CHAPTER 2: LITERATURE SURVEY

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A fair amount of research has been put in such that the existing works are thoroughly studied and investigated before the proposed work is decided upon. Since the topic of research is Wavelet based image compression algorithms and since both compression techniques as well as wavelet transforms are the favoured areas of research, a vast amount of data is available in this field. Having sifted through these research works carefully, the summary of the literature survey conducted is as follows:

In spite of the evolving of numerous innovative compression algorithms, JPEG2000 still holds its own place in the world of digital communication. Hence it was necessary to gain an insight into its construction and working. Unser and Skodras et al. [13,2] have provided just that. At the same time, KR Rao and Yip have provided a complete picture regarding the Discrete Cosine Transform (DCT) in their book ‘Discrete Cosine Transform: Algorithms, Advantages, Applications’. In addition to this, all the basic information regarding the Discrete Wavelet Transform (DWT) has been gathered via the works of Valisavljevic et al. and Vetterli [14-16]. Ran and Farvardin, in their paper titled ‘A Perceptually Motivated Three-Component Image Model’ have discussed some interesting psycho visual aspects regarding the working of the human visual system. The significance of edge information during the perception of information has been stressed upon. The authors have provided this interpretation in a mathematical environment, resulting in the development of an algorithm which models the image using its three components- the strong edges, the smooth background and the textures. The aspect of perception has been incorporated in the proposed work.
Zeng and Venetsanopoulos [8] have proposed “an interpolative coding approach using JPEG technology with the aim of reducing the visually unpleasant blocking artifacts produced by JPEG at low bit rates” or higher compression levels. When compared with JPEG, this scheme has achieved higher PSNR at low bit rates. Bruckstein, Elad and Kimmel have also worked in the same direction in order to improve on the objective as well as the subjective performance of JPEG. They have employed a down sampling approach based on image statistics, size and the available bit budget, prior to JPEG coding. This approach has several advantages. Since the down sampling is done prior to coding, the computational complexity in the coder/decoder is decreased significantly. The visual quality and the PSNR performance are also enhanced considerably. Also, this approach allows an expansion in the range of the employable bit-rates in compressing the image satisfactorily. However, this work is limited in that it uses fixed filters for decimation and interpolation. Inspired by the above work, Tsaig et al. have improved upon it by introducing optimal filters for decimation along with interpolation stages, thereby achieving significant gain in both qualitative and quantitative metrics. Though all these schemes have good proposals, they are limited in the under stated aspects: a) The down sampling ratio is fixed by the user; b) the critical bit rate is low and is image-dependent; c) the encoder has to switch between a down sampling scheme and traditional scheme to give a good coding quality for different images.

The proposed work has considered these limitations and developed an algorithm to overcome them.

The use of elementary operators by directional lapped transforms for directional selectivity as proposed by Xu et al.[17], the efficacy of the contourlet transform for
efficient directional multiresolution image representation proposed by Do et al.[18,19] and Chappelier et al.[20] and the separable filtering approach for multi-directional representation using directionlets proposed by Velisavljevic et al.[21] have all provided the necessary insight to implement the proposed algorithm.

Claypoole et al. [22,23] have developed new algorithms which employ the lifting scheme to decompose the wavelet. The desirable properties of the wavelet transform are safeguarded in the update stage. These algorithms have shown improvement in denoising performance over existing non-adaptive orthogonal transforms. W Ding et al. [6] have proposed a directional lifting scheme which adapts to the orientations in the image using local windows. This scheme has achieved high directional resolution and perfect reconstruction and has outperformed JPEG2000 in both PSNR and visual quality metrics. But this proposal has the limitations that its scope is restricted to only two orientations and therefore, arbitrary directional features may possibly be blurred. Simultaneous to the above work, Chang and Girod [24] have proposed an algorithm that is localized as it employs directional lifting based on image content. They have supported the results obtained with mathematical analysis. These two algorithms have, to an extent, provided the platform for the proposed work in this thesis.

Following the works projected by the above two authors, Liu and Ngan [25] have also adopted the lifting based approach and designed the Weighted Adaptive Lifting (WAL) scheme whose main design objective is to lessen the mismatch between the predicate and update steps, preserve the perfect reconstruction and to improve the directional properties of interpolated images in comparison with the proposal put by Ding [6]. Though the lifting algorithm has not been put to use in the proposed thesis work, it certainly provides
a scope for the extension of this work. This paper has been useful in that context and contains information that can be put to use at a latter stage.

Wu et al. [5] have addressed the route taken by digital photography while compressing an oversampled image and then treating it with sparse sampling techniques. They have proposed Compression via Adaptive Downsampling and Upconversion (CADU) with a uniform spatial down sampling procedure made adaptive by employing a spatially varying and directional low pass filter. The results outperform JPEG2000 with respect to PSNR metric at low bit rates in addition to improving the visual appearance of the image. Improving upon the previous algorithms, Tanaka et al. [4] have proposed a directional wavelet transform which can recognize and adapt to three directional features – vertical, horizontal and diagonal. However, this algorithm compromises the computational speed. In this thesis, this concept of directional adaptation has been adopted. Vrankic et al. [26] have implemented a locally adaptive wavelet decomposition scheme based on local image characteristics. It uses a lifting procedure on a quincunx grid. This algorithm has performed well for images with periodic patterns. Since the objective of this thesis is to design algorithms which are image-independent, this procedure has not been directly adopted. However, it has provided some necessary inputs for the present thesis. Lin and Dong [27] have proposed an adaptive algorithm which chooses between different down sampling modes for different regions of the original image and switches automatically between the traditional JPEG mode and the down sampling mode based on the performance metrics. This approach has shown good PSNR performance at low bit rates with respect to that of JPEG compression.
The present thesis proposes the use of such variable down sampling for different regions of the image and the algorithm has been developed such that the PSNR performance holds good even at higher bit rates. Also, the complexity involved in implementing the algorithm has been reduced considerably by first generating an adapted or reference image. The SPIHT Algorithm [28-31] has been employed along with the wavelet transform to ensure efficient encoding.

Olhede [12] in his paper ‘Hyperanalytic Denoising’ has successfully used the vector valued hyperanalytic signal employing the Hilbert transform for image de-noising. The decomposition coefficients are prioritized using a new threshold rule. Adam et al. in their ‘A New Implementation of the Hyperanalytic Wavelet Transform’ have chosen the then recently formalized Hyperanalytic Wavelet Transform (HWT) to improve upon the limitations of the DWT. Though Fernandes [32] has proved the success of DWT at controlled redundancies, Adam et al. have reasoned that the proper choice of mother wavelet can result in the enhancement of both shift invariance and directional selectivity properties of the transform. This work has been taken up with an intention of implementing it for de-noising applications. Another Bayesian de-noising approach proposed by Adam et al. differs from the above in two aspects i.e., in the method of implementation of the 2D Hyperanalytic Wavelet Transform and in the filters used in the wavelet environment. The effectiveness of the algorithm has been established on comparison of the simulation results of both the approaches. Nafornita et al.[33] have employed the HWT successfully in their Watermarking Method. Olhede and Metikas [34] have presented a comprehensive description of 2D vector-valued mother wavelet functions leading to the concept of hyperanalyticity and the hyperanalytic wavelets. Their
properties have been dealt with thoroughly in this report. The information contained in this study has provided valuable insight into the relatively novel concept of hyperanalyticity and the hyperanalytic wavelets. Yet another image de-noising approach has been proposed by Firoiu et al. [11] laying emphasis on the selection of the mother wavelets used for Hyperanalytic Wavelet Transform computation. They have used the bishrink filter to design and successfully implement a new de-noising algorithm. Firoiu et al. [35] have further introduced the concept of Hyperanalytic Wavelet packets and have proved through their implementation the superiority of the HWT over the DWT in the context of the features namely frequency localization and invariance, both shift and rotational. Closely following this proposal, Firoiu et al. [36] have proposed “an improved version of the Inverse Hyperanalytic Wavelet Transform” (IHWT). The implementation of the IHWT has been simplified by using the Analytical DWT. Also, because of its flexible structure, any orthogonal or bi-orthogonal mother wavelets can be employed to optimize the computational time. Firoiu et al. [10] have furthered their contribution and combined the Hyperanalytic Wavelet Transform with the filtering techniques already in use for Discrete Wavelet Transform, thereby developing a simple and quick de-noising algorithm. Isar et al. [37] have presented a comprehensive study regarding “the second order statistical analysis” of the HWT, bringing out its merits in comparison with DWT. Simultaneously, Nafornita et al. [38] have also considered “the second order statistical analysis of the HWT in the context of designing signal processing systems based on wavelet theory”. Firoiu [9] has proposed and proved that the best results are obtained using bi-orthogonal mother wavelets Daubechies 9/7 for image de-noising applications.
Also, Firoiu [39] has put forth a statistical analysis of the HWT based on the probable levels of their inter-scale and inter-band dependency.

With respect to the works presented by Olhede, Adam et al., Firoiu et al. and Naforinna et al. (referred above) regarding the concept of Hyperanalyticity and the Hyperanalytic wavelets, it can be observed that the implementation of this concept has been limited to image de-noising applications. The theoretical aspects and other observations regarding the Hyperanalytic Wavelet Transform (HWT) as presented by above mentioned authors have been adopted in the proposed work and the use of HWT has been newly extended successfully to the field of image compression with a view of overcoming the restrictions imposed on the procedures due to the inherent limitations of the DWT.
REFERENCES


to JPEG2000 working Group, Nov 1997


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