Multi Spectral Band Selective Coding for Medical Image Compression

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Abstract

Medical image compression has recently evolved as an area of research for progressive transmission. The distance based medical diagnosis, demands for high quality imaging at faster data transfer rate. As the information?s are highly informative, each pixel information defines a sample observation. Hence the coding in medical diagnosis need to be of higher accuracy than conventional image coding. In the approach of image coding multi spectral coding is developed as new coding approach to achieve the objective of higher visualization accuracy. With this observation in this paper a multi spectral coding using multi wavelet transformation is developed. The multi spectral coding is improved by a band selective approach using inter band correlation factor. The evaluation factors for such a coding technique are observed to be improved over conventional multi-spectral coding.

Index terms— multi-spectral image coding, medical image compression, correlative band selection coding.

1 Introduction

edical image processing is a very important area of application in the field of medicine. Every year, terabytes of medical image data are generated through advance imaging modalities such as magnetic resonance imaging (MRI), computed tomography (CT), digital subtraction angiography (DSA), positron emission tomography (PET), X-rays and many more recent techniques of medical imaging. But storing and transferring these huge voluminous data could be a tedious job. In recent days, due to the hasty development of heterogeneous services in the field of image oriented applications, the future digital medical images and video applications finds several limitations with the available resources. In order to overcome these limitations medical images are getting transferred in the compressed/coded format. In medical image coding [2] diagnosis and analysis are doing well simply when coding techniques protect all the key image information needed for the storage and transmission. As in telemedicine, videos and the medical images are transmitted through advanced telecommunication links, so the help of medical image coding to encode and decode the data without any loss of useful information is immense importance for the faster transfer of the information. There are many medical image compression [1] techniques are available. In current approach of image coding, medical imaging finds it application in various real time applications. In the area of image coding for medical application [2], multi bit rate [3] applications are emerging. Conventional coding approaches are limited to their application due to network diversity issues. In various coding approaches the quality of coding allows partial coding for faster transportation. The conventional coding approaches developed for medical image coding are limited to multi stream bit coding at multi bit stream coding. In the case of multi bit rate [3] applications, the conventional multi bit-stream approaches are constrained and inefficient to the heterogeneity issue. At various resolutions and at various quality levels the multi bit stream coding allows partial decoding. In earlier, various scalable coding algorithms have been proposed at various international standards, but these earlier coding methods are applicable only for limited applications and also having limited decoding properties. The main problem of conventional multi bit stream approaches, inefficient and impractical due to the issue of wide varying requirements of user resources. The scalable codec's developed based on bit-level for this system allow optimal reconstruction of a medical image from an arbitrary truncation point within a single bit-stream. Recently, in the field of medical image compression, the wavelet transform has been developed as a cutting edge technology. Wavelet-based coding [4], [5], [6], [7] methods provide an improved picture quality at high compression ratios. To achieve the better compression performance, the wavelet filters should have the property of symmetry, orthogonality, higher approximation order and short support. Due to the constraints in the implementation, scalar wavelets can't satisfy all these enhanced properties. Compared with scalar wavelets, Multiwavelets [8], [9], [12] have several advantages and are generated by only a finite set of functions. One of the main advantage with multiwavelet, it can possess symmetry and orthogonality simultaneously [10], [11], whereas the scalar DWT can't possess these two properties simultaneously. These two properties of multiwavelet made it to offer the increased performance and also high degree of freedom compared with scalar wavelets, in image processing applications. Though multiwavelet are observed to be an effective approach for image compression coding, the resulting coefficients of such coding at very large due to multiple band decomposition. In the coding of multiwavelet though finer coefficients are derived it is observed that, among all the decomposed bands few bands reflect a similar spatial property as compared to others. With this observation, a selective band coding is proposed to reduce computational overhead. Band selection process is proposed as a developing approach in signal processing [13], wherein among 'K' band of decomposition, 'k-n' bands are selected as effective bands for processing. Such coding approach is termed as Adaptive band filters (ABF) [13]. To achieve a greater extent of coding efficiency, these selective bands are then coded for bit plane coding using a hierarchical coding. The coding approach is a hybridization of the zero block [14] and context coding [16]. To present the stated work, this paper is presented in 5 sections. The approach of multiwavelet coding for image compression is outlined in section 2. Section 3 presents the proposed adaptive coding approach. The proposed inter band hierarchical coding in presented in section 4. The obtained experimental results are presented in section 5. Section 6 outlines the conclusion made for the developed work.

2 II.

3 Multiwavelet Coding

The wavelet transform is one of the signal transform technique, used commonly in image compression. An enhanced version of wavelet transform is multiwavelet transform. Multiwavelets and wavelets are almost similar but having some important differences. Wavelets have only two functions, wavelet function ?(t) and scaling function ?(t), whereas multiwavelet have multi scaling and multi wavelet functions [10]. The scaling function set for multiwavelet coding can be written as? (t) = [? 1 (t),? 2 (t)?, ? r (t)] T

, where ?(t) is a multi-scaling function. Similarly, the multiwavelet function set for multiwavelet coding can be written as ?(t) = [? 1 (t), ? 2 (t)?, ? r (t)] T . in general 'r' can be a large value, but the study on Multiwavelets to present date is for r=2 [14]. The two scale equation for multiwavelet can be defined as??(??) = ?2 ? ?? ?? ??(2?? ? ??) ? ??=?? ? (1) ð ??"ð ??"(??) = ?2 ? ?? ?? ??(2?? ? ??) ? ??=?? ? (2)

Where, {H k } and {G k } are matrix filters, i.e., H k and G k are 'r x r' matrices for each integer k. The filter coefficients of these filters provide more degree of freedom compared with scalar wavelets [4]. Due to this extra degree of freedom, the extra useful properties such as orthogonality, symmetry and higher order approximation can be incorporated into the multiwavelet filters.

Multiwavelets, compared with scalar wavelets, can achieve better level of performance with same computational complexity. A scalar wavelet transform In the process of multi wavelet transform as the decompositions are made for each band isolately, the obtained coefficients are hence divided into further bands and processing over such 'n scale-bands' results in processing overhead. It could be observed that in multi level band decomposition, the lower level bands are derived from the upper level subbands, hence the obtained information formulate a quad-band decomposition. Wherein each subband is represented into 4 lower bands. As these 4 bands are finer details of a detail sub band these bands reflects a co-similarity among the 4 bands. Hence to reduce the coefficients and to retain the property of multi wavelet a selective coding for band selection is proposed. The approach of selective coding for band selection is defined in following section.

4 III.

5 Selective-Mwvlt Coding

In various signal and image processing applications, refinement of a signal is made to achieve higher level of accuracy. In the process of band decomposition, it is observed that, finer details reveal more clear information's than the original processing signal. However as the band decomposition increases, the probability of redundancy among different bands increases. This redundancy of information increases the processing overhead, and intern makes the system slower. Hence it is required to have an adaptive band selection process for extracting the actual informative band from the processed bands. In the process of signal processing a adaptive band selection process for subband coding was made in [13]. However no such approach of band selection is observed in image coding. With reference to band selection process in this work the process of adaptive band selection is developed for multi wavelet coefficients. Considering the

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Volume XV Issue III Version I Year ( ) analysis and synthesis filter of the transformation as shown in figure 2, the generalized multiband decomposition can be shown as; In this process the analysis bank decomposes the image I into K subbands, each produced by a branch H z (k) of the analysis bank. After decimation and expansion by a factor N, the full band signal is reconstructed from the subbands in the synthesis bank by filtering with filters G k (z) followed by summation. The analysis filters H k (n) are derived from the real value of a lowpass FIR filter p[n] of even length L p. For the estimation of signal using such filtration cost optimization approached is used where the subband are processed adaptively termed as subband adaptive filter (SAF) [13].The SAF operation is based on the LMS-type adaptive filter. The converged of such filter is based on the optimization of this LMS function, wherein weight functions are used to optimize the mean error. To converge the cost function faster in [15] a Normalized SAF (NSAF) is proposed. In this approach the convergence speed is increased by increasing the number of subband filters while maintaining the same level of steady-state error. However, it suffers from huge complexity when used in adapting an extremely long unknown system. To overcome this problem in [17] a dynamic selection based NSAF (DS-NSAF) scheme is proposed. This approach sorts out a subset of the subband filters contributing to convergence performance and utilizes those in updating the adaptive filter weight. This approach dynamically selects the subband filters so as to fulfill the largest decrease of the successive mean square deviations (MSDs) at every iteration. This approach reduces the computational complexity of the conventional SAF with critical sampling while maintaining its selection performance. The operational approach for the conventional DS-SAF approach [15] is as outlined.

In a SAF system the desired band d(n) that originates from an its lowering band is defined by,??(??) = ??(??)?? ?? + ??(??) ? (3)

where w 0 is an unknown column vector to be identified with an adaptive filter, v(i) corresponds to a variance ? v 2 for each band, and u(n) denotes a row input vector with length M defined as;??(??) = [??(??) ??(?? ? 1) ? ??(?? ? ?? + 1)] .. (**4**)

In the process of adaptive selection, the Normalized SAF (NSAF) [17] approach was proposed. A basic architecture for such coding is as shown in figure **??**.

Figure **??** : NSAF filter architecture [15] In this approach the image sample is partitioned into N subbands by the analysis filters H 0 (z), ? H n-1 (z). The resulting subband signals are then critically decimated to a lower sampling rate relative to their demanded bandwidth. The original signal d(n) is decimated to k signals and the decimated filter output at each subband is defined as;y i , D (k) = u i (k)w(k), ?(**5**)

Where, u i (k) is a 1 x M row such that, ??? ?? (??)? 2 ?? ??,?? (??)?????1 ??=0 ? (7)

Where µ is the step size. This weight is used to optimize the band selection process where in it takes a large computation to converge for the optimization. To overcome this issue in [15] a MSD based weight optimization is proposed. In this DS-NSAF approach the largest decrease of the MSDs between successive iterations is used.

Hence the weight error vector is then defined as, ?? ?(??) = ?? ?? ? ??(??). The weight optimization is then defined as,?? ?(?? + 1) = ?? ?(??) ? ?? ? ?? ?? ?? (??) ??? ?? (??)? 2 ?? ??,?? (??) ???1 ??=0 ? (8)

Using this weight vector and taking the expectation a MSD is computed which satisfies the absolute expectation as,????? ?(?? + 1) ? 2 = ????? ?(??) ? 2 + ?? 2 ?? ?? ?? ??,?? 2 (??) ??? ?? (??)? 2 ???1 ??=0 ? ? 2???? ?? ?? ?? (??)?? ? (??)?? ??,?? (??) ??? ?? (??)? 2 ???1 ??=0 ? ? (9) ?E??? ?(??) ? 2

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Volume XV Issue III Version I Year ( )Where Î?" = ?? ? ?2?? ? ?? ?? (??)?? ? (??)?? ??,?? (??) ??? ?? (??)? 2 ? ? ???? ? ?? ??,?? 2 (??) ??? ?? (??)? 2 ?? ???1 ??=0 ? (10)

Defines the difference of MSDs between two successive bands. With bands having minimum MSD is then chosen to have a selective band for processing rather to all decomposed bands. This band selection process reduces the processing coefficient with minimum deviation due to the selecting criterion of minimum MSD value. To this selected band then a modified encoding process is used to achieve higher level of compression as presented below.

IV.

8 Hierarchical Encoding

In the process of encoding image coefficient for compression various approaches of image coding were proposed in past. In current system a inter band relation coding for wavelet band coefficients are used called as hierarchical coding. Various such coding approaches are well known such as EZW [14], SPHIT [18], and EBCOT [19] etc. In all these coding technique the coding takes the advantage of the nature of energy relations for subband coefficients in frequency and in space. This class of coders applies a hierarchical set partitioning process to split off significant coefficients with respect to the threshold in the current bit-plane coding pass, while maintaining areas of insignificant coefficients. In this way, a large region of zero pixels is coded into one symbol.

When an image is wavelet transformed the energy in the subbands decreases as the scale decreases, so the wavelet coefficients will, on average, be smaller in the higher subbands than in the lower subbands. In this method for every pass a threshold is chosen for which all the wavelet coefficients are measured. If a wavelet coefficient is larger than the threshold it is encoded and removed from the image, if it is smaller it is left for the next pass.

When all the wavelet coefficients have been visited the threshold is lowered and the image is scanned again to add more detail to the already encoded image. This process is repeated until all the wavelet coefficients have been encoded completely or another criterion has been satisfied (such as, maximum bit rate criterion).

As an initialization step, the number of magnitude refinement passes that will be necessary is determined from the maximum magnitude of the coefficients. Initially, all pixels are treated as insignificant. The initialization is followed by three major passes -the sorting pass, the magnitude refinement pass and the quantization step update pass which are iteratively repeated in this order till the least significant refinement bits are transmitted. During the sorting pass, the pixels in the LIP, which were insignificant till the previous pass, are tested and those that become significant are moved to the LSP. Similarly, the sets in LIS are examined in order for significance and those which are found to be significant are removed from the list and partitioned. The new subsets with more than one element are added to the LIS and the single pixels are added to LIP or the LSP, depending upon their significance. During the magnitude refinement pass, the pixels in the LSP are encoded for n th most significant bit. The encoding algorithm can be summarized as follows:

Step-1:initialization Output n= ?log 2 (max (?? 1 ,?? 2) {??? ?? 1 ,?? 2 ?})? Set the LSP={?} Set the LIP={(?? 1 , ?? 2) ? ??} and LIS={??(?? 1 , ?? 2), (?? 1 , ?? 2) ? ??}

Step-2 : Sorting pass

Step-2.1 : For each entry in the LIP, output the significance (”1” if significant, ”0” if not significant). If found significant, remove it from the LIP and add to the LSP.

Step-2.2 : For each entry in the LIS, output the significance. If found significant, output its sign. Perform the set partitioning using the rule-2 or rule-3, depending upon whether it is the ??(?? 1 , ?? 2) set or the ??(?? 1 , ?? 2) set.

According to the significance, update the LIS, LIP and LSP.

Step-3 : Refinement pass: For each entry in the LSP, except those which are added during the sorting pass with the same n, output then th most significant bit.

Step-4: Quantization-step update pass

In this pass, n is decremented by 1 and the steps-2, 3 and 4 are repeated until n = 0.

The decoder steps are exactly identical. Only the output from the encoder will be replaced by the input to the decoder.

The proposed approach reduces the processing overhead by the selective approach for multiple bands generated in the process of multi wavelet transformation, and a modified encoding approach to hierarchical coding is proposed resulting in minimization of processing overhead. To evaluate the proposed approach a simulation on the developed approach is carried out, the obtained results are as explained in section 5.

9 V.

10 Result Observations

A comparative analysis is carried out for the developed approaches, wherein a qualitative measurement of the proposed approach of selective MWVLT (S-MWLT) is carried over the conventional multi wavelet coding (MWVLT) and DWT based coding. For the process of evaluation various test samples were The recovered image samples after the DWT based coding at different noise variances is shown in figure **??** (a) and(b). The same test sample is then processed for multiwavelet coding. The observation for such coding is as illustrated. The recovered samples based on the coding of multiwavelet decomposition is illustrated in figure **??** (a)and (b) under a noise variance of 0and 0.03 respectively. Wherein to optimize the operational performance to such coding a selective coding was proposed. The selected band for this multiband using proposed S-MWT is shown in figure 10. the processing coefficient is minimized as well with the selection approach, PSNR is improved. To obtain the multi-spectral bands in S-MWT the selected are replicated. The regenerated bands for the selected band is as shown in figure 11. To evaluate the coding performance of the developed coding system a parametric evaluation of the suggested methods is performed, the obtained observations are as illustrated below.

11 Figure 13 : Compression ratio with variation in coding rate

The compression ratio is observed to be improved in case of S-MWVLT coding with increase in coding rate. It is observed that at lower coding rate the compression is considerably high in case of MWVLT coding, as comparison to other two methods, however with increase in coding rate this factor get reduced in MWVLT and increases in S-MWVLT. This is achieved due to appropriate selection of bands, which reduces the coding coefficients, hence at higher coding rate; the number of processing bits is minimized. The overhead for the developed methods are observed to be increasing with increase in coding rate. This is comparatively higher in case of MWVLT coding, wherein lower in S-MWVLT coding and minimum is DWT based coding. The computation time taken for processing of these coefficients are recorded and illustrated in figure15. The processing time taken is considerably lower than MWVLT in proposed approach.

12 Figure 16 : PSNR with variation in coding rate

The PSNR for the developed approach is as illustrated in figure16. It is observed that, PSNR for the proposed approach of higher due to proper selection of multispectral bands and is retained about constant level at higher coding rates as well. A simulation test on various such medical samples are carried out and the obtained processing overhead and PSNR is as illustrated in table I,II respectively.

13 Conclusion

A new encoding approach for image compression is developed. The process of band selection for multi spectral information of multi wavelet coefficients is proposed. The approach of band selection process for subband coding based on normalized sub band coefficient selection procedure is adapted for band selection process. A least mean band difference for lower levels of band coefficient is proposed to achieve band selection procedure. To achieve optimal coefficient section process for hierarchal coding a pre tracing for multiple selected bands is proposed. The approach of hierarchical coding is hence optimized by a 1-dimentional tracing approach to obtain selective coefficient for performing hierarchical coding. The process of coefficient selection is achieved by the process of threshold correlation process as carried in conventional hierarchical coding. The process of encoding is then modified to encode the selected coefficients reducing the processing overhead for compression. [1] [2] [3]

2

Figure 1: decompose a 2 -

1

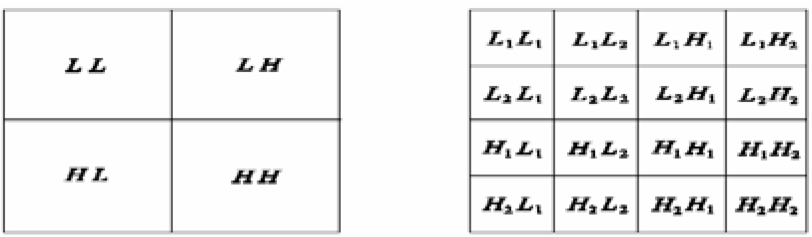
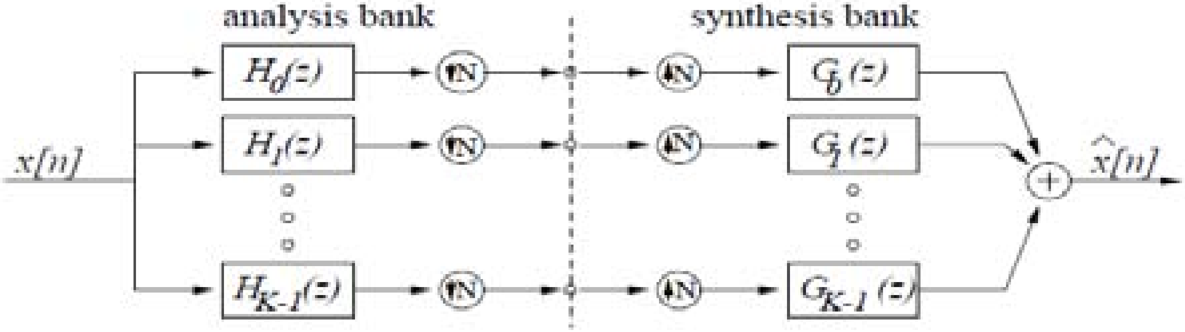


Figure 2: Figure 1 :



2

Figure 3: Figure 2 :

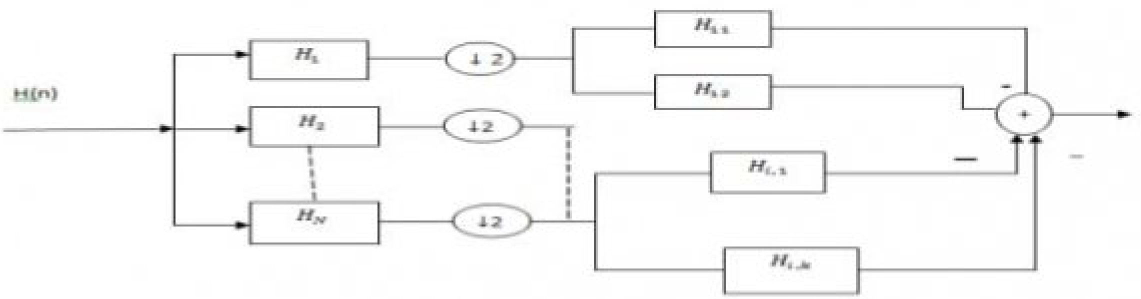


Figure 4:

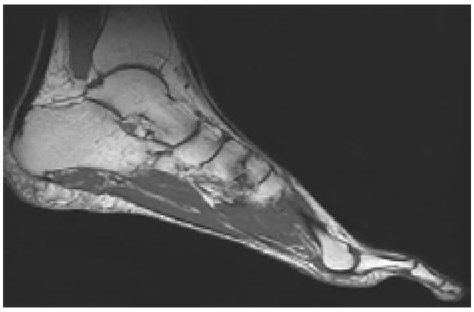


Figure 5: Global

45

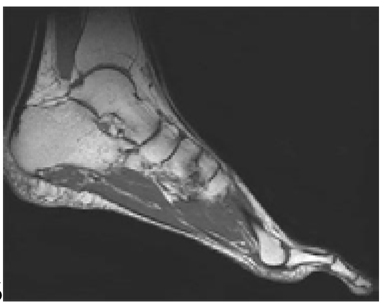


Figure 6: Figur 4 :Figure 5 :

6

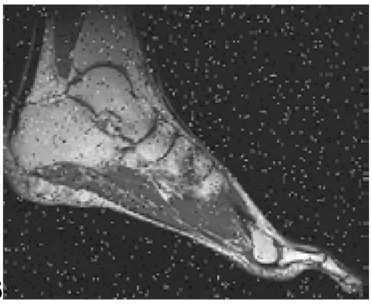


Figure 7: Figure 6 :

89

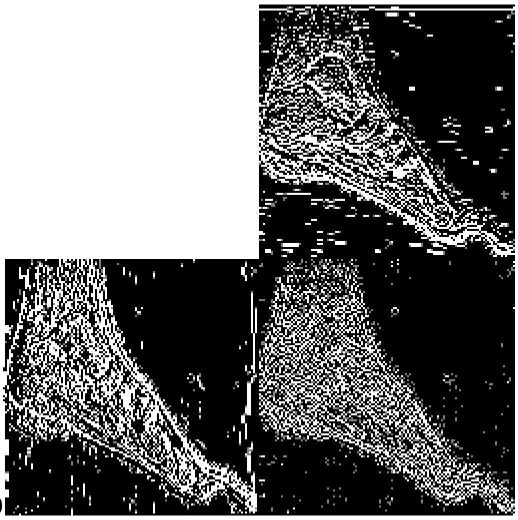


Figure 8: Figure 8 :Figure 9 :

10

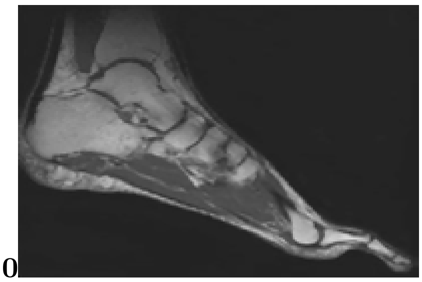


Figure 9: Figure 10 :

1112

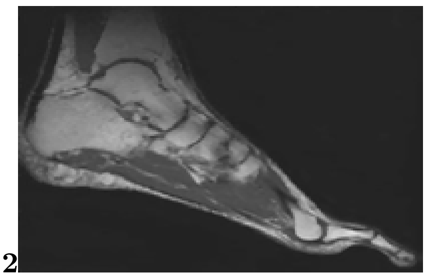


Figure 10: Figure 11 :Figure 12 :

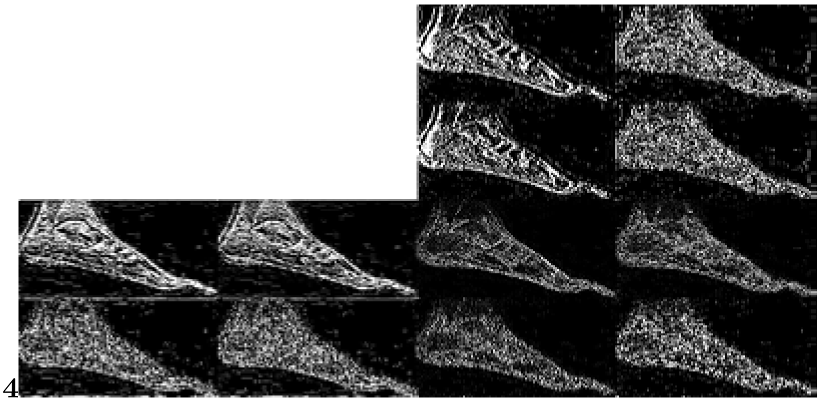
14 

Figure 11: Figure 14 :

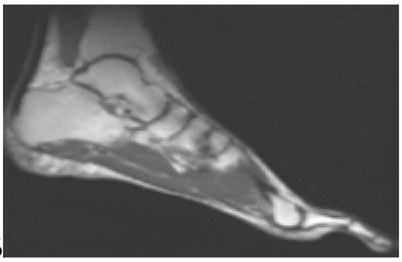
15 

Figure 12: Figure 15 :

I

Figure 13: Table I :

II

Figure 14: Table II :

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