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JPEG2000 vs. Full Frame Wavelet Packet Compression for Smart Card Medical Records

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Abstract— **This paper describes a comparison among different compression methods to be used in the context of electronic health records in the newer version of "smart cards". The JPEG2000 standard is compared to a full-frame wavelet packet compression method at high (33:1 and 50:1) compression rates. Results show that the full-frame method outperforms the JPEG2K standard qualitatively and quantitatively.**

Keywords— **Electronic Medical Records, Image compression, JPEG2000, smart cards.**

I. Introduction

Much work has been carried out on medical image compression. The prospect of reducing the large file sizes and long transmission times for this kind of information has resulted in a large number of approaches despite the fact that storage costs have gone down and bandwidth availability has increased significantly in the recent past. The DICOM standard for digital imaging communications and storage in its latest version includes the specification for the use of compressed images, most notably using the (relatively new) JPEG 2000 standard. Most of the recent developments are based on methods that apply a transformation on different sub-images in order to reduce the computation time. However, this constraint is applicable only to systems where the image has to appear "instantly" as is the case of telemedicine, web-based transmission or in PACS systems.

In the case of electronic patient records, recent developments in the field of semiconductor memory and microprocessors have led to the design of a new generation of "smart cards" that can hold a significant amount of patient data and can fulfill the ideal of a patient carrying all his important health information with him at all times. However, the memory capacities of these cards and the applications that have been developed up to date have been based around the storage of text information. The development of new methodologies of efficient image compression allows us to propose the use of a wavelet-based (full frame wavelet packets) method to achieve a 50:1 compression ratio with qualities that surpass other standardized approaches.

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This manuscript is organized as follows: Section II deals with the methodology of the study, Section III shows the results, while Section IV discusses the results and proposes the application of the results to Medical Health Record files on "smart cards".

II. Methodology

For this study, we used three magnetic resonance images (axial, sagittal and coronal) from the same subject, and an additional "Lena" image. The magnetic resonance images were selected from a database provided by the Institute of Neurobiology at the National University, UNAM. All the images were 8 bit gray level and 256 x 256 pixels in size. The images were compressed to the JPEG2000 standard using JPEG2000 Dropper 1.1, which uses 32 x 32 pixel tiling and the Daubechies 9/7 filter banks. The full-frame compression was carried out using Matlab's Wavelet Toolbox, using a 5 level wavelet packet decomposition of the 2.8 biorthogonal filters and the entropy criterion for the selection of the best trees. We followed this latter approach due to the fact that previous studies have proven the suitability of these filters for wavelet packet compression of magnetic resonance images at high rates. Images were compressed to a 33:1 and 50:1 ratios, corresponding to 0.56 and 0.37 bits per pixel (3 and 2% of the original file size respectively).

III. Results

Images were compressed and decompressed according to the previously outlined methodology. Image matrices were converted to an intensity image in [0,1] and the peak signal to noise ratio was calculated. Peak signal-to-noise ratio, (PSNR), is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR is most commonly used as a measure of quality of reconstruction in image compression. The higher the ratio, the better the reconstruction. Typical values for the PSNR in image compression are between 30 and 40 dB. It is most easily defined via the mean squared error (MSE) which for two mxn monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left[I(i,j) - K(i,j)\right]^2$$

The PSNR is defined as:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

Where, MAX_I is the maximum pixel value of the image.

Table 1 shows the results of the PSNR as calculated for both sets of images. As it can be seen, the results show that except for one case, PSNR are higher for the images compressed by the full-frame method. As expected, higher ratios were obtained for “better behaved” images, where the extent of the dark backgrounds eliminated the border artifacts, and thus had less amount of noise.

	Jpeg2000	Ffwpbi28
Axial33	36.33	38.1
Coronal33	38.00	39.73
Sagittal33	32.99	35.91
Lena33	33.05	32.91
Axial50	33.05	35.03
Coronal50	35.30	35.30
Sagittal50	30.84	31.42
Lena50	30.51	32.92

Table 1. Peak signal to noise ratios for compression at 33:1 and 50:1 for Jpeg2K and Ffwpbi28

IV. DISCUSSION

In the case of medical image compression, a quantitative analysis of the PSNR is desirable, but is not the only type of evaluation possible. There are cases where an image has a higher PSNR than another, but is visually inferior, so care should be taken to include a qualitative analysis whenever possible. Figures 1 and 2 shows a series of images in order to make the compression results available for a qualitative analysis. Only 50:1 compressed images are shown in order to make the differences more noticeable. Top images are the originals, and are followed by JPEG2000 and FFWP respectively. In the Lena and Sagittal images, JPEG images are more blurred, while FFWP presents a little high-frequency noise. The same comments can be said for the Coronal images, but in the case of the axial MR image, the result for the FFWP is practically the same as for the original image. These qualitative results are similar to the PSNR figures, but differ in the case of the best reconstruction, where the best figures are for Coronal (PSNR) vs. axial (qualitative). The case of the coronal PSNR figures illustrates some of the previously expressed comments: the values are the same for both methods, but image quality is discernibly better in the case of the FFWP method.

In order to make the differences of the images more noticeable, we present a series of false color images of the differences between the original and the transformed images. We provide a color bar to show the significance of these differences. On the left side, we present the images compressed with the JPEG2K algorithm while the right side presents the differences for the full-frame wavelet packet decompositions. As it can be seen, intensities of the differences in the JPEG2K algorithm are higher, showing a greater degree of mismatch than the FFWP. In addition to this, the difference images in the first case show a greater error in the details of the edges of the images. This means that there is a larger error in the structural elements in this case when compared to the methodology we propose. These two qualitative results show the advantages of our method over the standardized JPEG2000. One drawback of the full-frame method is that the algorithm is significantly slower than the JPEG2000. This is to be expected, as the latter method carries out its decompositions on sub-images as small as 32 x 32 pixels when compared to a complex 5 level 256 x 256 pixel transform.

V. CONCLUSIONS

The results show that the full-frame method is better than the JPEG2000 approach. However, it should be noted that JPEG2K images are of good quality and the calculations are fast. Moreover, these latter images are significantly better than regular JPEG compressed images at the same rates. When dealing with the task of storing compressed images in a portable medical archive or patient file on a device such as a “smart card”, it should be noted that available devices still do not possess a large amount of storage “on board”, so the efficient compression of images with good enough quality for review is important, while the necessity of an immediate result is lessened. Compression times of the order of a few minutes can be acceptable, and thus the approach we present can contribute to make the idea of a complete transportable patient record manageable.

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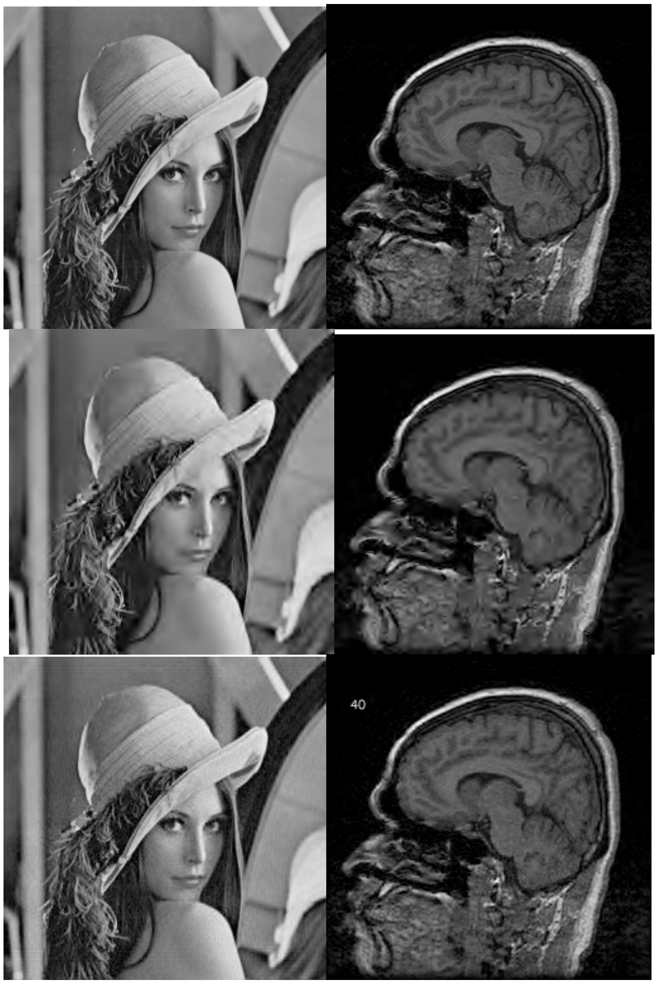

Figure 1. Comparison among original (top), Jpeg2k (middle) and FFWP (bottom) at a 50:1 compression rate (2% of coefficients are not zero). Lena(left) and Sagittal MR (right) images

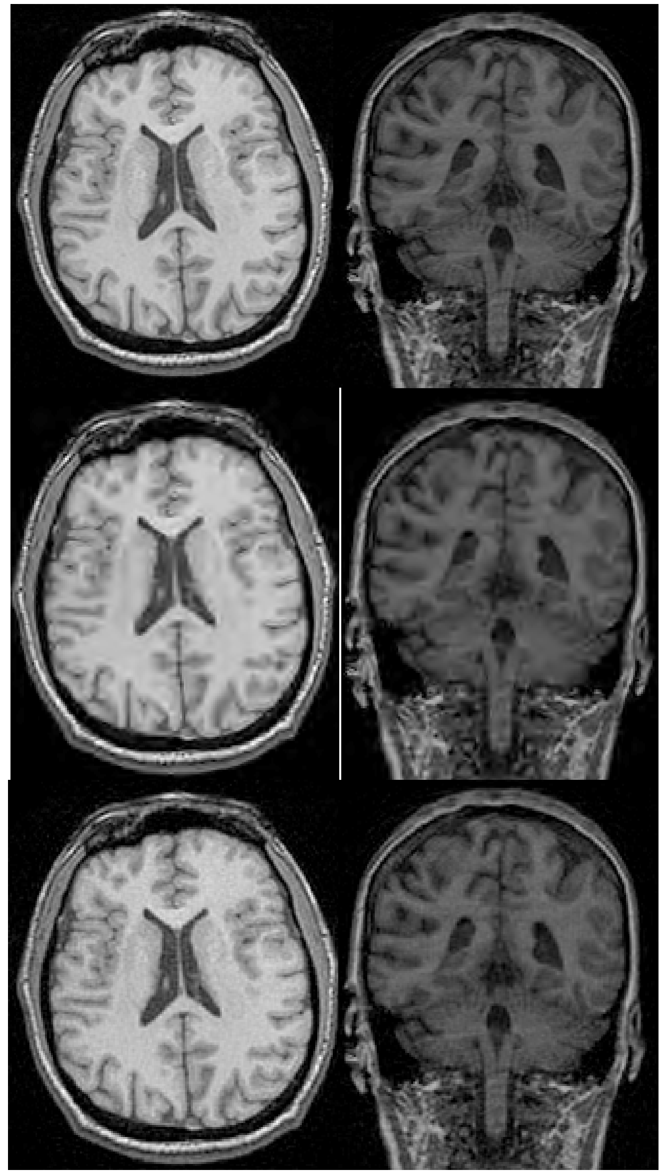

Figure 2. Comparison among original (top), Jpeg2k (middle) and FFWP (bottom) at a 50:1 compression rate (2% of coefficients are not zero). Axial(left) and coronal (right) views.

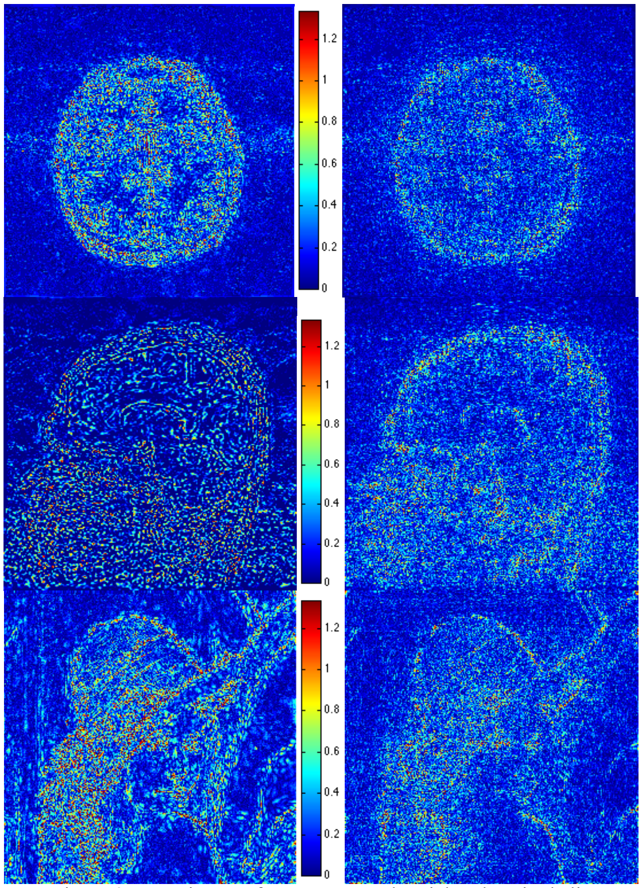

Figure 3. Error images for MRI coronal, axial and sagittal slices as well as for the Lena image left: jpeg2000, right, ffwp. Color scale shows full scale variation.