Adaptive Still Image Compression Using Semi-automatic Region of Interest Extraction

N. Lamouri, M. Gharbi, M. Benabdellah, F. Regragui and E. H. Bouyakhf

Abstract—**In most image processing applications, the user is only interested in parts of the information conveyed through the image. In this paper, we present an adaptive method of compression of still images. It consists first on a semi-automatic extraction of the region of interest (ROI) based on region growing segmentation. The context and the ROI are then processed separately so as to preserve the information in the ROI and degrade in a controlled way the context using reversible and irreversible techniques such as JPEG, JPEG 2000 and Run Length Encoding (RLE). Performances of these techniques in terms of compression rate are compared based on their applications to biomedical images.**

Key words—**Adaptive compression, region of interest (ROI), extraction, region growing segmentation, JPEG, JPEG 2000, run length encoding (RLE).**

I. INTRODUCTION

Digital images belong to the data type whose storage requires a broad capacity and for which the transmission needs a broad band-width. However, in most image processing fields, the user is only interested in part of the information transmitted through the image. It would be then interesting to apply non-uniform processing to various regions of the image in order to preserve data in the ROI and degrade the context in a controlled manner.

Adaptive image compression is found in several works. Indeed, Guisto *et al* [14] proposed a compression method which first locates the ROI and then applies techniques such as polynomial approximation and vectorial quantization to these regions. Nguyen [15] proposed a selective video compression method based on region for transmission with very low rate. In 1998, Benharrosh [16] developed a compression method which avoids losses in the ROI. The new image coding standard JPEG 2000 gave rise to several applications to ROI compression [10]—[13]. Indeed, this new standard provides the possibility to define the ROI in rectangular or elliptic forms. Thus, it is possible to non-uniformly assign the quality in an image. In most processed images including biomedical images, the ROI take random forms. In the case of manual extraction, the operator must select rectangular or elliptic zones which must contain the ROI. This will involve a discontinuity between the selected areas and the context. This discontinuity will act negatively on the visual quality of the image. To mitigate this problem, we propose to extract the ROI using a semi-automatic method: the user selects part of the concerned zone, and the algorithm automatically seeks the remainder of the ROI and integrates it. Then, these regions are slightly compressed using reversible or irreversible techniques provided that the context is highly compressed using non conservative techniques, not necessarily the same ones applied to the ROI.

Section II of this paper gives details on the suggested principle of ROI extraction. Section III describes an adaptive still image compression approach. Experimental results are presented in section IV. Finally, we conclude the paper in section V.

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II. REGION OF INTEREST EXTRACTION

The first stage of the proposed strategy consists of detecting and then extracting the existing ROI in the image. The extraction can be carried out manually [1]. In this manner, the user selects objects of interest directly on the image. Thus, the selected form is linear, rectangular or elliptic. It is well known that the ROI take random forms and the user cannot select them manually (e.g., several infected cells in a biomedical image). Instead, he will define geometrical forms containing these ROI; this will involve a discontinuity between pixels of the context and the retained pixels. Consequently, the visual quality of the image will be degraded. To overcome this problem, we propose a semi-automatic extraction based on region growing segmentation [2], [3].

A. Region growing segmentation

This method consists of growing a region around one or more initially selected pixels. The decision to integrate a pixel into the region under construction is based on a similarity criterion imposed on this region.

In our case, the operator selects the starting region manually. This region must belong to the ROI. Fisher test [4] is employed to determine the degree of similarity Ds

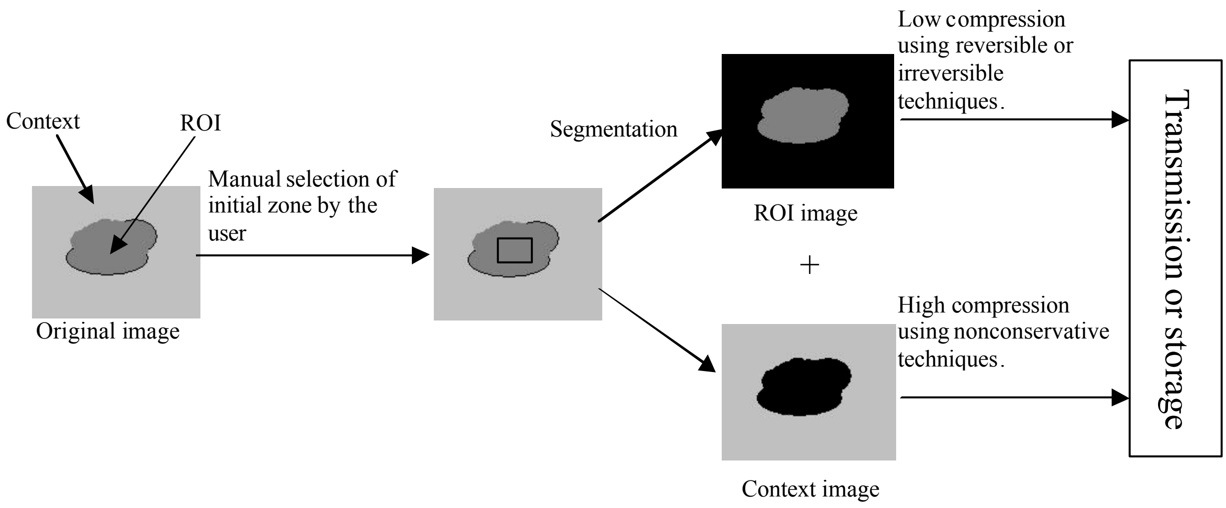


Fig. 1. Adaptive compression scheme

between a pixel pc of intensity $I(i,j)$ and pixels in the region under construction Rc :

$$Ds(Rc,pc) \equiv \left[\frac{\left| m_{Rc} - I(i,j) \right|}{s_{Rc}} \leq S_k \right] \tag{1}$$

m_{Rc} and s_{Rc} denote respectively the average and the standard deviation of the region under construction, given by:

$$m_{Rc} = \frac{1}{Card(Rc)} \sum_{i,j \in Rc} I(i,j) \tag{2}$$

$$s_{Rc} = \sqrt{Var(Rc)} \tag{3}$$

and where,

$$Var(Rc) = \frac{1}{Card(Rc)} \sum_{i,j \in Rc} (I(i,j) - m_{Rc})^2 \tag{4}$$

and S_k is a threshold value.

This extraction approach is very effective when the ROI is relatively homogeneous. To extend the method to complex ROI, other segmentation techniques must be employed such as contour detection and texture analysis.

B. Semi-automatic extraction of the region of interest

The suggested approach consists of separating the ROI pixels and those of the context into two distinct images (Fig. 1). In this way, it will be possible to apply different compression techniques to the ROI and the context. Moreover, the pixels retained initially by the user and those introduced after segmentation take the same space co-ordinates as the original image. The intensity value of the other pixels of the ROI image is reduced to zero. This will make it possible to easily locate the ROI during image reconstruction and to reduce the quantity of information transmitted in the ROI image and consequently increase the compression ratio.

III. ADAPTIVE COMPRESSION

The adaptive compression approach is based on separating the treatment of the ROI with that of the context. Fig. 1 presents a diagram of the steps in the suggested method.

A. Region of interest compression

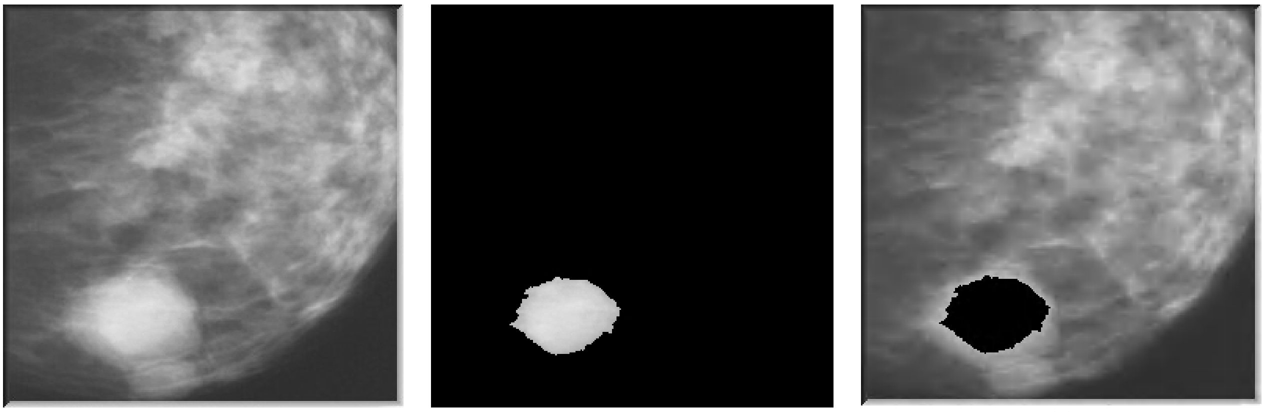
The objective of the proposed method is to preserve the information transmitted through the image in the ROI. One can choose to use reversible compression algorithms on the ROI to avoid degrading them [5]. However, one could allow a light degradation in order to increase the compression ratio.

B. Context compression

In the context, the problem is completely different. Indeed, the context must allow the user to locate the scene as a whole. It does not need to be represented with full resolution [1], [6]. One can choose to strongly compress it according the user's needs.

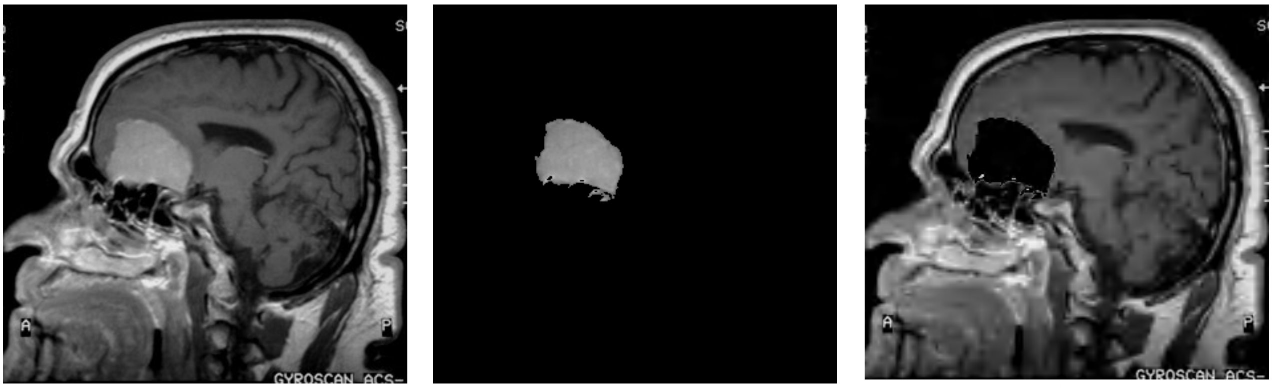
C. Image reconstruction

The two images are compressed and stored or transmitted in two distinct files. After compression/decompression cycle, the image is reconstructed by superposing the ROI image and context image: each pixel of the reconstructed image is obtained by calculating the sum of the ROI and context pixel radiometries which are in the same position. However, this method may cause degradation in the reconstructed image at the interface (see Fig. 4 and 5). To overcome this problem, a third image can be used during the adaptive compression cycle in such a way that this image locates the ROI and the context by assigning to each pixel the value 1 if this one belongs to the ROI and 0 if it belongs to the context. Thus the image will be binary and will not take much space of storage.



(a) (b) (c)

Fig. 2. (a) **Originale mammography image:** Dimensions=256x256 pixels. File size=64,01Ko. File type=PGM. (b) **Compressed ROI image:** Dimensions=256x256 pixels. File size=2,45Ko. Quality=85%. File type=JPEG 2000. Threshold value=2,6. (c) **Compressed context image:** Dimensions=256x256 pixels. File size=3,17 Ko. Quality=25%. File type=JPEG 2000.



(a) (b) (c)

Fig. 3. (a) **Original brain image :** Dimensions=305x285 pixels. File size=84,90Ko. File type=PGM. (b) **Compressed ROI image:** Dimensions=305x285 pixels. File size=2,93Ko. Quality=85%. File type=JPEG 2000. Threshold value=3,15. (c) **Compressed context image :** Dimensions=305x285 pixels. File size=3,94 Ko. Quality=25%. File type=JPEG 2000.

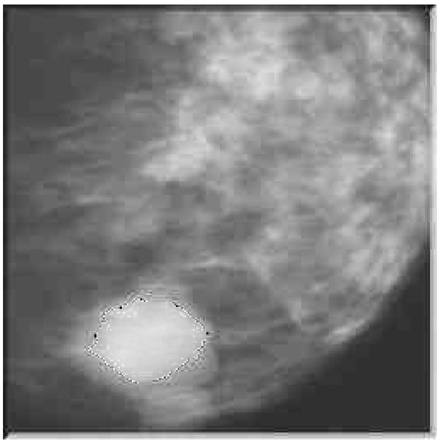


Fig. 4. Reconstructed Mammography image .

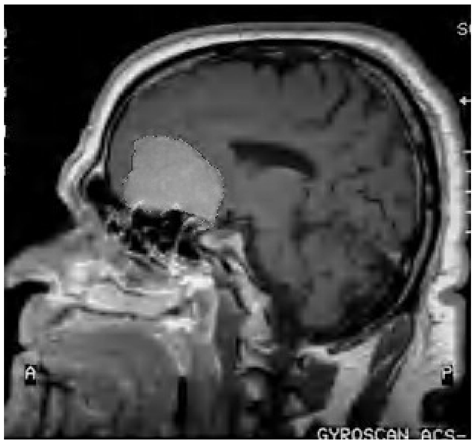


Fig. 5. Reconstructed brain image.

TABLE I

UNIFORM COMPRESSION RESULTS

	PGM	JPEG	JPEG 2000	RLE
Mammography	64Ko*	28Ko*	25Ko*	75Ko*
Brain	85Ko*	45Ko*	42Ko*	87Ko*

Ko : Kilo Octet.
* Lossless compression

TABLE II

ADAPTIVE COMPRESSION RESULTS

		JPEG	JPEG 2000	RLE
Mammography	Context	7Ko** R=9.28	3.7Ko** R=17.56	79Ko R>1
	ROI	4Ko* R=16.25	2.5Ko* R=26	5.6Ko R=12
Brain	Context	7Ko** R=12.14	5Ko** R=17.00	86Ko R=1
	ROI	4Ko* R=19.77	3Ko* R=28.33	6Ko R=14

Ko: Kilo Octet.
R: Compression ratio.
* Lossless compression.
** Lossy compression.

IV. RESULTS

The method was applied to images with one ROI. Figure 2 presents the results of the application of the method by using JPEG 2000 on a mammography containing one suspect zone (ROI).

Figure 3 shows the results of the applying the method on a brain image revealing a tumour (ROI). The starting images are of type PGM in gray-scale with 8 bits per pixel. We applied lossless compression to the ROI and lossy compression to the context. We tested the method with various compression algorithms: JPEG, JPEG 2000 and RLE (Run Length Encoding). Table I illustrates the results of uniform compression for both the ROI and the context found in the mammography and brain images. Table II shows the results when adaptive compression is applied to these images.

Comparison of these results reveals that adaptive compression makes it possible to reach high compression ratios with an assessed visual quality, especially on the ROI (fig. 4 and 5). These results depend on the compression techniques used, the dimensions of the ROI and certainly the number of ROI existing in the image.

V. CONCLUSION

In this paper, we presented an adaptive compression method based on the fact that the user is interested only in part of the information conveyed through the image. The ROI are extracted using a semi-automatic method. They are compressed thereafter with a reversible or irreversible algorithm with low degradation. The context is highly compressed using an irreversible algorithm. The results obtained showed that this method makes it possible to obtain a high compression ratio while preserving good visual image quality especially in the ROI. Our study was limited to images with relatively homogeneous ROI. However, it is possible to extend this approach to images which contain more complex ROI by combining other segmentation techniques such as contour detection and texture analysis.

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