An Adaptive Search Ordering For Rate-Constrained Successive Elimination Algorithms

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Abstract

We propose an adaptive ordering of block matching candidates that eliminates unnecessary block matching operations and allows for early termination. Block-matching algorithms (BMAs) must select the best candidate matching operations. For example, let \((x_i, y_i)\) be the best candidate found so far, if \(RCSAD(x_i, y_i) \leq RCSAD(x_i, y_{i-1})\), we use \(RCSAD(x_i, y_i)\) for each candidate, where \(x_i, y_i\) is the predicted motion vector (MV). Sort in ascending order the retained candidates by RCADS. Stop the BMA when eq. 3 is met for a candidate (early termination).

Introduction

- Block-matching algorithms (BMAs) must select the best candidate block \((C)\) from a search area in one or many anchor frames to serve as a predictor for the content of the current block \((B)\) (see Fig. 1).

- Beyond HD video formats (e.g., 4K or 8K), multiview video content and feature-rich video compression standards are all factors that require video encoders to consider more block sizes, more anchor frames, and use bigger search areas.

- The solution space for BMAs is so big, that state of the art approaches only consider a subset of that space and won’t always find the optimal solution.

- We propose an adaptive ordering of block matching candidates that eliminates unnecessary block matching operations and allows for early termination.

Adaptive Search Ordering

- The efficiency of RCSEA depends on the ordering of block matching candidates.
- For example, the best filtering is achieved when \((x_i, y_i)\) is the best candidate (see eq. 3).
- The proposed solution is outlined in Fig. 2. The main ideas are:
  - Prune the candidates with eq. 3, but instead of \((x_i, y_{i-1})\), we use \(RCSAD(x_i, y)\) for each candidate, where \(x_i, y\) is the predicted motion vector (MV).
  - Sort in ascending order the retained candidates by RCADS.
  - Perform BMA on the ordered candidates using RCSEA.

- The rate-constrained successive elimination algorithm (RCSEA) uses a 1D projection of the RCSAD, the rate-constrained absolute difference of sums (RCADS), as a lower bound for the RCSEA.
- The RCSEA can use this lower bound to filters out unnecessary block matching operations. For example, let \((x_i', y_i')\) be the best candidate found so far, if \(RCSAD(x_i', y_i') < RCSAD(x_i, y_i)\), then computing \(RCSAD(x_i, y_i)\) is unnecessary.

Rate-Constrained Successive Elimination Algorithm

- The BMA evaluates candidates by computing the rate-constrained sum of absolute differences (RCSD).
  
  \[
  RCSAD(x, y) = \sum |B - C(x, y)| + |R(x, y)\cdot e|
  \]  
  (1)

- The rate-constrained successive elimination algorithm (RCSEA) uses a 1D projection of the RCSAD, the rate-constrained absolute difference of sums (RCADS), as a lower bound for the RCSEA.
  
  \[
  RCADS(x, y) = \sum |B - C(x, y)| + |R(x, y)\cdot e| \leq RCSAD(x, y)
  \]  
  (2)

- The RCSEA can use this lower bound to filters out unnecessary block matching operations. For example, let \((x_i', y_i')\) be the best candidate found so far, if \(RCSAD(x_i', y_i') < RCSAD(x_i, y_i)\).
- Both sets contain the same candidates.

Experimental Results

- Our experiments where performed on the first 100 frames of Class C (832 x 480) video sequences ("Basketball Drill", "Party Scene", "BQ Mall" and "Race Horses") using the main profile.
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- The results are presented by block sizes and by QP values in Fig. 4.
- The proposed algorithm is more effective for smaller block sizes.

- Smaller blocks comprise fewer pixels leading to more precise ADS values. This filters out unnecessary cost function evaluations.
- As the QP increases, the effectiveness of the proposed algorithm also increases.

Conclusion

- An adaptive search ordering for the motion estimation module that evaluates only necessary cost functions.
- An early termination criterion for the BMA.
- Without our algorithm, an RCSEA using a spiral scan search ordering in the H.265/HEVC HM reference software would evaluate, on average, 3.5% of unnecessary cost functions.
- In some instances, the percentage of cost function evaluations can be reduced up to 15%.