Public Abstract

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Title:Decoder-Learning Based Distributed Source Coding for High-efficiency, Low-cost and Secure Multimedia Communications

Multimedia applications are becoming more and more an integral part of our daily lives. For most multimedia applications, high-performance compression and cost-efficient communication of the multimedia data are essential. Conventional image and video compression is simple in decoding but complex in encoding, thus is not suitable for some emerging applications such as wireless sensor networks, where the encoders usually have limited functionalities and power supplies. Therefore it is desired to shift the bulk of computational burden to the decoder side. The resulting new coding paradigm is called distributed source coding (DSC).

Most practical DSC schemes only achieve good results when dealing with ideal sources, where a priori knowledge about the source statistics is assumed. For real-world applications such as distributed compression of images and videos, such knowledge is not really available. In this dissertation, we focus on designing decoder-side learning schemes for better understanding of the source statistics, based on which practical DSC systems can be built for high-efficiency, low-cost, and secure multimedia communications.

We propose a multi-resolution motion refinement (MRMR) scheme for the decoder-side motion learning for distributed video coding. We present both theoretical analysis and a practical wavelet-domain codec. Our MRMR predictor with extensive motion exploration has achieved performance comparable to the H.264/AVC predictor.

In some applications, an encoder needs to compress encrypted sources without decrypting them. In this dissertation, we propose the use of resolution-progressive distributed compression, such that the decoder can improve the learning of the source statistics progressively. The scheme has shown significant advantages in both coding efficiency improvement and complexity reduction, when compared to existing approaches.

We also address the fundamental rate-allocation problem for distributed coding of multiple correlated sources. The goal is to find the optimal rate-point that minimizes the overall transmission power consumption of a wireless sensor network. A novel water-filling model is established, based on which a greedy algorithm is proposed for the decoder to solve the rate-allocation problem. The feasibility and optimality of the proposed solution are analyzed mathematically. Compared to the exhaustive search approach, our algorithm achieves dramatic reduction in computational complexity.

The framework developed in this dissertation will provide significant insights and become important building blocks in distributed video applications, including those that are of significant importance to the national security, agriculture, economy, and healthcare.