Abstract

This dissertation investigates several topics belonging to the category of helper-assisted lossy multiterminal source coding, including multiterminal source coding with a helper, binary chief executive officer (CEO) problem with a helper, lossy source coding with helpers, lossy communications with lossy-forwarding (LF), and practical coding design.

Initially, for multiterminal source coding with a helper, we derive an inner bound on the achievable rate-distortion region, which is then utilized to evaluate the upper bound of the outage probability over block Rayleigh fading channels. The numerical results demonstrate the performance improvement and the diversity gain by introducing a helper. Interestingly, the system with a helper has higher energy efficiency while also reducing the outage probability.

Subsequently, we solve the binary CEO problem with a helper by decomposing it into two steps as multiterminal source coding and final decision. We derive an outer bound on the achievable rate-distortion region, and formulate a convex optimization problem to minimize the distortions at the first step of multiterminal source coding with a helper. For the step of final decision, we investigate the distortion propagating from the joint decoding results to the final decision.

Moreover, we present an inner bound on the achievable rate-distortion region for lossy source coding with helpers by the proof of achievability. The theoretical inner bound is verified to be a generalization of the Wyner-Ziv theorem.

For lossy communications with an LF relay, we determine an inner bound on the achievable rate-distortion region of lossy source coding with a helper for the first step. Then, we calculate the upper bound of the outage probability over block Rayleigh fading channels. We also conduct a series of simulations to compare the outage performance of LF with that of amplify-and-forward (AF) and decode-and-forward (DF).

Finally, we develop the hybrid majority voting (HMV) code for practical lossy compression. We theoretically analyze the rate-distortion performance of the HMV code, and prove that it has superior performance in spite of low complexity. In addition, we find the bit flipping (BF) code as the complement code of HMV code for successive refinement. By this means, the distortion in the standalone link can be conspicuously reduced while the refinement link can keep almost the same performance as before. Furthermore, we conclude the methodology of hybrid codes design for lossy source coding. We develop the hybrid code based on the Hamming codes as an example, and also find its syndrome as the complement code for successive refinement.

Keywords: Multiterminal source coding, lossy compression, side information, rate-distortion, outage probability.