Fast HEVC Intra Mode Decision Based on Edge Detection and SATD Costs Classification

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Outline

- Introduction
- Problem statement
- Background
- Literature review
- Proposed method
- Experimental results
- Conclusion
Introduction

• New demands for video coding standards
  – Demand for high quality video (4K × 2K and 8K × 4K)
  – Video delivery on mobile devices
  – High resolution 3D or multiview video

• HEVC can reduce the bit rate by half relative to the previous H.264/MPEG-4 standard
Problem Statement

• HEVC encoding could require up to 10x more computational complexity than H.264 with 2x-3x for decoding [1]
  – Need for new algorithms to reduce its complexity without sacrificing the coding performance

• Our focus is on HEVC intra coding complexity reduction
  – All-intra profile to replace the current intra coding techniques

Background

• Coding unit splitting
• Segmentation units
  – Coding tree units (CTUs)
  – Coding units (CUs)
  – Transform units (TUs)
  – Prediction units (PUs)
Background

- Intra mode decision
- HEVC intra modes
  - 33 directional modes
  - DC to predict the homogeneous regions
  - Planar to produce smooth sample surfaces
Background

• Intra mode decision processes (HM)
  – Rough mode decision (RMD)
    • SATD: Sum of absolute transformed differences
      \[ J_{RMD} = D_{SATD} + \lambda_{RMD} \times B_{RMD} \]
  – Rate distortion optimization (RDO)
    • SSE: Sum of squared errors
      \[ J_{RDO} = D_{SSE} + \lambda_{RDO} \times B_{RDO} \]
Literature Review

• Edge detection

• Neighboring blocks’ modes

• RDO cost estimation
Literature Review

- Mode decision
  - Edge detection [2, 3, 4]

Literature Review

• Mode decision
  – neighboring blocks [5]

Literature Review

- Mode decision
  - RDO cost estimation [6]

Proposed Method

- Intra mode decision based on
  - Improved edge detection
  - Most relevant modes (MRMs) of the neighboring blocks
  - Selecting promising candidates based on SATD
Proposed Method

• Edge detection operator

\[ \tilde{G} = G_x \hat{j} + G_y \hat{i} \]

\[ G_x = p_{i-1,j+1} + 2 \times p_{i,j+1} + p_{i+1,j+1} - p_{i-1,j-1} - 2 \times p_{i,j-1} - p_{i+1,j-1} \]

\[ G_y = p_{i+1,j+1} + 2 \times p_{i+1,j} + p_{i+1,j+1} - p_{i-1,j-1} - 2 \times p_{i-1,j} - p_{i-1,j+1} \]

\[ |\tilde{G}| = \sqrt{G_x^2 + G_y^2} \quad \rightarrow \quad |G_x| + |G_y| \quad \text{Ang}(\tilde{G}) = \tan^{-1}\left(\frac{G_y}{G_x}\right) \rightarrow \frac{G_y}{G_x} \]

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(a) \( G_x \)

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(b) \( G_y \)

Sobel masks
Proposed Method

- Three assigned modes for each edge

Detected edge and three related modes
### Proposed Method

- High and low limits of $G_y/G_x$ for angular modes

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Proposed Method

- Weights of main and adjacent modes

\[ \text{mainModeWeight} = |G_x| + |G_y| \]

\[ \text{modeWeightFactor} = (\text{highLimit} - \frac{G_y}{G_x})/(\text{highLimit} - \text{lowLimit}) \]

\[ \text{adjacentMode1Weight} = (1 - \text{modeWeightFactor}) \times (|G_x| + |G_y|) \]

\[ \text{adjacentMode2Weight} = \text{modeWeightFactor} \times (|G_x| + |G_y|) \]

- Special mode (10)

\[ \text{modeWeightFactor} = 0.5 \times (1 + 40.73548/\left|\frac{G_y}{G_x}\right|) \]
Proposed Method

• Adding DC, planar and most relevant modes (MRMs)
• MRM: A neighboring mode that based on its direction is a promising mode for the current block
  – 2n+1 modes
Proposed Method

- Mode ordering, binary classification
- RDO dodging
  - If the mode with lowest cost is one of MRMs select it as a final mode

\[ \text{Gap} = \alpha \times (C_{\text{max}} - C_{\text{min}}) \]

\[ \alpha \leq 1 \]
Experimental Results

• Implementation setup
  – HEVC test model HM 15.0 (All-Intra profile)
  – Implementation platform: Intel® i7-3770 CPU-3.40, 12 GB of RAM, running Windows 7
  – 100 first frames of the recommended sequences [7]
  – Quantization parameters: 22, 27, 32, 37
  – Parameters of the algorithm: \( N = 8 \) and \( \alpha = 1/4 \) for block sizes \( 4 \times 4 \) and \( 8 \times 8 \) and \( N = 3 \) and \( \alpha = 2/3 \) for block sizes \( 16 \times 16 \), \( 32 \times 32 \) and \( 64 \times 64 \), \( n=3 \)

# Experimental Results (Versus HM 15.0)

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<thead>
<tr>
<th>Class</th>
<th>Video Sequences</th>
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<th>BD-Rate (%)</th>
<th>BD-PSNR$_Y$ (dB)</th>
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Experimental Results

RD curve of the proposed method and HM 15.0 for the RaceHorses sequence
Originality of the Work

• Using an improved edge detector
  – Considering three adjacent modes for each detected edge

• Using all five possible neighboring blocks and select only the relevant modes from them

• Using low-complex SATD in a novel way
  – Select the promising modes based on a Gap

• Simple to implement
Conclusion

• Goal
  – Optimize HEVC intra coding processes for complexity reduction for the same quality

• Procedure
  – Obtain the best intra mode based on edge detection and binary classification
    • We have achieved 35% time reduction using the proposed approach with about 1% BD-rate increment
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