

SIGNAL CONDITIONING BASED WAVELET PACKET ALGORITHMS FOR SIGNAL AND IMAGE COMPRESSION

by

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Submitted
in fulfillment of the requirements of the degree of
Doctor of Philosophy

to the



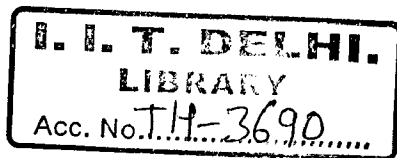
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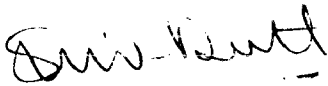
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To all children of God

Who brings Peace, Happiness and Healing

Certificate

This is to certify that the thesis entitled “Signal Conditioning based Wavelet Packet Algorithms for Signal and Image Compression” being submitted by Mr. Lalit Kumar Jiwani for the award of the degree of Doctor of Philosophy to the Department of Electrical Engineering, Indian Institute of Technology Delhi, is a record of bonafide work done by him under our joint supervision and guidance. In our opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.



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Abstract

The increasing use, storage, and transfer of multimedia signals like audio, images and videos over varied type of media and devices have necessitated the development of schemes for better compression of these signals using efficient signal processing algorithms. In this regard apart from compression performance of a scheme, the associated computational complexity is also an important issue. In applications dealing with compression, appropriate signal transforms are the core components of any representation and coding process. The Discrete Wavelet Transform (DWT) has been extensively used for signal and image representation and approximation because of energy compaction property and available flexible design choices. Also their efficient implementation through multirate filter banks can be done and is used for speech, audio coding and is core component of image compression standard JPEG2000.

The work in this thesis is based on the observation that DWT, in its original form, is blind to the characteristics of a given signal and is particularly suited for low pass signals and also is not adaptive. But the signals encountered in practice like audio, speech as well as images do deviate from the low pass nature. On the other hand, present day schemes for finding an optimal Wavelet Packet (WP) basis, which can represent signal and images with arbitrary spectra, efficiently, are computationally overwhelming and are difficult to implement in a practical setting.

Since the DWT is typically suited for dominantly low pass signals, it is intuitively appealing to consider transforming a given signal so that it adapts to the given DWT filter bank structure. So we propose a signal-conditioning transformation to accomplish this. The exploitation of spectral information is the most important feature of the proposed

signal-conditioning scheme. First, signal-conditioning transformation is introduced to find a signal adaptive DWT system for 1-D signals and 2-D images. Then computationally efficient algorithms, to extract the signal and image conditioning information, are proposed. Next the problem of images coding, in the context of image conditioning, is addressed. In this regard, for progressive transmission of images, a modified Embedded Zerotree (EZT) coding is introduced. Next a multiresolution framework based on the concepts of signal conditioning and signal-matched wavelet transform for signals and images with arbitrary spectra is proposed. This results in a wavelet system that is signal adaptive.

The signal conditioning, as proposed, is shown to have an important discriminatory decomposition property. Based on this a Spectral Density Driven Wavelet Packet (SDDWP) scheme is proposed for 1-D and 2-D signals. This scheme provides a framework for fast WP basis selection, with a control over the computational cost and implementation complexity, for arbitrary signals and images. The proposed wavelet packet framework can be considered as a good approximation to the best WP basis and is the WP tree on which pruning algorithm, to find the best basis, can be applied. Specifically for images, the zerotree relation for SDDWP is introduced and exploited in image coding. The pruned SDDWP basis is compared with the existing methods in terms of compression performance and computational cost of finding the best basis with substantial improved performance. The outcome of this framework is a progressive transmission, variable-rate compression scheme that takes into account the computational complexity to find transform, with allowable complexity of encoder, decoder and available bit budget.

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