Abstract

Motion estimation is one of the fundamental problems in video compression. Although the existing block matching algorithms are simple and robust, they have many drawbacks because of the block-based motion estimation and the assumptions regarding the nature of motion in a frame. The block-based motion compensation effectively converts a frame into two sources of information: the prediction error frame and the motion field. We focus on reducing the bit rate for the motion field, the prediction error energy (with improved subjective quality of the motion compensated frame) and the computational complexity of the motion estimation.

We consider the motion in a frame to have two components: the global motion due to the camera movements and the local motion due to the object movements. We apply different compensation schemes to these two kinds of motion.

First we consider the local motion, and propose various algorithms to improve the above performance measures. To reduce the motion field bit rate, we propose a backward temporal predictive coding scheme for the motion fields, and a variable-length coding scheme for the residual motion vectors. Based on an auto-regressive model, the prediction for a motion vector is obtained from the temporal neighbourhood using a minimum mean squared error criterion. The proposed variable-length coding scheme decides the bits required for a residual motion vector depending on its magnitude. To reduce the prediction error, we propose segmentation based and subblock matching based motion estimation schemes. The former is a backward approach which uses the background-foreground segmentation of the previous frame in the motion estimation, whereas the latter is a forward approach which estimates the motion vector of a block by splitting it into four subblocks. These schemes reduce the prediction error in the blocks lying along the boundaries of the moving objects through better compensation. In the process, the subjective quality of the motion compensated frame is also enhanced due to the reduction of the blocking artifacts at these blocks. We reduce the computational complexity of the block matching algorithm using a predictive search with a reduced search window, and the conditional motion estimation. In the predictive search scheme, the predicted motion vectors obtained by the proposed backward predictive coding scheme are used as the search centers. In the conditional motion estimation, a threshold
s used to find the blocks having significant gray level changes from the previous frame. The threshold value is determined automatically through an iterative approach based on the rate-distortion performance consideration. We also propose a simpler matching criterion for the hardware efficiency of the block matching algorithms.

Then we consider the global motion, and propose various algorithms to improve the above performance measures. To reduce the motion field bit rate, we propose a generalized 4-parameter global motion model. The model parameters are estimated using various proposed estimation schemes. To reduce the prediction error, we propose various global motion compensation schemes. We reduce the complexity in the global motion estimation by using a least-squares approach.

Finally, we consider the compensation of both the global motion and the local motion by using a two-stage compensation procedure. We present experimental results with existing test sequences to validate the efficiencies of the proposed algorithms.