

MSE Optimal Bit Rate Allocation in the Application of JPEG2000 Part 2 to Meteorological Data

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In this paper we solve the problem of optimal bit rate allocation for 3-D JPEG2000 compression. JPEG2000 Part 2 has the capability to compress 3-D data by treating data as separate 2-D slices. The separate slices could be taken directly from the data or from the data that has undergone a decorrelation transformation in one direction. In this paper we consider data where the 2-D slices are compressed using JPEG2000, and the third dimension is decorrelated using the Karhunen-Loève Transform.

The question that arises is how to optimally allocate bits to the separate slices since JPEG2000 does not require that any specific method be used. In more precise terms, we solve the problem: given a desired average bit rate, assign bit rates to the individual slices so that the Mean Squared Error (MSE) distortion metric is minimized. The traditional approach uses standard high rate approximation to rate distortion, that in effect leads to bit rate allocation based on the logarithms of variances of the corresponding slices. We propose two new methods. The first approach is here called the Rate Distortion Optimal (RDO) method and is based on Post-Compression Rate-Distortion (PCRD) optimization concept. In JPEG2000 PCRD optimization is used for the problem of selecting the optimal truncation points for the bit streams of the code-blocks. The RDO approach is valuable because it gives an optimal MSE lower bound for the bit allocation problem. Since this approach makes use of experimentally obtained rate distortion curves, it's main disadvantage is computational complexity.

The second approach is here called the Mixed Model (MM) approach and consists of extending the traditional high-resolution model with a region that is accurate for low bit rates. The low bit rate part of the model follows the results of Mallat and Falzon for a general transform coder. Advantages of the mixed model approach are that it can give performance nearly identical to the RDO approach with a much lower computational complexity.

The proposed bit allocation methods are tested by applying them to Meteorological (Met) data. The specific data set used was generated by the Battlescale Forecast Model (BFM), which is the analytical model developed by the Army Research Lab. Test results show that the mixed model approach gives distortion results that are nearly identical to the RDO approach on this data, while significantly reducing computational complexity.

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