Abstract

The contemporary image and video coders such as JPEG2000 and H.264/AVC give excellent compression performance, but the use of many optimized coding tools makes them computationally complex. However, with the growing popularity of wireless networks and the availability of low cost portable devices, a host of image and video applications and services require improved compression efficiency at considerably reduced computational complexity. The focus of this thesis is to design image and video coding systems with state-of-the-art compression performance at reduced computational complexity. Since wavelet has proven to be the most effective tool for providing a range of functionalities in addition to its superior coding performance, a wavelet-based approach has been used in this work.

In this research a family of coding systems built upon a new wavelet-based coding framework, wavelet block-tree coding (WBTC), is developed for a variety of digital image and video coding applications requiring low computational complexity. The motivation for the development of WBTC is to use a unified approach for exploiting both inter- and intra-subband correlations in a wavelet transformed image. Most of the existing wavelet-based image coding algorithms exploit only one of these correlations through the use of either a tree- or a block-based approach. The tree-based algorithms such as set partitioning in hierarchical trees (SPIHT) exploit inter-subband correlations by aggregating insignificant coefficients in the form of zero-tree. On the other hand, block-based algorithms such as set partitioning embedded block (SPECK) exploit intra-subband correlations by combining insignificant coefficients in the form of zero-block. The proposed WBTC algorithm uses a block-tree hierarchical structure, due to which it is able to exploit both inter- as well as intra-subband correlations jointly. This not only improves the coding efficiency, but also reduces the computational time by reducing the memory access time due to list processing.

In this thesis, first an image coder for greyscale as well as color images is developed based on the WBTC algorithm. Then, the approach is extended to three-
dimensional (3-D) wavelet video coding by designing an efficient 3-D spatio-temporal block-tree. Since most of the conventional video coders use hybrid structure, the performance of WBTC algorithm is also investigated for residual frames in a wavelet-based hybrid video coder. Simulation results show that though the WBTC algorithm gives comparable coding performance, its execution time for encoding and decoding is up to 2 and 6 times faster as compared to JPEG2000, respectively. For video coding, it outperformed state-of-the-art wavelet-based video coders and though it has a slightly inferior performance, its execution time is 11-15 times faster as compared to H.264/AVC.

Since tree-based approach for wavelet coefficients quantization is based on aggregation of insignificant coefficients in trees, careful design of a tree structure is the key issue for a better performance. The role of tree structuring on the performance of wavelet video codecs is also investigated. Six different tree structures with characteristics varying from simple to relatively complex and composite tree structures to code the luminance-chrominance components of a video sequence are considered. It is observed that, in general, more complex and longer trees do not necessarily improve the coding efficiency. However, the tree structures encapsulating more elements per tree are memory efficient. It is also observed that in order to increase the number of elements in trees for a given set of wavelet coefficients, it is better to grow trees in breadth than in depth. This will allow exploiting intra-subband correlations in addition to the inherent inter-subband correlations already being exploited in the tree structures. Also, this approach reduces the memory requirements and encoding complexity. Further, the simulation results show that by designing an efficient tree structure, depending on the picture content, the performance of a video coder can be improved by upto 2.0 dB, while reducing the computational complexity by 45-60 % as well as the memory requirements by almost 29-35%.