Quality Measurement of Compressed Medical Images: Block Effect Measures.

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Abstract: The evaluation of the usefulness of six different measures of blocking artifact is presented. Three kinds of images: CT, MR and scintigraphy were compressed with the application of Block DCT-based lossy technique and increasing blocking artifact (with growing compression ratio) was counted. Four criteria of measures efficiency were used: monotonicly growing, possibly linear dependence of measure values upon the growing block effect, great selectivity, e.g., independence upon noise level, great dynamics of measure value changes in studied range of blocking artifact, great effectiveness in possibly wide set of compressed medical images. Two proposed measures (REOBD, RMMBD) are clearly better than the others and they could be used as a good measure of blocking artifact for a wide range of applications.

INTRODUCTION

Lossy compression techniques applied for medical images are rejected by many specialists and doctors because of data corruption. New directions of compression algorithm research (meant to improve compression efficiency) should be closely connected with the elaboration of better methods for determining diagnostic accuracy of compressed images. Great deal of research should be performed in the area of the characteristics of lossy compression distortion effects. Better objective measures of diagnostically important distortion should be developed. Good criteria and proper tools to construct compression algorithm, based on those measures, are being searched.

The comparison of the advantages of block and full-frame compression methods shows that block techniques are more effective in many applications [1]. The main disadvantage of these methods is blocking artifact, which can disturb diagnostic accuracy. This is the effect of image light function discontinuity at the boundaries between adjacent blocks. It is caused by coarse quantization made independently in each block, mostly by large quantization step size for d.c. component.

Eskicioglu [2] proposed to measure the blocking artifacts by EOBD, defined as follows:

$$EOBD = \{E[\Delta f(M,n)] + E[\Delta f(m,N)]\}^{1/2}. \quad (1)$$

with

$$\Delta f(M,n) = [f(M,n) - f(M+1,n)]^2,$$

$$\Delta f(m,N) = [f(m,N) - f(m,N+1)]^2$$

where $f(m,n)$ denotes a reconstructed pixel value.

The aim of our research is to work out the proper measure of blocking artifact for implementation in image quality tests and construction of the effective lossy image compression methods. We have evaluated the usefulness of EOBD and proposed five other measures, which seem to be comparable or even better in some applications and we have compared their effectiveness in block effect estimation. As a testing set of medical images, three standard, typical CT, MR and scintigraphy images were used. Noised images were created by applying a Poisson distribution noise generator at each image pixel and Block DCT lossy compression technique was used.

METHOD

The proposed measures of blocking artifact are as follows:

- **MBD** (*measure of block distortion*):

$$MBD = \{[\Delta f(M,n)]^2 + [\Delta f(m,N)]^2\}^{1/2}, \quad (2)$$

with

$$\Delta f(M,n) = E[f(M,n) - f(M+1,n)],$$

$$\Delta f(m,N) = E[f(m,N) - f(m,N+1)].$$

- **MBE** (*maximum block error*)

$$MBE = \max\{\Delta f(M,n), \Delta f(m,N)\}, \quad (3)$$

with

$$\Delta f(M,n) = |\,|f(M,n) - f(M+1,n)| - |f'(M,n) - f'(M+1,n)|\,|,$$

$$\Delta f(m,N) = |\,|f(m,N) - f(m,N+1)| - |f'(m,N) - f'(m,N+1)|\,|,$$

where $f'(m,n)$ denotes the original pixel value.

- **REOBD** (*relative* EOBD):

$$REOBD = \{E[\Delta f(M,n)] + E[\Delta f(m,N)]\}^{1/2}. \quad (4)$$

with

$$\Delta f(M,n) = [|f(M,n) - f(M+1,n)| - |f'(M,n) - f'(M+1,n)|]^2,$$

$$\Delta f(m,N) = [|f(m,N) - f(m,N+1)| - |f'(m,N) - f'(m,N+1)|]^2.$$

- **RMMBD** (*relative module measure of block distortion*):

$$RMMBD = \{[\Delta f(M,n)]^2 + [\Delta f(m,N)]^2\}^{1/2}. \quad (5)$$

with

$$\Delta f(M,n) = E[|\,|f(M,n) - f(M+1,n)| - |f'(M,n) - f'(M+1,n)|\,|],$$

$$\Delta f(m,N) = E[|\,|f(m,N) - f(m,N+1)| - |f'(m,N) - f'(m,N+1)|\,|].$$

- **RMBD** (*relative measure of block distortion*):

$$RMBD = \{[\Delta f(M,n)]^2 + [\Delta f(m,N)]^2\}^{1/2}. \quad (6)$$

with

$$\Delta f(M,n) = E[|f(M,n) - f(M+1,n)| - |f'(M,n) - f'(M+1,n)|],$$

$$\Delta f(m,N) = E[|f(m,N) - f(m,N+1)| - |f'(m,N) - f'(m,N+1)|].$$

We have applied the following criteria to choose the best measure of blocking artifact:

- monotonicaly growing, possibly linear dependence of measure values upon the growing block effect (e.g., upon growing compression ratio CR),
- great selectivity, e.g., independence upon noise level; dependence upon the noise level is evaluated by W factor,

$$W(f) = \left| \frac{\bar{f} - \bar{f}_n}{\bar{f}} \right| \cdot 100\%, \quad (7)$$

with f - the measure, $\bar{f}$ - average value of measure for the image in examined range of CR, $\bar{f}_n$ - average value of measure for the noised image in studied range of CR.

- great dynamics of measure value changes in examined range of blocking artifact; this dynamics is estimated by d factor,

$$d(f) = \frac{f_{max} - f_{min}}{\bar{f}}, \quad (8)$$

f_{max}, f_{min} - maximum and minimum value of measure in studied range of CR.

- great effectiveness in possibly wide set of compressed medical images.

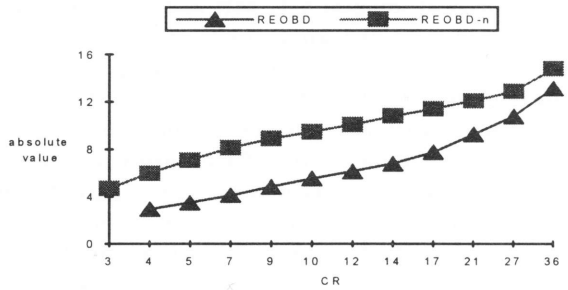
RESULTS AND CONCLUSIONS

The first criterion is correctly fulfilled only by REOBD and RMMBD in a comparable level of effectiveness (fig 1 a,b). RMBD gives proper results for CT and scintigraphy images, but is rather unsuitable for noised MR image (fig.2). Global characteristic of MBE value changes for growing CR is correct (the worst for scintigraphy image), but fragmentary growth is disturbed. EOBD is correct for CT and MR original images but it is not for scintigraphy and noised images. MBD is unsuitable in each case.

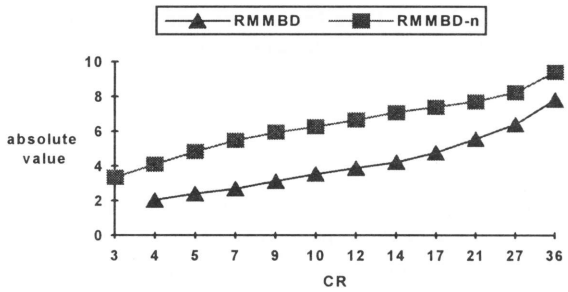
The smallest impact of the noise level on measure values was noticed for MBD (4-16% of W). The next sequence of measures is as follows: MBE (6-38%), EOBD (16-46%), RMBD (18-72%), REOBD (32-82%) and RMMBD (31-97%). Values of the d factor for each block effect measure show that taking into account the third criterion, clearly the best results were achieved for RMBD (1,5-2,69) and the next group of four measures: MBE (0,34-1,96), REOBD (0,29-1,56), RMMBD (0,29-1,33), MBD (0,67-1,00), followed by clearly the worst EOBD (0,28 - 0,51).

Based on the three criteria presented, REOBD seems to be the best measure of blocking artifact for a wide range of applications. RMMBD gives slightly worse results (noise and dynamics) but also may be applied for all tested medical images. Using RMBD and MBE seems to be also possible with great effectiveness, but rather in smaller set of applications. Regarding these criteria EOBD and MBD seem to be less advantageous. In spite of the fact that their dependence on noise level is the smallest, bad results in the range of the first and the third criteria eliminate these measures from majority of applications.

a)



b)



c)

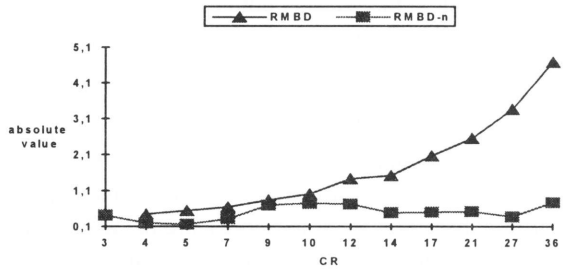


Figure 1. Values of REOBD (a), RMMBD (b) and RMBD (c) in dependence of compression ratio CR. 8-bit head MR image was compressed with using Block DCT technique. The results of these three measures for the same but noised image with Poisson noise distribution at each point are marked as -n.

REFERENCES

[1] A.Przelaskowski, M. Kazubek and T. Jamrógiewicz, "The most effective medical image compression methods," *Polish Journal of Medical Physics and Engineering,* Vol. 1, No 2, pp.133-144, 1995.

[2] A.M. Eskicioglu, "An improved graphical quality measure for monochrome compressed images," *Optical Engineering Midwest '95,* Illinois Institute of Technology, Chicago, IL, May 1995.