Abstract

In last decade, Internet broadcasting has experienced explosive growth along with the Internet infrastructure. Most current Internet video applications involve web-based video playback where pre-compressed video is streamed from a server to a client upon request. Many video compression schemes optimize their reconstruction quality for a specific target bitrate. However, a fixed transmission rate is not suitable for Internet video transmission, because the communication channel is shared among users and the bandwidth available to a specific user is time-varying. In this dissertation, we propose a solution to this problem by adopting a joint source-channel coding (JSCC) approach to design a wavelet-based fine granular scalable (WavFiGS) video codec. The WavFiGS coding system consists of a base layer (BL) codec that employs a hybrid coding – motion compensation with discrete wavelet transform (DWT) – architecture and an error-resilient enhancement layer (EL) codec that uses a robust progressive bit-plane coding scheme.

The research work starts with the design of an efficient wavelet-based still image codec. The objective is to design with simple and efficient techniques that achieves good compression performance and maintains a low computational complexity. We have demonstrated with our proposed schemes that a relatively simple context modeling technique, when coupled with other well-known techniques, achieves better compression than other more complex schemes.

The simplicity of the proposed schemes stimulated our efforts to exploit their potential. We discovered that the information asymmetry between an encoder and a decoder could be exploited so that all bit-planes within a pyramid can be encoded simultaneously. This is a major breakthrough in parallel wavelet image coding since it provides a new dimension of processing flexibility in addition to the conventional

parallelization approaches. It was also discovered that in the embedded image coding, the encoding order of refinement bits within one bit-plane has little or no impact on the peak signal-to-noise ratio (PSNR) quality of the reconstructed image. This concept of parallel bit-plane coding is general so that parallelization of other wavelet image coding schemes could also benefit from it.

The proposed still image coding scheme is employed in the intra-frame coding of the BL. The inter-frame residual coding is completed by the proposed macro-block stack-run codec. The EL codec is based on error-resilient elementary Golomb (EG) coding and progressive bit-plane coding. The output bitstream of the EL coder can be fragmented in such a way that each delivered EL packet is decoded independently and contributes to the improvement of the reconstruction quality of the decoded video.

Finally, we propose an efficient transmission strategy to stream an FGS video. Based on the justification that the BL is essential to the reconstruction of a video signal and that the delivery of the EL is less critical, it is proposed that the BL be protected by forward error correction (FEC). The EL be left without any FEC and is only protected by the error resilience incorporated into the EL source coder. We also establish an analytical model to optimally determine the channel coding rate under different packet loss probabilities. The effectiveness of both the streaming strategy and the analytical model was corroborated by our experimental results.