On the Performance of JPEG2000 for Aerial Photo Compression

Tian-Yuan Shih*

Jung-Kuan Liu**

Houn-Chien Wu***

*Department of Civil Engineering
National Chiao-Tung University
1001 Ta-Hsueh Road, Hsin-Chu, China Taipei
Email: tyshih@mail.nctu.edu.tw

**Department of Civil Engineering
National Chiao-Tung University
1001 Ta-Hsueh Road, Hsin-Chu, China Taipei
Email: tyshih@mail.nctu.edu.tw

***Department of Civil Engineering
National Chiao-Tung University
1001 Ta-Hsueh Road, Hsin-Chu, China Taipei
Email: tyshih@mail.nctu.edu.tw

Abstract:

JPEG2000 is a wavelet based new standard for image compression. This standard has several advantages over the DCT based JPEG. In this study, the performance of JPEG2000 is evaluated for aerial image compression. Different compression ratios are applied to scanned aerial photos of 1/5000scale. The evaluation of the performance is based on the visual analysis of the objects in the scene. The entropy and PSNR values are also computed for different ratios with both JPEG2000 and JPEG..

1. Introduction

JPEG2000 is a newly approved image compression standard intended to replace the existing JPEG standard. While JPEG is based on the Discrete Cosine Transformation, JPEG2000 is based on the wavelet transformation. In this study, the performance of JPEG2000 is evaluated for the aerial photos. The images used for the experiments are scanned from 1/5000 scale color aerial photo at the 20ì m resolution. Although the original photo is taken in color, only the grayscale image is scanned and stored. The typical dimension of a scanned image file is 11995×11905 pixels.

The JASPER 1.5 is used in this study to perform image compression with JPEG2000. JASPER is freely available for academic uses and supports various image formats, including bmp, jp2, jpg, pnm, and ras (Adams, 2001a, b).

2. The Compression Ratio, Entropy and PSNR

There are two commonly applied indices for image compression ratio. The first index is to divide the original image size by the compressed image size (Tai, 2001). The second is computing the bits per pixel after the compression. Because the first index is adopted as the input parameter in JASPER, it is used in this report.

$$Ratio = \frac{\text{The number of bits of the original image}}{\text{The number of bits of the compressed image}}$$

Gonzalez and Woods (1992) stated that there are two fidelity criteria for image processing: the objective and the subjective. While visual inspection is the most dominant way for subjective evaluation, there are a number of numerical indices for the objective measure. Among many numerical indices, PSNR and Entropy are selected to serve as the fidelity measures in this study (Chen, 2002).

1. Peak Signal to Noise Ratio (PSNR):

$$PSNR = 10 \cdot \log_{10} \frac{\left(\text{peck-to-peak value of the referenced image}\right)^2}{s_e^2}$$

For a 256 level gray scale image, PSNR is defined as:

$$PSNR = 10 \cdot \log_{10} \frac{255^2}{MSE}$$

A larger PSNR value indicates higher reconstruction fidelity. Peak Signal-to-Noise Ratio (PSNR) avoids this problem by scaling the MSE according to the image range.

2. Entropy: The average information per source output is called the uncertainty or entropy of the source. Entropy defines the average amount of information obtained by observing a single source output. A larger entropy value indicates more uncertainty, therefore more information is associated with the source.

$$Entropy = -\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} P(x,y) \log P(x,y)$$

where P(x,y) denotes the probability of the pixel(x,y) occurs.

Besides the visual inspection and evaluating with numerical indices, Li, et al. (2002) reported the evaluation scheme designed for the geometric accuracy of point positioning.

3. The Experiments and the Analysis

3.1 Visual Evaluation

As shown in Figure 1, eleven different compression ratios ranging from 1 to 100, are performed in the experiments. For visual evaluation, three different objects, the road, the

building corner, and a signalized target, are taken as samples and listed in Figure 1. It is concluded that the image quality is fairly good up to compression ratio 25.

Ratio	1	2	5	7.7	11.1	13.3	15.6	20	25	33.3	50	100
Road												
Corner												
GCP												

Figure 1: The Visual Effect and the Compression Ratio

3.2 Entropy and PSNR

The entropy and PSNR value are computed for two photos of a stereo-pair. The entire image is used. The relation between compression ratio and the entropy is shown in Figure 2. Where, JP2_L is the left image compressed with JPEG2000, and JP2_R is the right image of the stereo-pair. JPEG_L is the left image compressed with JPEG, and JPEG_R is the right image.

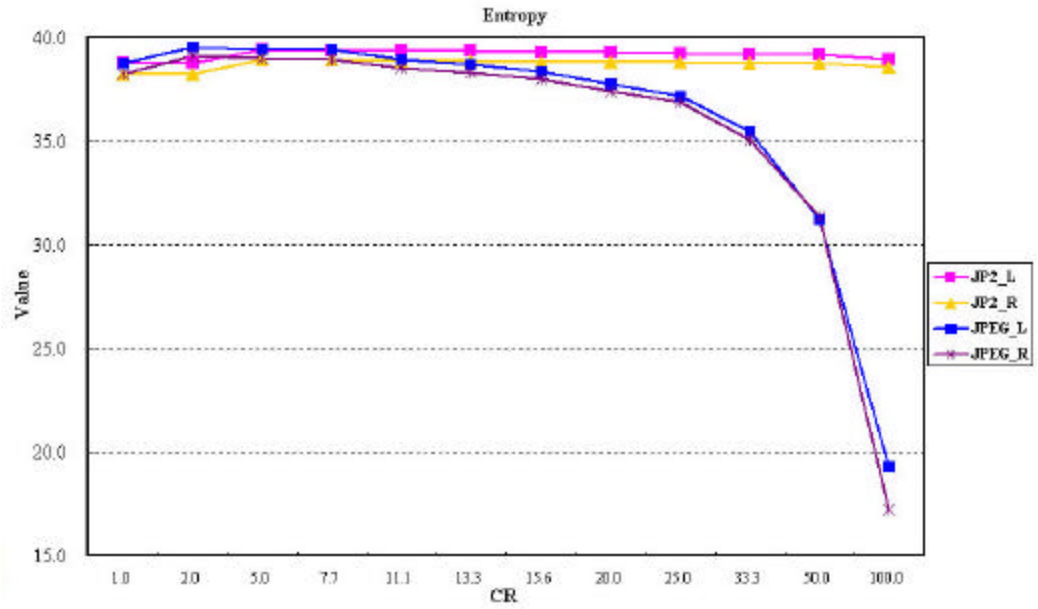

Figure 2: The Compression Ratio and the Entropy

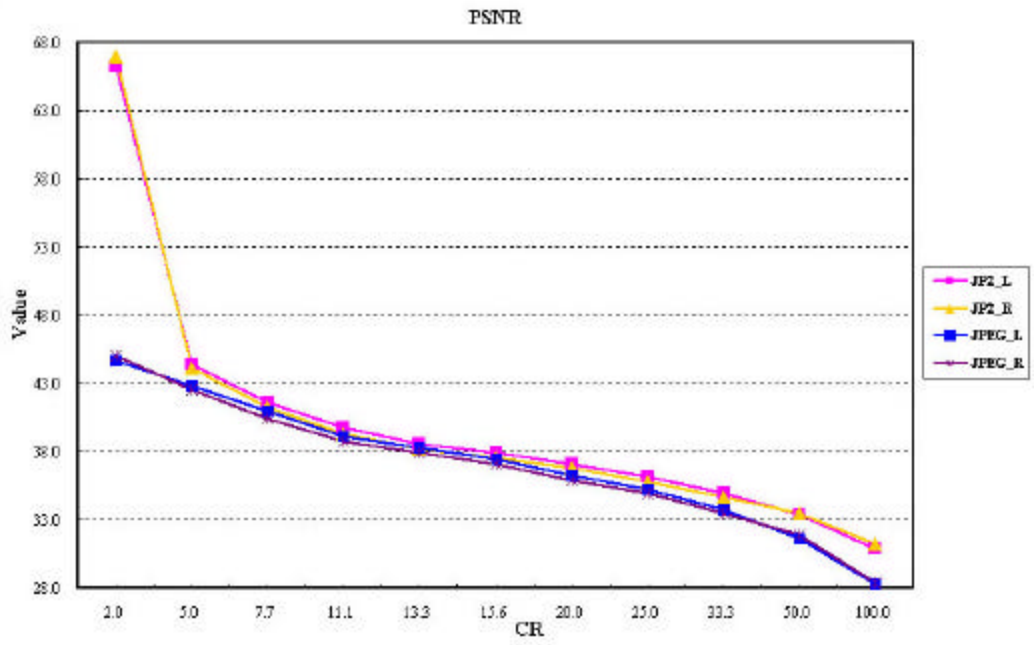

Figure 3.The Compression Ratio and PSNR

From the data shown in Figure 2, the increase of compression ratio for JPEG2000 has no effect on the decrease of the entropy value, up to compression ratio 100. However, the entropy does drop with the image compressed with JPEG. This seemingly indicates that JPEG2000 preserves the information content better than JPEG for compression ratio higher than 30.

From Figure 3, it also shows that JPEG2000 always has better PSNR value than JPEG for the same compression ratio. The difference becomes more significant when the compression ratio is larger than 30.

4. Concluding Remarks

From the preliminary study performed in this study, JPEG2000 performs better than JPEG for the grayscale image scanned from aerial photos. While JPEG has been applied for aerial photo compression in various digital photogrammetric works, there is no softcopy stereo-plotter or digital photogrammetric workstation currently supporting JPEG2000 to the authors' knowledge. However, it is expected that this situation will change soon.

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