Inferring BP Priority Order Using 5D Tensor Voting for Inpainting-based Macroblock Prediction

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This paper proposes a new video compression framework based on the traditional H.264/AVC by adding an inpainting-based macroblock prediction mode (**IP**- mode) for the intra and inter coding. Each MB could be predicted via intra-, inter-, or **IP**- mode, and rate-distortion optimization (RDO) is maintained to select the optimal mode. In **IP**- mode, the prediction is constructed through belief propagation (BP) algorithm under the framework of Markov Random Field (MRF) to model the spatio-temporal consistency of general video sequences. For efficiently optimizing the MRF, a priority-based BP is proposed to explore the frame structure and motion information in the videos. The structure sparsity is applied to assign the priority of message propagation in BP, and motion information is used to pruning the unimportant candidates. Considering the bit burden in video compression, no side information is encoded into the bitstream in the proposed scheme, and all the features are estimated by tensor voting algorithm, which can recur in decoder side. As a consequence, only the macroblock head and residual data are encoded into the bitstream, and the residual of **IP**- mode is averagely lighter in homogeneous texture region than the existed intra- and inter- modes in H.264.

Tensor Voting algorithm to predict features: For an efficient compression, the structured sparsity and motion information are extracted and analyzed to guide and modify the priority BP algorithm. The two main elements in tensor voting algorithm are tensor calculus for data representation and linear tensor voting process for data communication. Each input site communicates its information which is presented as a tensor to its neighborhood in a predefined tensor field, and each site collets all the votes cast at its location and encodes them into a new tensor. We address the 2D tensor voting to estimate the structure sparsity and 5D tensor voting to predict motion vector.

Pirority Belief Propagation: In the proposed **IP**- mode, the prediction result is obtained by selecting and copying suitable candidate patches from the reconstructed regions in both the current and previous frames. The inpainting problem is modeled under the MRF and transferred into the energy minimization task, and BP is applied to solve optimization problem. The priority BP adopts the message scheduling principle that the nodes who are more confident about their candidates should transmit outgoing messages to their neighbors earlier. To further reduce the computing complexity, for each node, assorting to the feature extracted and predicted in advance, the candidate patches can be reviewed, where only several candidate patches with high possibilities are preserved and a large number of unlikely candidates are discarded. So that the dimension of messages and beliefs is reduced, which saves time and resources.

Results: The proposed inpainting-based prediction scheme with **IP**- mode can increase up to 1dB gain at the same bit-rate *versus* H.264, and the coding gain is more obvious in lower bit rate conditions. In addition, with the structured sparsity regularization and priority arrangement, only one iteration including forward process and backward process in priority BP is needed to obtain the result of little residual, and the pruning process based on motion information largely reduce the computing complexity. Examples show that the priority BP with only one iteration saves more than 10 times complexity than the traditional ordered BP of several iterations.

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