COMPRESSION OF REMOTELY SENSED DATA USING JPEG

Dafer Ali Algarni
Assistant Professor
King Saud University, Riyadh, Saudi Arabia

Commission III Working Group 4

KEY WORDS: Image, Compression, Automation, Classification, Digital, Distortion

ABSTRACT

The automation complexity may be lessened by compressing digital images without effecting the image fidelity. The Joint Photographic Experts Group (JPEG) algorithm is tested for compressing remotely sensed data, e. g. Landsat TM images. The compressed images are compared to the original images at different rates of compression in two different experiements. It is found that JPEG can be as useful in digital mapping as it is in video and other visual applications. Compressing a complicated scene to about 12%, which saves more than 700,000 bytes of three TM band with a size of 786,432 bytes, is possible with irregular degrading in the visual quality. Beyond this limit, the image is highly degraded. This may meet certain mapping applications where other measures, rather than high accuracy, are sought. The statistical analysis shows, however, that JPEG can not be recommended for precise mapping, and that the geometric and visual quality of the output of compression is a scene-dependent matter and can not easily be generalized for all images.

1. INTRODUCTION

The increase in the methods of data-gathering and automation for the purpose of digital mapping are strongly inter-related. For automation to be well accomplished, it needs the contribution of different information and techniques. On the other hand, too much information may cripple the advance of automation, making the process of obtaining useful information very slow and confusing.
Furthermore, if we were to process different data with different numerical and symbolic characteristics, automation will become very difficult.

In discussing the implementation of softcopy workstations, Miller et al. (1992) stated that ''the generic problems are in the image processing area....While storage of such images is no longer a serious problem, fast accessing and processing certainly are''. Therefore, the amount of data and qualiy have a direct effect on the amount and quality of automation. If the processed data is somehow reduced to a little but sufficient and correct amount, not only the image processing is facilitated but also the possibility of automation will increase and many other related mapping problems will be solved.

The main theme of this paper is to study the applicability of the JPEG technique for compressing remotely sensed data. This technique was found to be useful in reducing and transmission of still images for visual applications (Paik, 1992). A study was made on compressing aerial image of smooth distinctive features using JPEG shows that a 10% reduction can be used without degrading the visual or geometric quality (Lammi, and Sarjakoski, 1995). It is of great interest to test the applicability of JPEG to remote sensing images of subtle texutre varations. In this study, a simple measure of evaluation is used where the effect of compression on subsequant processes such as image classification is tested. The paper is organized in the following manner. In the next section, the JPEG concept is presented and evaluated. Image classification is introduced in section three to facilitate evaluating the JPEG effect on the compressed TM images. The experiment and analysis are evaluated in section four, and the conclusion is made in section five.

2. JPEG CONCEPT

JPEG is an international standard for achieving image compression to reduce the amount of stored data and the period of transmission of such data. JPEG was found useful in compressing different types of images especially those of terrestrial successive frames (Langdon, et. al 1992) by taking advantage of the data redundancy in the coding process (Pennebaker and Michell, 1988). The overall scheme is basically transforming 8*8 pixels from space domain to frequency domain. There are two main processes performed by the technique, namely encoding and decoding as shown in Figure 1.

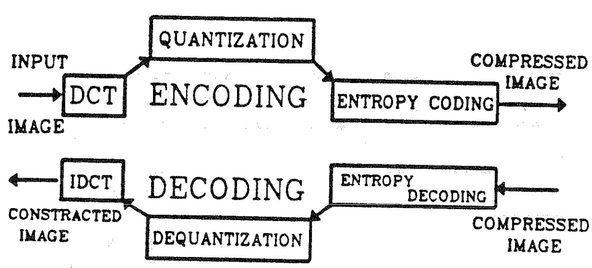

Figure 1. Encoding and Decoding for Image Compression

In the encoding process, the raw data passes through the discrete cosine transform (DCT) function to transform it to a domain in which it can be more efficiently encoded. The DCT follows the following mathematical model.

$$X(u,\upsilon) = \frac{1}{4} K(u)\, K(\upsilon) \sum_{i=0}^{7} \sum_{j=0}^{7} x(ij) \cos\frac{(2i+1)\,u\pi}{16} \cos\frac{(2j+1)\,\upsilon\pi}{16} \qquad (1)$$

where i, j, u, $\upsilon \in [0, 7]$, x(i,j) = (i, j)th element in an 8x8 block, X(u, υ) = (u, υ)th coefficient in an 8x8 DCT coefficient matrix, and K(u) = $1/\sqrt{2}$ for u = 0 and 1 for u $\neq$ 0.

Then, the data is scaled down to lower-precision demanding fewer bits, a proces called quantization. It employs the following equation in which C(u,v) is an integer and Q(u,v) is a suitable number.

$$C(u,v) = \frac{X(u,v)}{Q(u,v)} \qquad (2)$$

The resulting data is then coded using Huffmn representation. Such a process leads to a compressed image.

The decompressed image is subjected to the inverse of the DCT function and the quantization processes. The mathematical model for inverse DCT (IDCT) is as follows:

$$x(i,j) = \frac{1}{4} \sum_{u=0}^{7} \sum_{v=0}^{7} K(u)\, K(v)\, X(u,v) \cos\frac{(2i+1)\,u\pi}{16} \cos\frac{(2j+1)\,v\pi}{16} \qquad (3)$$

Dequantization is the opposite of quantization presented by the following equation:

$$X'(u,v) = C(u,v)\; Q(u,v) \qquad (4)$$

Where, X′(u, v) is the dequantized DCT coefficients.

The JEPG concept is discussed by a number of researchers such as in (Wallace, 1992). This technique is applied to the original TM images, then the images are classified to make possible the processes of comparison and evaluation.

3. IMAGE CLASSIFICATION

Classification is, in general, the technique by which images can be easily analyzed and possibly interpreted. There are many techniques available for image classification (Congalton, 1991 and Jensen, 1986). The classification techniques take advantage of the statistical characteristics of the image content and produce a thematic map containing a number of classes. Each class represents one feature of the scene. These visual and statistical characteristics of classification are utilized in this research where the effectiveness of JPEG is attested by applying the unsupervised isodata image classification technique to the compressed remotely sensed data.

4. EXPERIMENT AND ANALYSIS OF RESULTS

The input images are two 512 x 512 TM with three band each (2, 3, 4). For simplicity, the LAN and GIS images of experiment one will be abbreviated by E and that of experiement two by Ex in the text, tables and figures. Some times E and Ex are associated with numbers indicating the rates of compression. The original images (E.LAN and Ex.LAN) were classified prior to the compression, as shown in Figure 2 (E.GIS) and Figure 3 (Ex.GIS). Both E.GIS and Ex.GIS were considered to be free of error for the sake of comparsion. Then, the E.LAN and Ex.LAN were classified after being compressed at different levels of compression and several thematic GISmaps were obtained as also presented in Figure 2 (E8%.GIS, E10%.GIS, E12%.GIS) and Figure 3 (Ex9%.GIS, Ex12%.GIS, Ex14%.GIS). These sries of compressed GISmaps are compared visually and statistically with original E.GIS and Ex.GIS maps (the latter being assumed error-free). Notice that that two images of Figure 3 are omitted for simplicity.

In Figure 2, for example, the E8% and E10% GISmaps compressed images are visually similar to the original E.GIS map. The E12% compressed image shows some differences when compared with the original classified image. The statistical analysis shows significant changes in classes such as 3, 5, 6, 7, and 9 as illustrated in Table 1. This table shows the number of pixels in each class for the original and the compressed image at different compression rates. The ideal case is to have no change in pixels' values for all images. Table 2 presents the same information for experimeint Ex. Figure 4 and Figure 5 show the graphical difference in pixels between the uncompressed and the compressed images for selective classes from both experiements. The ideal shape for each figure is to have no deviation in the vertical axis, and to have only one horizontal line representing all images' pixels. This line should have zero slope and can be visualized as the horizontal compression ratio axis.

Class	E.GIS	E8%	E10%	E12%
1	4025	4204	4482	4105
2	5281	5698	5445	5298
3	8696	9781	10841	8424
4	5451	5417	4975	5704
5	9540	9293	7921	10711
6	10752	10108	9666	7651
7	8077	6401	7747	9098
8	6871	7131	6485	6197
9	2214	3286	3299	3564
10	4599	5217	4675	4884

Table 1. Number of Pixels of Original E.GISmap and Three Compressed GISmaps.

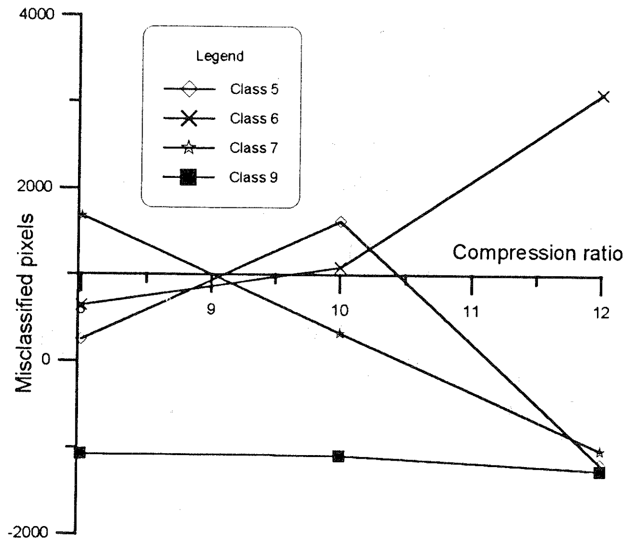

Figure 4. Misclassified Pixels for Some Selective Classes of E.

Class	Ex.GIS	Ex9%	Ex11%	Ex12%	Ex13%	Ex14%
1	4875	5487	5574	5618	5655	5629
2	7322	6815	7006	6821	6741	6834
3	4080	4705	4601	4763	5050	4829
4	5988	5164	5285	5161	5074	5073
5	4236	5014	4836	5159	5009	5158
6	5442	5434	5373	5790	5472	5348
7	6636	6519	5\6119	4838	6230	5834
8	9666	9466	9643	9759	9102	9732
9	13689	13367	13558	14082	13615	13535
10	3342	3563	3536	3543	3586	3564

Table 2. Number of Pixels of Original Ex.GISmap and Five Compressed GISmaps.

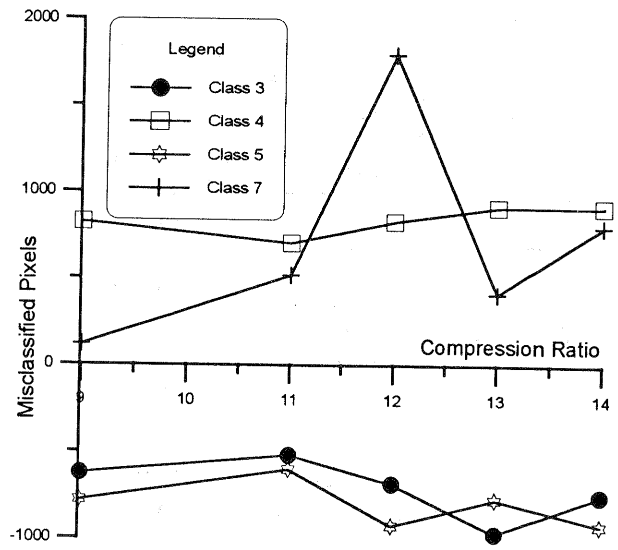

Figure 5. Misclassified Pixels for Some Selective Classes of Ex.

It can be concluded that image compression using JPEG is a scene dependent process, and the result of one scene can not be generalized for all scenes. Another remark is that features which are very distinguished in nature and have sharp edges with their surrounding areas may survive high rate of compression. Such a characteristic may have valuable applications in digital mapping.

Table 3 and Table 4 summarize the amount of data reduction at different rates of compression as exercised in experiements E and Ex. It can be pointed out that more than 700,000 bytes can be reduced for the three band TM image with a maximum of 4.5% misclassified pixels (or loss of information) out of 65,536 pixels.

Image	Size	Reduction
E.lan	786944	0
E8%	100033	686911
E10%	78477	708467
E12%	66284	720660

Table 3. Amount of Reduction in Storage for Experiment E (in bytes)

Image	Size	Reduction
Ex. lan	786432	0
Ex9%	84365	702067
Ex11%	71090	715342
Ex12%	65592	720840
Ex13%	59345	727087
Ex14%	55284	731148

Table 4. Amount of Reduction in Storage for Experiement Ex (in bytes)

5. CONCLUSION

The problem of compressing images that are used for mapping using JPEG is of a compromising nature, since more compression saves a significant amount of space and facilitates image processing but causes appreciable loss of information. For some applications of digital mapping, compression might be very useful even if some information is lost. In this experiment, compressing the image up to 12%, is possible with little effects on the visual appearance and with appreciable changes in the pixels number of some classes. In this particular experiement, for a three-band TM image, more than 700 kb of storage could be saved in the compression process. If high accuracy is not necessary for identifying image features, the classification parameters can be adjusted to accommodate the minor changes in the pixels values. It is also noticed that the effect of JEPG is a scene-dependent matter. It seems that scenes of few heterogeneous classes may be more amenable to high compression rate than scenes with many homogeneous classes.

ACKNOWLEDGEMENT

The author would like to thank King Abdul Aziz City for Science and Technology (KACST) for provideing the TM data for this study.

REFERENCES

Congalton, G. R., 1991. A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of Environment, 37(1), pp. 35-46.

Miller, S., U. V. Helava, and K. D. Helava, 1992. Softcopy photogrammetry workstations. Photogrammetric Engineering & Remote Sensing, 58(1), pp. 77-83.

Jensen J., 1986. Introductory Digial Image Processing: A Remote Sensing Perspective. Prentice-Hall, New Jersey, U.S.A., pp. 177-230.

Lammi, j., and T. Sarjakoski, 1995. Image compression by the JPEG algorithm. Photogrammetric engineering & remote sensing, 61(10), pp. 1261-1266.

Langdon, Gulati, G. A. and E. Seiler, 1992. On the JPEG model for lossless image compression. In: Proceedings of Data Compression Conference (DCC'92), IEEE Computer Society, pp.172-180.

Paik, H. W., and A. Khubchandani, 1992. Quantization scheme for JPEG baseline sequential encoding of still images. IEEE, pp. 976-979.

Pennebaker, W. B., and J. Mitchell, 1988. Probability estimation for the Q-coder. IBM J. Res. Development, 22(6).

Wallace, G. K., 1992. The JPEG still picture compression standard. IEEE Transaction on Consumer Electronics, 38(1), pp. 18-34.