Directional Feature based Subsampling Algorithm and Hardware Architecture for Adaptive Loop Filter in H.265/HEVC

Research background

- In the new standard, adaptive loop filter (ALF) is one of most promising tools.
- ALF is extremely efficient for high resolution encoding
- Calculating correlation matrix is the most time consuming part in ALF

Research Target

- Calculating correlation matrix for 4K × 2K @30fps sequences in real time
  - Low complexity algorithm: reduce ALF processing time while keep similar coding efficiency
  - Hardware architecture: process 4K × 2K sequences in real time

Proposed method

- Low complexity algorithm

  Directional feature based subsampling algorithm
  - SML reusing based directional feature analysis
    - Sum Modified Laplacian (SML) is applied in previous step

\[
\text{var}(i,j) = \sum_{k=-1}^{1} \sum_{l=-1}^{1} \left( 2R(i+k,j+l) - R(i+k-1,j+l) - R(i+k,j+l-1) - R(i+k,j+l+1) \right)
\]

\[
DF = \sum_{k=-1}^{1} \sum_{l=-1}^{1} \left( 2R(i+k,j+l) - R(i+k-1,j+l) - R(i+k,j+l-1) - R(i+k,j+l+1) \right)
\]

Subsampling patterns decision

- Horizontal SP1
- Horizontal SP2
- Vertical SP1
- Vertical SP2

Parity pixel organization method

Conclusion

- Time Reduction: 38.08%
- BDRATE increases 0.10%
- BDPSNR decreases 0.0025dB
- Process 4K × 2K @30fps sequences with 336.825MHz

Experiment results

<table>
<thead>
<tr>
<th>Sequences</th>
<th>Coding Efficiency</th>
<th>Time Reduction</th>
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<tbody>
<tr>
<td></td>
<td>BDRATE(%)</td>
<td>BDPSNR(dB)</td>
</tr>
<tr>
<td>vidyo1</td>
<td>0.1513</td>
<td>-7.50E-04</td>
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<tr>
<td>vidyo3</td>
<td>0.0588</td>
<td>-9.19E-04</td>
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<tr>
<td>vidyo4</td>
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<td>BQ Terrace</td>
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<td>1080P</td>
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<td>-0.0111</td>
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<tr>
<td>BasketballDrive</td>
<td>0.285</td>
<td>-0.0081</td>
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