# *Medical Image Compression Using IIR Wavelet Filter Banks*

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**Abstract.** The proper utilization of digital medical imaging technology and applications requires image compression. The proposal in this paper is based on the IIR wavelet filter bank, and it suggests an image compression algorithm. The performance of the scheme has been measured using prescribed performance measures. The results demonstrate that the proposed method performs preferable compression than other compression methods. The results obtained are compared with wavelet-based filters bank in order to improve the compression using our approach. When compared to standard approaches, the results are quite excellent in terms of compression ratio and compressed image quality.

## INTRODUCTION

Digital medical imaging is an important and well-established part of the full chain of patient dealing in all modern hospitals. Medical imaging styles include: magnetic resonance imaging, computerized tomography, X radiographs , and ultrasonography, etc. These styles allow you to view anatomical cross sections and physiological states in a variety of ways. The medicinal images have large storage requirement. Due to network bandwidth and storage space constraints, the images must be compressed before being sent and saved. As a result, image compression techniques are required to save storage and transmission space and time [1][2]. Lossless compression and lossy compression are the two types of medical image compression techniques [3].

## LITERATURE REVIEW

In 2012 M. M. H. Chowdhury and A. Khatun proposed in [4] an image compression technique based on DWT. This technique achieves high compression ratios while avoiding image quality degradation. Using a set of genuine images, the effectiveness and resilience of this approach has been demonstrated. The suggested compression technique was compared to other commonly used compression strategies. When compared to alternative compression strategies, the proposed methodology performs better.

In 2016 R. Sharma,et al. Discussed in [5] a lossless compression model with a high compression rate. The medical photos are accurately coded thanks to the hybrid technicality.

In 2017 F. Liu,et al. The current state of image compression standards in medical imaging applications, as well as the legal and regulatory issues surrounding compression in medical settings, were discussed in [6].

Based on IIR wavelet filter banks, this paper proposed a new algorithm for medical image compression that could provide the best compression performance.

## IIR WAVELET FILTER BANKS BASED COMPRESSION

DWT is an efficient tool for image processing applications. DWT that implemented efficiently with a filter banks, which can be accomplished using IIR or FIR filters [7]. The wave digital filter is one of the IIR digital filters' structures. [8]. A Bireciprocal Lattice Wave digital filters (BLWDFs) are special form of lattice wave digital filters(LWDFs) [9]. Wavelet transform implementations and wavelet bases are obtained from orthonormal perfect reconstruction quadrature mirror filter bank. Figure 1 shows the structure of a 2-channel QMF bank. [10].

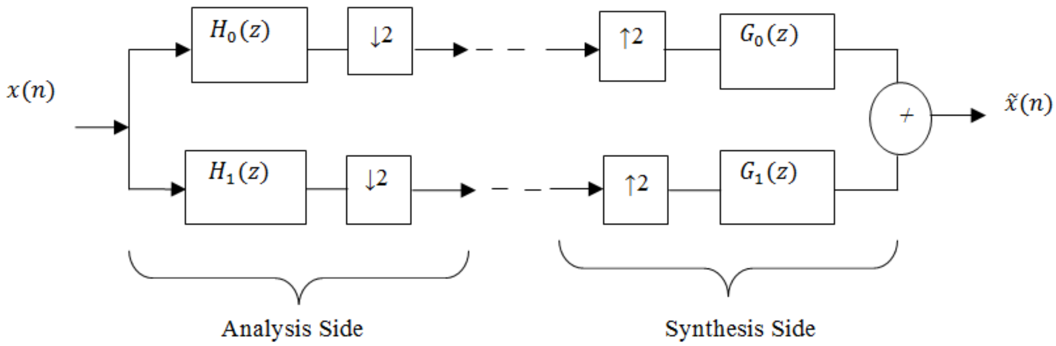



**FIGURE 1.** Structure of a 2-channel Quadrature Mirror Filter bank [10].

An efficient Quadrature Mirror Filter bank structure is achieved by an all-pass based polyphase network implementation according to Fig. 2.

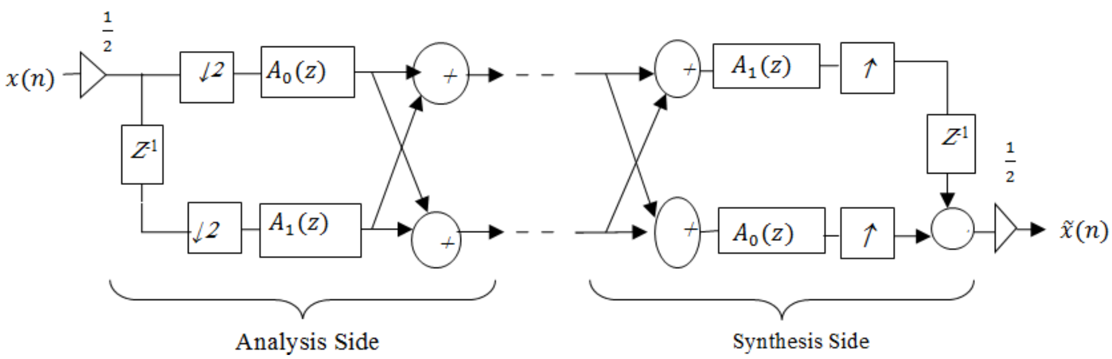



**FIGURE 2.** Efficient structure of the wavelet filter bank with IIR filters [9].

As shown in Fig. 2, the transfer function of a low-pass BLWDF is

$$H_o(z) = \frac{1}{2}[A_o(z) + z^{-1}A_1(z)] \quad (1)$$

where $A_o(z)$ and $A_1(z)$ are all-pass sections and can be expressed, as [9]

$$A_0(z) = \prod_{i=2,4,..}^{(N+1)/2} \frac{\alpha_i + z^{-1}}{1+\alpha_i z^{-1}} \quad (2)$$

$$A_1(z) = \prod_{i=3,5,..}^{(N+1)/2} \frac{\alpha_i + z^{-1}}{1+\alpha_i z^{-1}} \quad (3)$$

where $\alpha_i$ is the multiplier coefficient's value in the $i^{th}$ all-pass function and N is the $H_o(z)$ filter order, which are selected as in refrences [11] [9] [12] for getting ($7^{th}$ ,$9^{th}$ ,$11^{th}$ ) IIR Wavelet Filter Banks.

## IMAGE QUALITY MEASUREMENT

Throughout this paper numbers are given for four measures of compression performance. These measures are

**1. compression ratio (CR)**

The compression ratio (CR) is the proportion of the original image size to the compressed image size [13].

$$Compression\ ratio = \frac{original\ image\ size}{compressed\ image\ size} \quad (4)$$

**2. SNR and PSNR**

The basic methods for quantitatively comparing a reconstructed image with the original are SNR and PSNR. SNR is measured in decibels (dBs).

$$SNR = 20\ log_{10} \frac{\sqrt{\frac{1}{RC}\sum_{r=1}^{R}\sum_{c=1}^{C}[y(r,c)]^2}}{\sqrt{MSE}} \quad (5)$$

MSE: mean square error is computed as

$$MSE = \frac{1}{RC}\sum_{r=1}^{R}\sum_{c=1}^{C}|y(r,c) - \tilde{y}(r,c)|^2 \quad (6)$$

$y(r,c)$ is the original image.
$\tilde{y}(r,c)$ is the reconstructed image.

and PSNR is calculated in dBs by the following equation:

$$PSNR = 10\ log_{10}\left(\frac{[S-1]^2}{MSE}\right) \quad (7)$$

Where S =$2^{\upsilon}$, υ is number of bits/pixel (S=256 for images with resolution of 8 bits/pixel) [14].

**3. Correlation factor (Cor)**

Correlation factor (Cor) is a metric that determines how similar two images as [15]:

$$Cor = \frac{\sum_{r=1}^{R}\sum_{c=1}^{C}(y(r,c)-\bar{y})\ (y(r,c)-\bar{\tilde{y}}\ )}{\sqrt{[\sum_{r=1}^{R}\sum_{c=1}^{C}(y(r,c)-\bar{y})^2][\sum_{r=1}^{R}\sum_{c=1}^{C}(\tilde{y}(r,c)-\bar{\tilde{y}}\ )^2]}} \quad (8)$$

where
$\bar{y}$ is the mean of $y(r,c)$, that is,

$$\bar{y} = \frac{1}{R\times C}\sum_{r=1}^{R}\sum_{c=1}^{C}\ y(r,c) \quad (9)$$

$\bar{\tilde{y}}$ is the mean of $\tilde{y}(r,c)$ , that is,

$$\bar{\tilde{y}} = \frac{1}{R\times C}\sum_{r=1}^{R}\sum_{c=1}^{C}\tilde{y}(r,c) \quad (10)$$

## SIMULATION RESULTS

The presented approaches are simulated in Matlab. A set of MRI images are selected as test data. All are gray level images shown in figure 3.The Decomposition of MRI images using three IIR wavelet filter bank structures are shown in figure 4. Table 1 gives the performance of designed IIR wavelet filter bank on the input images. The performance of these wavelet filter banks was analyzed and plotted in figure 5.

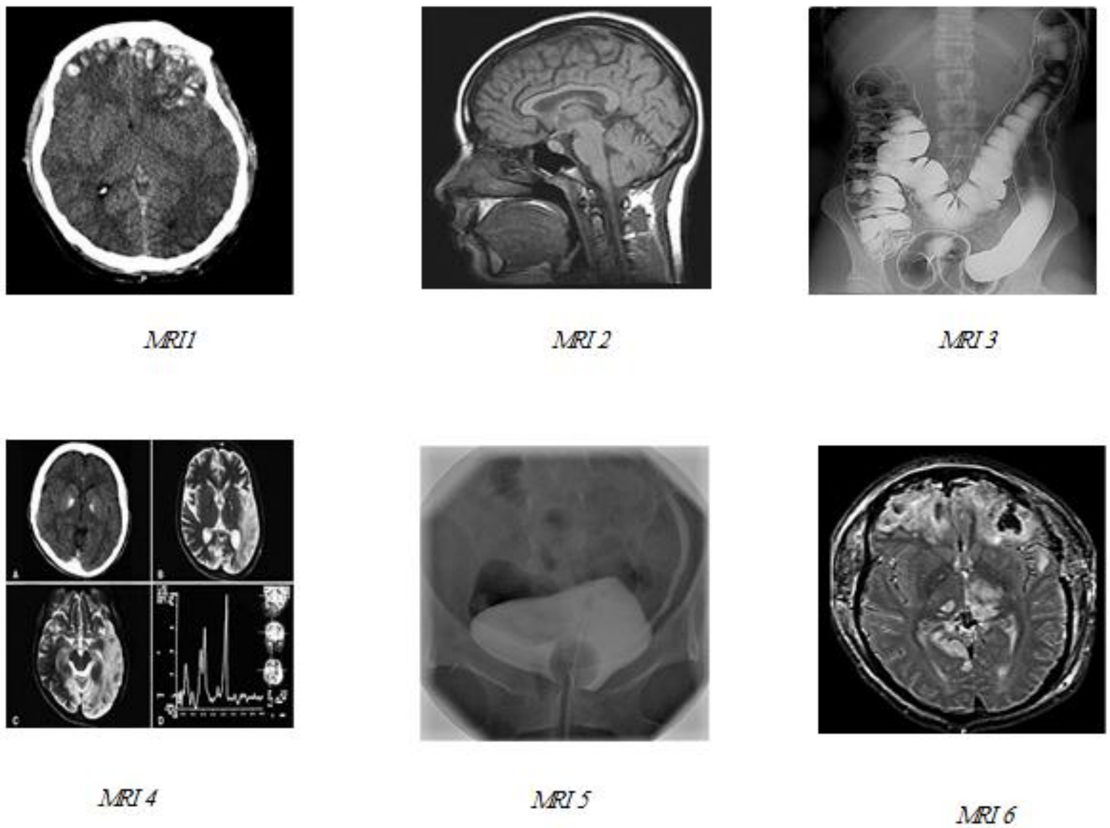
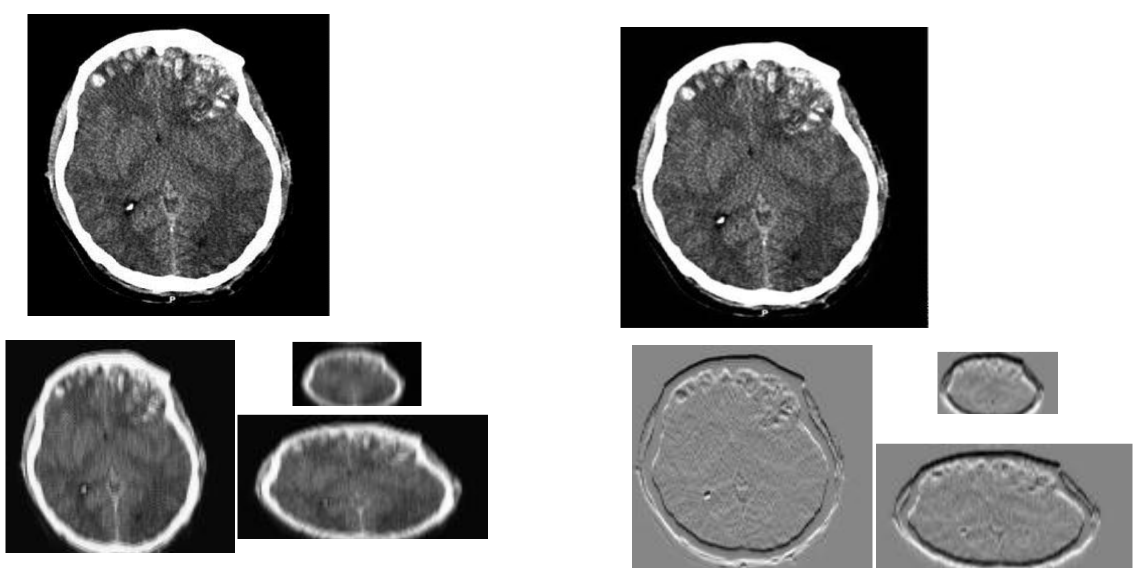
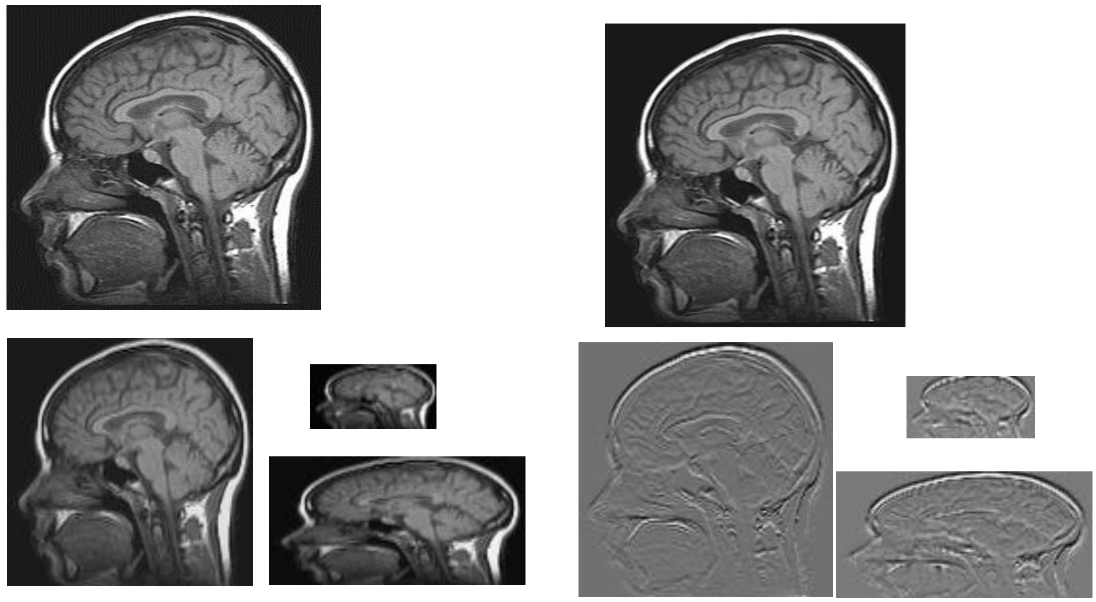


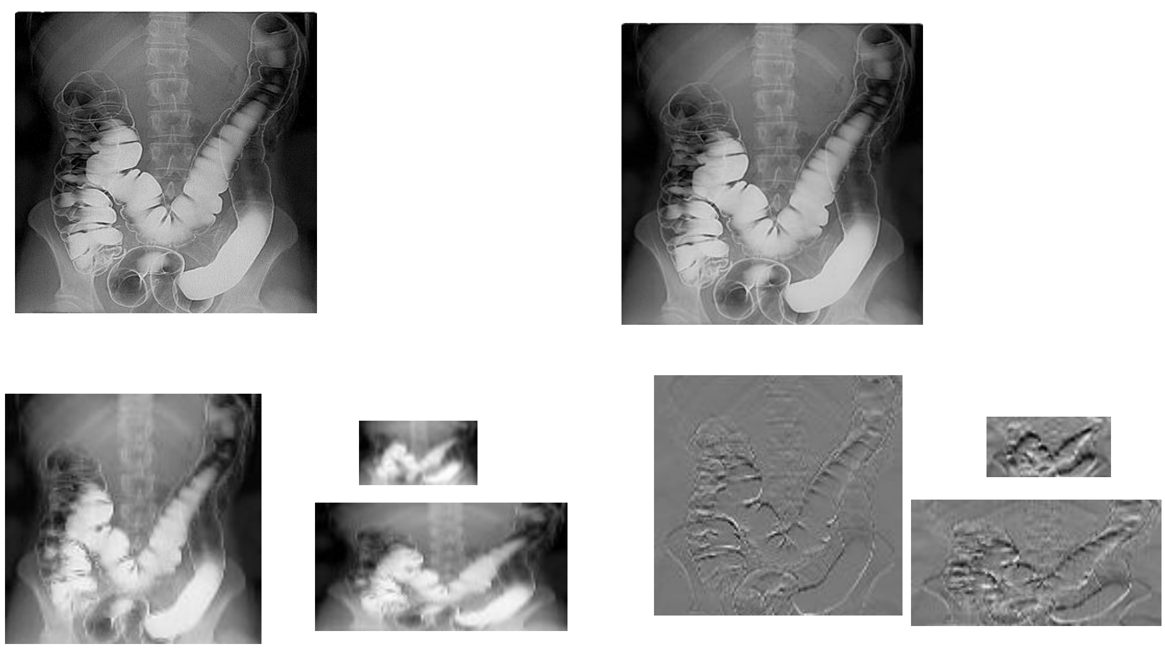

**FIGURE 3.** Input MRI images.



( a)



( b)



(c)

**FIGURE 4.** Decomposition of MRI images using (a) 11th order Wavelet Filter Bank (b) 9th order Wavelet Filter Bank (c) 7th order Wavelet Filter Bank.

**TABLE 1**. Performance of designed IIR wavelet filter banks on medical images.

| Image | Parameter | 7th IIR Filter Banks | 9th IIR Filter Banks | 11th IIR Filter Banks |
|---|---|---|---|---|
| | CR | 17.8029 | 18.045 | 22.679 |
| **MRI1** | PSNR(db) | 62.1761 | 49.457 | 45.8379 |
| | SNR(db) | 54.3650 | 41.6458 | 38.0258 |
| | Corr. | 1 | 0.9999 | 0.9999 |
| **MRI2** | CR | 39.1376 | 39.1376 | 39.1376 |
| | PSNR(db) | 74.9069 | 62.1476 | 58.5278 |
| | SNR(db) | 66.6928 | 53.9335 | 50.3137 |
| | Corr. | 1 | 1 | 1 |
| **MRI3** | CR | 48.7029 | 46.4891 | 56.3727 |
| | PSNR(db) | 65.2457 | 63.8763 | 47.8546 |
| | SNR(db) | 58.5235 | 57.1541 | 41.1323 |
| | Corr. | 1 | 1 | 0.9998 |
| **MRI4** | CR | 29.5721 | 22.247 | 33.3936 |
| | PSNR(db) | 65.3794 | 54.7146 | 51.14 |
| | SNR(db) | 56.1996 | 45.5377 | 41.961 |
| | Corr. | 1 | 1 | 0.9999 |
| **MRI5** | CR | 28.25 | 28.25 | 28.25 |
| | PSNR(db) | 56.9628 | 44.8623 | 39.8046 |
| | SNR(db) | 48.7074 | 36.6069 | 31.5492 |
| | Corr. | 0.9999 | 0.9992 | 0.9973 |
| **MRI6** | CR | 58.0918 | 53.0197 | 69.006 |
| | PSNR(db) | 63.3656 | 50.6466 | 47.0266 |
| | SNR(db) | 53.8963 | 41.1773 | 37.5573 |
| | Corr. | 1 | 0.9999 | 0.9998 |

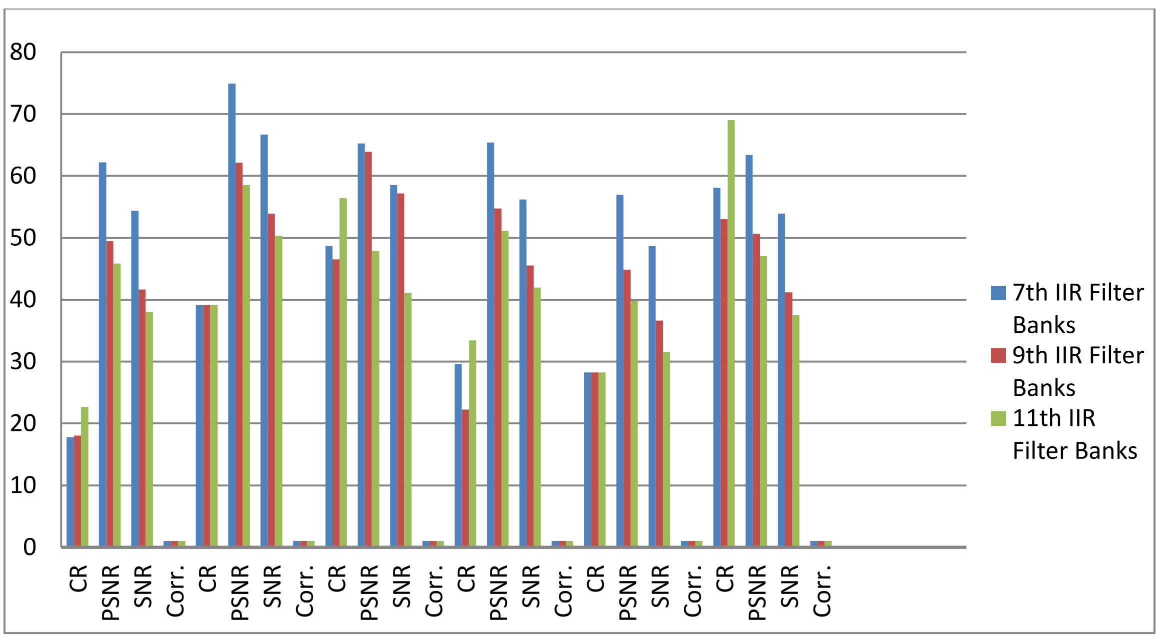



**FIGURE 5.** Performance of designed IIR wavelet filter banks on medical images.

## CONCLUSIONS

A medical image compression method is proposed that preserves the original image's quality. It is based on IIR wavelet filter bank. Many image quality measurements, such as the SNR and PSNR, have been used to show the efficiency and performance of the proposed design. The design's simplicity makes real-time implementation easy.

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