مجلة غريان للتقنية / المعهد العالي للعلوم والتقنية غريان
Gharyan Journal of Technology, High Institute of Science & Technology Gharian
Issue (4), December- 2018 -العدد الرابع، ديسمبر

Region of Interest Based Lossy-Lossless Hybrid Compression Technique for Medical Images Using DWT and GSM

Seddeq. E. Gharare [1], Esam Elossta [2]
[1] Department of Electrical and Computer Engineering, Faculty of Engineering, University of Gharyan, Libya
[2] Department of Computer Engineering, The Higher Institute of Science and Technology, Gharyan, Libya
seddeq@jgu.edu.ly [1], eelossta@ymail.com [2]

الملخص

تعتبر الصور الطبية من الطرق الشائعة الاستخدام لتشخيص الامراض. تشمل هذه الصور صور الحاسوب المقطعية وصور الرنين المغناطيسي وصور الموجات فوق الصوتية وصور اشعة اكس وغيرها. تعتبر كمية البيانات في الصور الطبية كبيرة جدا وبالتالي فانها تحتاج الى مساحة وسرعة عالية لتخزينها او ارسالها وعليه فان عملية ضغط تلك الصور يعتبر الحل الامثل لتقليل حجمها وزيادة سرعة ارسالها.

في هذه الورقة تم اقتراح طريقة هجينة لضغط بيانات الصور الطبية باستخدام الضغط بدون فقد والضغط بفقد للاجزاء المهمة والاجزاء الغير مهمة على التوالي. هذه الطريقة تعتمد على استخدام محول الموبجة المتقطع لضغط بيانات الصورة بفقد ومصفوفتى التدرج الرمادى والثنائية للضغط بدون فقد. النتائج المتحصل عليها تثبت ان الطريقة المقترحة افضل من بعض الطرق الاخرى في حالة الاجزاء ذات الاهمية صغيرة الحجم.

الكلمات المفتاحية: محول الموبجة المتقطع ، الاجزاء ذات الاهمية ، ضغط الصور ، الصور الطبية.

Abstract:

Medical images modalities are extensively adapted and used for disease diagnosis. These imaging modalities include computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), and X-ray… etc. The problem associated with medical images is the storage space and bandwidth required for archiving and transmission of this kind of images. Thus image compression is a key factor to reduce the bit rate for transmission or storage while maintaining an acceptable reproduction quality.

In this paper, an efficient ROI compression approach using hybrid lossy-lossless compression technique will be presented. This method is based on applying discreet wavelet transform (DWT) as a lossy method and grayscale matrix (GSM) coding algorithm as lossless method. The results show that the performance of the proposed method is much better than the other existing techniques especially with smaller regions of interest.

Keywords : DWT, ROI, Image Compression, Medical Image.

I. Introduction

Visual inspection of medical images is an important task in diagnosis that demands experience and great concentration. The rapid advancement in digital image processing has led to computer assisted diagnosis (CAD) [1]. Even the CAD is used for diagnosis purposes, still medical images have to be in a compressed form. [1,2]

Image communication systems for medical images have bandwidth and image size constraints that result in time-consuming transmission of analog raw images [2,3]. The movement towards digital images in radiology and telemedicine presents the problem of how to conveniently and economically store, retrieve and transmit volumes of digital images. Thus digital image data compression is necessary in order to reduce the storage of medical images and solve practical limitations of transmission bandwidth. However, as the number of digital modalities increases, the demand for an efficient medical image compression is increasing. Thus image compression is a key factor to improve transmission speed and storage, but it risks losing relevant medical information [2]. It exploits common characteristics of most images that are the neighboring picture elements or pixels are highly correlated [4]. It means a typical still image contains a large amount of spatial redundancy in plain areas where adjacent pixels have almost the same values.

Image compression techniques can be classified into two different categories; lossy and lossless. Lossless compression allows for the perfect reconstruction of the original images, but yields small compression ratios around 3:1 even under state of the art coding methods. [5]. On the other hand, significantly higher compression ratios can be obtained if the loss of quality can be allowed, thus; more compression is obtained at expense of higher image degradation, which may cause misdiagnosis. However, a hybrid lossy-lossless compression technique can be applied on different regions of the image. Since only a small portion of the image (ROI) might be diagnostically useful, this region can be lossless compressed while the rest is lossy compressed.

In this paper, an efficient hybrid lossy-lossless compression technique has been proposed. Our new lossless algorithm used as lossless technique to compress the ROI [6], while a lossy wavelet-based compression is used as lossy technique for the rest of image regions. More details on this technique will be explained in the next section.

II. Materials and Methods

A region of interest (ROI) is defined as the area of an image which is clinically or diagnostically important to doctors who can free to identify the ROI based on their needs. In this study a sample of 8-bit per pixel grayscale images have been used. The original MRI test images are shown in figure 1, while the original CT test images are shown in figure 2. These images are first read then a region of interest is chosen and extracted.

There are two methods to identify the ROI, one is manual and the other is automatic. The manual method was used in our case to identify the ROI of 10% and 15% size. The ROI has been losslessly compressed whereas the remaining image was lossy compressed.

The following figures show some of compressed images, where the GSM algorithm proposed in [6] were used as a lossless technique to compress ROI, while the DWT was used as a lossy technique to compress the remaining image. The general block diagram of the proposed method is illustrated in figure 3.

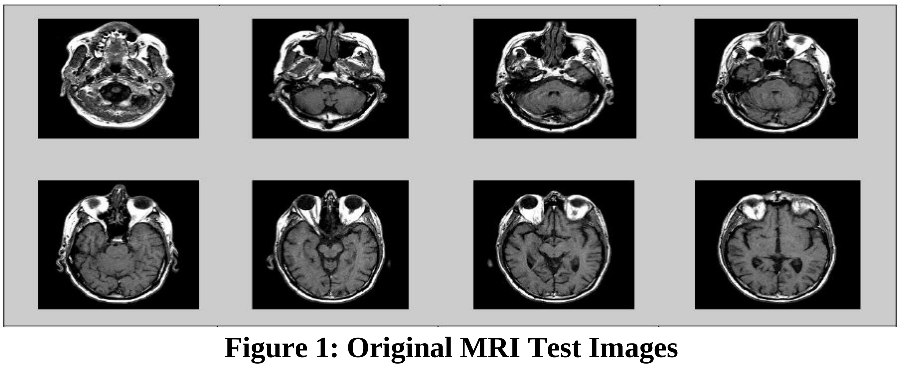

Figure 1: Original MRI Test Images

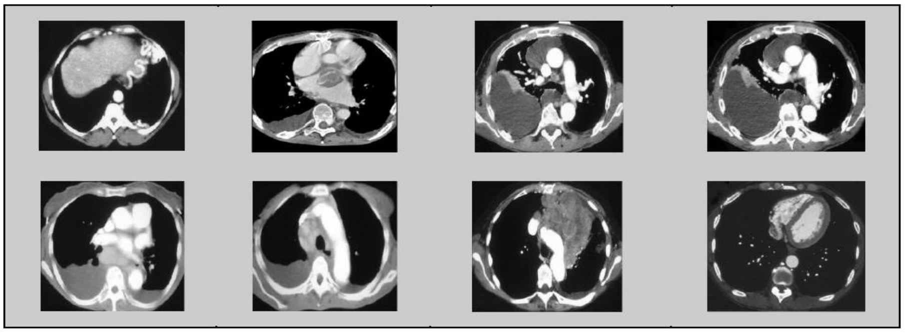

Figure 2: Original CT Test Images

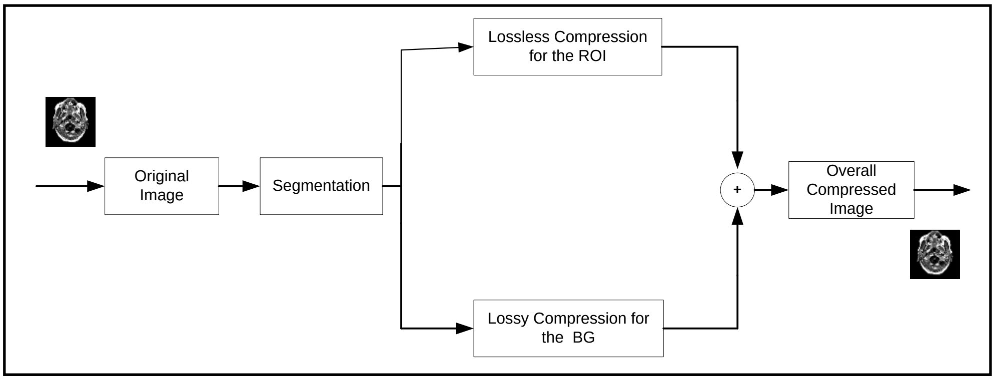

Figure 3: General Block Diagram of the Proposed Method

Table 1: Steps of the Proposed Method

1:// start 2:// Read the original image 3// Segment the image into ROI and BG subimages 4:// Segmentation Process: 5:// Select the coordinates of the ROI subimage 6:// if the selected coordinates are correct Extract the (ROI) 7:// else goto 5 8:// For the (ROI) subimage Apply the lossless algorithm [6] 9:// for the rest of mage Apply lossy compression using DWT 10:// end

The proposed lossless algorithm is based on only two matrices, binary matrix and grayscale matrix, that's why is called GSM The main steps of the proposed algorithm are as follows:

STEP1: Read the original image matrix [OR].

STEP2: Construct the binary matrix [BM] and grayscale matrix [GSM] as explained in the next steps.

STEP3: Compare each pixel in the matrix [OR] with the previous pixel in the same matrix as indicated in figure 3.

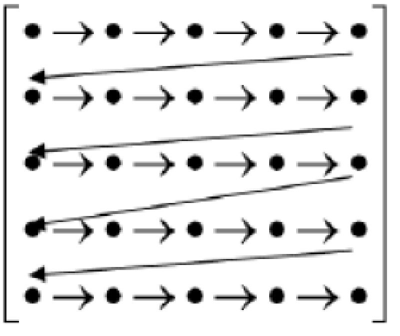

Figure 3: Original Image Pixels Comparaison

STEP4: The binary matrix elements are calculated as follow

$$[BM]_{i,j} = \begin{bmatrix} 0 & if \quad [OR]_{i,j} = [OR]_{i,j+1} \\ 1 & otherwise \end{bmatrix} \tag{1}$$

where: ***i****= 0, 1, 2… M*
j*= 0, 1, 2… N*
M*,* ***N*** *is size of the original image*

STEP5: First element in [GSM] is set to be equal to the value of the first pixel of [OR]

STEP6: The rest of the elements of [GSM] are calculated as follows:

$$[GSM]_k = \begin{bmatrix} nul & if & [OR]_{i,j} = [OR]_{i,j+1} \\ [OR]_{i,j} & otherwise & \end{bmatrix} \tag{2}$$

where: ***k****= 0,1 ,2….. **l***

***l** is size of the grayscale matrix [GSM]*

Note that [BM] is a two dimensions matrix while [GSM] is a one dimension matrix.

STEP7: The original image can be reconstructed as follows:

$$[rec\_img]_{i,j} = \begin{bmatrix} [GSM]_k & if & [BM]_{i,j} = 0 \\ [GSM]_{k+1} & if & [BM]_{i,j} = 1 \end{bmatrix} \tag{3}$$

The performance of the proposed algorithm is measured by compression ratio (CR) achieved which is defined as follows [7]:

$$CR = \frac{original \quad file \quad size}{compressed \quad file \quad size} \tag{4}$$

The quality of the compressed image is measured using Peak Signal-to-Noise Ratio (PSNR), based on the Mean Square Error of the reconstructed image. The formula for PSNR calculation is given by [7]:

$$PSNR = 20\log\left(\frac{2^B - 1}{MSE}\right)\text{dB} \tag{5}$$

where ***B*** is the bit depth of the image. For an 8-bit image, the PSNR is computed by [7]:

$$PSNR = 10\log\left(\frac{(255)^2}{MSE}\right)\text{dB} \tag{6}$$

MSE is the Mean Square Error and it can be calculated using the following formula [7]:

$$MSE = \frac{1}{NM}\sum_{1=0}^{N-1}\sum_{j=0}^{M-1}\left[\left|f(i,j) - f^*(i,j)\right|^2\right] \tag{7}$$

where:

M, N is the image size
f(i,j) is the original image
$f^*(i,j)$ is the compressed image

III. Results Discussion

The proposed method algorithm is explained in table 1. A sample of sixteen 8-bit grayscale images has been used in this study. Each image is broken down into two subimages (ROI and BG). The ROI size has been chosen to represent 10% and 15% of the original image.The ROI is processed using our proposed lossless coding algorithm [6], while the rest of the image is lossy compressed using discrete wavelet transform. Figure 4 and 5 shows the ROI technique applied on MRI and CT images respectively. The first row in each figure shows the original image, the extracted ROI and the background. The second row shows the compressed ROI using our lossless technique proposed in stage two, then the compressed background at high compression ratio and finally the overall reconstructed image with ROI and background.

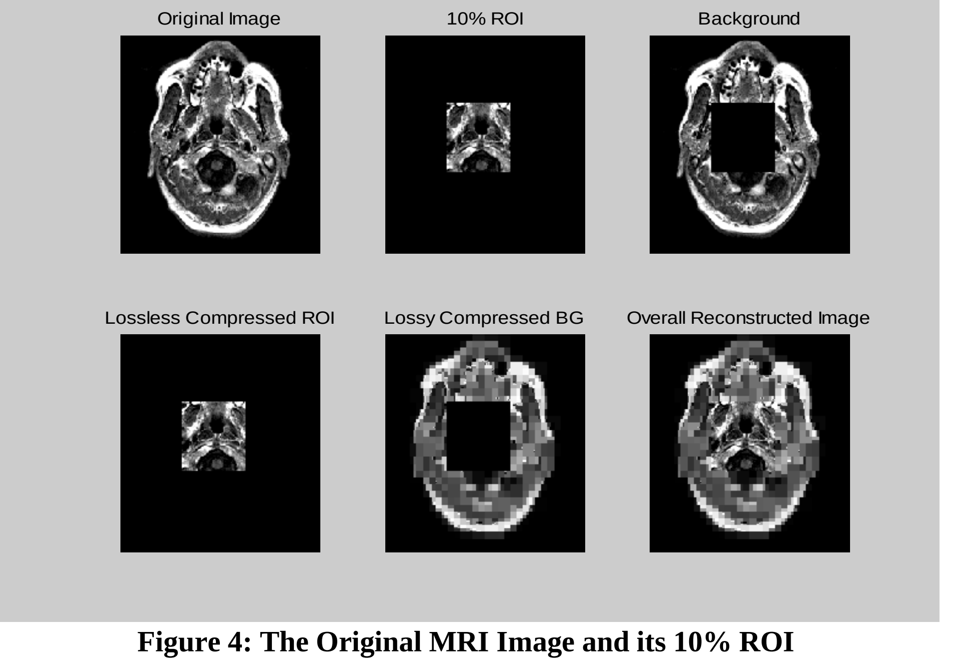

Figure 4: The Original MRI Image and its 10% ROI

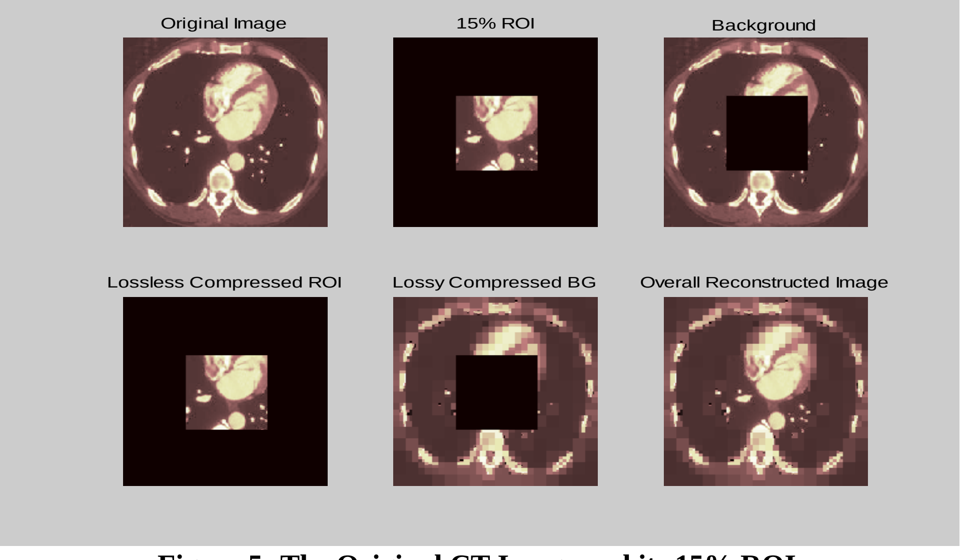

Figure 5: The Original CT Image and its 15% ROI

The PSNR comparison of the MRI images with 10% ROI and 90% background is plotted in figure 6 while the PSNR of the CT images with 15% ROI and 85% background is plotted in figure 7.

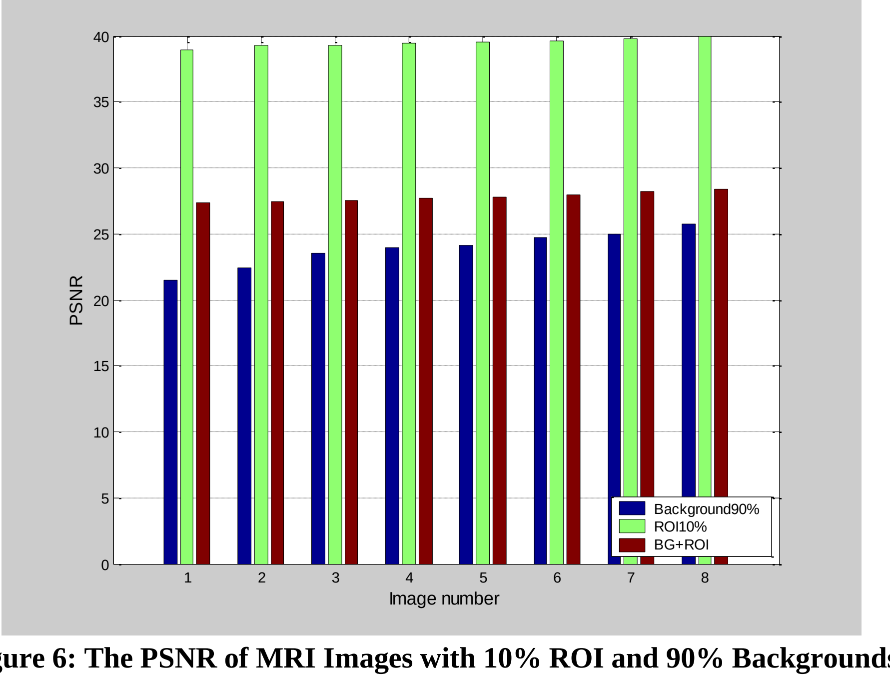

Figure 6: The PSNR of MRI Images with 10% ROI and 90% Backgrounds

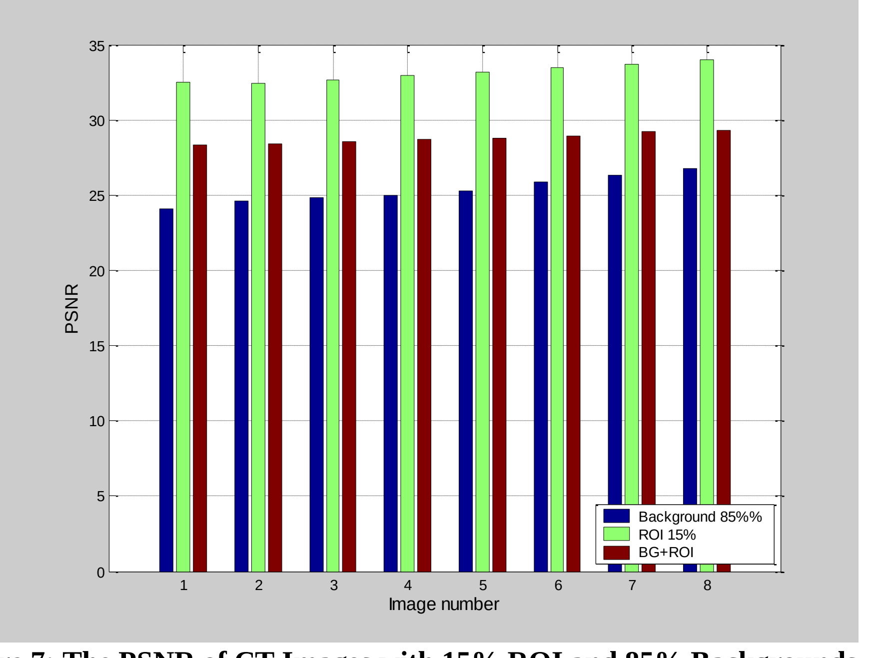

Figure 7: The PSNR of CT Images with 15% ROI and 85% Backgrounds

From these figures, if we compare the quality of the compressed image with respect to ROI size, it can be noticed that smaller ROI size can be compressed more efficiently. This is because of the correlation between neighboring pixels becomes higher in small regions than bigger ones.

The performance of the proposed technique is compared with other research results. The results comparisons are indicated in Table 2 which shows that the proposed technique performance is similar or better than other techniques.

Table 2: Performance Comparison of the Proposed ROI Technique

Method	***Technique***	***ROI size***	***CR***
Zhang & Wu Method [8]	DWT , JEPG2000	10% & 15%	12:1-18:1
Belc & Foo Method [9]	DWT , HC	10%	14:1 – 38:1
Chan Method [10]	DWT, Modified JPEG2000	10%	12:1 – 25:1
Christopolos Method [11]	DWT, Maxshift algorithm	8% - 25%	16:1 – 50:1
Proposed Method	DWT, GSM algorithm.	10% & 15%	16:1 – 48:1

VI. Conclusion

In this paper, ROI based lossy-lossless hybrid compression technique is presented. Different ROI's sizes are extracted in which the pixels in the ROI's have been replaced by zeros. The ROI is losslessly compressed using our proposed algorithms [6], while the rest of the image is lossy compressed with high compression ratio using discrete wavelet transform. The advantage of the proposed method comes from its simplicity and efficiency compared with existing methods.

References

[1] S.Yu,"A CAD System for the Automatic Detection of Clustered Microcalfications in Digital Mammogram Films", IEEE Trans., Medical Imaging, vol. 19(2), 2000, pp.115-126.

[2] Carbal J.E, Kim.Y, "Multimedia Systems for Telemedicine and Their Communication Requirements", IEEE Communication Magazine, pp 20-27, 1996

[3] S. D. Streams, L. Tan, and N. Magotra, "Lossless Compression of Waveform Data for Efficient Storage and Transmission", IEEE Transactions on Geosciences Remote Sensing, vol. 3I, no. 3, pp. 645-654, May 1993.

[4] D.Clunie,"Lossless Compression of grayscale medical Images-Effectiveness of Traditional and State-of-the-art Approaches", Proc.SPIE, Medical Imaging,vo.3980, San Diego, CA, pp.74-84,Feb 2004

[5] Sayood K. "Introduction to Data Compression", Second edition, Academic Press.NY, USA.2000

[6] Seddeq E Ghrare, Mohd. Alauddin. M. ALI, Mahamod Ismail, "An Efficient Low Complixity Losslss Coding Algorithm For Medical Imges", Americal Journal of Applied Science, 6(8), pp, 1502-1508, 2009

[7] Seddeq E Ghrare, , Mohd. Alauddin. M. ALI, Mahamod Ismail, Kasmiran Jumari, "Diagnostic Quality of Compressed Medical Images: Objective and Subjective Evaluation", The Second IEEE Asia International Conference on Modelling and Simulation, 12,13, Kuala Lumpur , Malaysia, pp 923-927, May 2008

[8] N. Chang Zhang, X. Wu, " A Hybrid Approach of Wavelet Packet and Directional Decomposition for Image Compression” Proceeding of IEEE CCECE’99 pp.755-780, 1999.

[9] Belc, D.V.; Foo, S.Y.; Roberts, R.O, “Comparisons of multi-resolution analysis methods for mammogram and fingerprint image compression”, The 18th International Conference on Systems Engineering, 2005. ICSEng 2005. 16-18 Page(s):269. Aug. 2005

[10] Chan, H.-Y., Sari-Sarraf, H., Grinstead, B. I., and Gleason, S. S.,“Content-Based Compression of Mammograms with Customized Fractal Encoding and a Modified JPEG2000,” *Journal of Optical Engineering, vol.* **43,** p. 2986, December 2004.

[11] C. Christopoulos, and Carlender, M.L. “Region of interest coding in JPEG 2000”. Journal of Signal Processing & Image Communication. 17: 105-111 , 2002

[12] Gonzalez R, R. Woods and S. Eddins, “Digital Image Processing using MATLAB”, International Edition, Prentice Hall. 2004

