A RELIABLE METHOD FOR ASSESSING THE IMAGE MEASUREMENT QUALITY UNDER THE INFLUENCE OF IMAGE COMPRESSION

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ABSTRACT:

Up to now, there is not any practical and available method to assess the image measurement quality under the influence of image compression. This paper provides a reliable method which not only agrees with the assessing criterion of the visual effect of decompressed images, but also can quantitatively point out the geometric position distortion of pixels in decompressed images. It is, therefore, suitable for high precision digital photogrammetry and other high precision digital image processing areas.

1 INTRODUCTION

The huge volume of digital image has been a serious obstacle for applications concered with storage and transmission of image. So, it is very important to compress image data. In a lossy compression, the reconstructed images (or decompressed images) differ from the originals. Measuring differences (or distortions) between decompressed images and originals is very significant. There have been successful methods for assessing visual quality of decompressed images, known as subjective and objective criterions. These criterions are acceptable in some applications, such as television and visual telephone. But in other areas, like digital photogrammetry and computer vision, these criterions are not acceptable, because they can not quantitatively point out the degree of geometric position distortion of pixels in decompressed images in contrast to homologous pixels in original images. This distortion, called geometric distortion, is most important in these areas, because it changes locations of image points and, consequently, influences the accuracy of objects reconstructed by photogrammetric procedures. But, up to now, how to measure the degree of geometric distortions, or how to assess the measurement quality of decompressed images, there is not any practical and scientific method. This paper provides a method for quantitatively assessing the measurement quality of decompressed images. It not only agrees with the objective criterion for assessing visual quality of decompressed imaegs, but also can quantitatively point out the degree of geometric distortions of decompressed images. It is, therefore, suitable for high precision digital photogrammetry and other digital image processing areas. The experimental results also verify this conclusion.

2. ASSESSING METHOD

2. 1 **LS image match.** Least square (LS) image match method is one which minimizes distance, in mean while, it takes gecmetric distortions and radiometric differences into account. It predicts distortional parameters according to the principle that the square sum of grey value differences of homologous pixels in search whindows is minimal, makes modification of parameters and finds out matched points in search windows (Zhizhuo, w. 1990).

Assume the grey values of same object point is $f(x_0, y_0)$ in target windows in original image and g

(x_d, y_d) in search window in decompressed image, respectively, when lossless compression, we have

$$f(x_o, y_o) = g(x_d, y_d) \quad (1)$$

If the origines of two windows' coordinate system are the centers of two windows, then,

$$x_0 = x_d \quad (2)$$

$$y_0 = y_d \quad (3)$$

where (x_0, y_0) stands for coordinate of object point in original image, and (x_d, y_d) for coordinate of homelegous point in decompressed image. Because of losy compression, there are geometric distortions and grey value differences between homologous points in images before and after compression, which makes (1) and (2) not correct, thus (1) becomes:

$$E(x_o, y_o) = f(x_o, y_o) - g(x_d, y_d) \quad (3)$$

This is the observation error equation.

In general, the difference of grey value is moded by following linear relationshlp:

$$f(x_o, y_o) = b_1 + b_2 g(x_d, y_d) \quad (4)$$

where b_1, b_2 are radiometric parameters.

But the geometric distortion is represented by following affine transformation:

$$\begin{pmatrix} x_o \\ y_o \end{pmatrix} = \begin{pmatrix} a_1 \\ a_4 \end{pmatrix} + \begin{pmatrix} a_2 & a_3 \\ a_5 & a_6 \end{pmatrix} \begin{pmatrix} x_d \\ y_d \end{pmatrix} \quad (5)$$

where $a_i (i=1,2,\cdots,6)$ are geometric distortion parameters. Under the conditions of (4)、(5), expending equations (3) in Tayler series in first order term, we obtain:

$$\begin{aligned} E(x_o, y_o) = &- b_2^0 \cdot g_x \cdot (d_x^0 d a_2) \\ &+ y_d^0 d a_3) - b_d^0 d a_6) + b_2^0 \cdot g_y \cdot (d a_4 + x_d^0 \\ &d a_5 + y_d^0 d a_6) + d b_1 + g(x_d^0, y_d^0) d b_2 \\ &+ f(x_o, y_o) - b_1^0 - b_2^0 \cdot g(x_d^0, y_d^0) \end{aligned} \quad (6)$$

where $g_x = \frac{\partial g}{\partial x}, g_y = \frac{\partial g}{\partial y}$. This is the linearized observation equation for every pixel pair in two windows.

2.2 **Assessing method.** The assessing method propesed in this paper is: chusing target window centered at (x_o, y_o) in original image and search window centered cat some initial position (x_d^0, y_d^0) in decompressed image, then getting linearized observing error equation, like (6) of each pair pixel in two windows, and finally finding out the final values of parameters involved in (6) by interately solving these equations. According to (5), we can get the matched point (x_d, y_d) of (x_o, y_o) in decompressed image. Let

$$\Delta x = x_o - x_d \quad (7)$$

$$\Delta y = y_o - y_d \quad (8)$$

for given limit error δ_x, δ_y, we can obtain the percentage of pixels that satisfy following canditions:

$$|\Delta x| \leqslant \delta_x \quad (9)$$

$$|\Delta y| \leqslant \delta_y \quad (10)$$

in total points in matcking process. Finally, we use this percentage to quantitatively measure the degree of geometric distortions of decompressed image on the whole.

3. EXPERIMENT RESULTS AND CONCLUSION

3.1 **Experimental results.** In experiments, we use two lossy compression method, called method 1 and method 2, to compress one aerial photograph at different compression ratio (CR). Then we use above assessing method to assess the degree of geometric distortions of decompressed images. The experiment results are listed in table 1 and table 2, where the method 1 is the international stardard JPEG (Joint Photograph Expert Group) algorithm (Wallace, G.K., 1991), and the method 2 is the compression scheme proposed by authors based on wavelet trans form (Malled, S.G., 1989).

3.2 **Conelusion.** Frome the results listed in table 1 and table 2, we can see that this method can be used for a scientific and objective criterion for assessing accuracy of pixels' geometric distortions in decompressed images.

Table 1 Experiment result

CR	Percent of unsuc*. point	PSNR	Percent of $\|\Delta x\| \leqslant 0.1$	Percent of $\|\Delta y\| \leqslant 0.1$
2	1.1%	38.34	99%	99%
4	1.3%	34.03	98%	98%
6	3.3%	31.24	90%	90%
8	7.1%	29.52	77%	81%

Table 2 Experiment result

CR	Percent of unsuc*. point	PSNR	Percent of $\|\Delta x\| \leqslant 0.1$	Percent of $\|\Delta y\| \leqslant 0.1$
2	1%	40.03	99%	99%
4	1.2%	37.62	98%	98%
6	3.1%	35.86	92%	92%
8	6.4%	31.92	84%	84%

(*):Unsuceess.

Notes:

1. In matching process, total number is 10000, searching window size is 15×15, iterate munber is 5.

2. "Unsuccess" means that the point is disapear, or the distortion of nearby region of this point is very great.

3. Tolerable linited error δ_x, δ_y can be defined by user (In table 1 and table 2, $\delta_x = \delta_y = 0.1$ pixel).

4. PSNR (Peak Signal — to — Noise Ratio) is defined:

$$PSNR = 10 \times \log 10 \frac{255 \times 255}{MSE},$$

$$MSE = \frac{1}{N \times N} \sum_{i,j}^{N} (x_{ij} - \hat{x}_{ij})^2,$$ where $x_{ij}, \hat{x}_{ij}$ stands for pixel grey value in original Image and decompressed image, respectively.

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