression technique has different effects on them. That is, the effects of JPEG 2000 and SPIHT on image classification are scene-dependent. For example, Mountain has high entropy (rich texture) and JPEG 2000 and SPIHT tend to have more effecting on it.

Generally speaking, with the same compression ratio, JPEG2000 has better performance than SPIHT, which means that JPEG2000 has little deterioration on image classification accuracy than SPIHT.

For future research, the effects of compression on automatic target recognition (J. D. Paola and R. A. Schowengerdt 1996) or spatial pattern detection should be examined.

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