Analysis of Motion Estimation Algorithm in HEVC

Multimedia Processing EE5359
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Outline

• Scope of this work
• HEVC Overview
• Motion Estimation
• Challenges for Motion Estimation in HEVC
• Approaches
• Implementation and Results
Outline

- **Scope of this work**
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Scope

- Analysis the computational complexity in HEVC motion estimation (ME) and state-of-the-art approaches.
- Implement the approaches into HEVC Model.
- Quality assertion methods:
  - PSNR [20]
  - SSIM [21]
  - Bjontegaard BD-PSNR [22]
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HEVC Overview

- HEVC is the current joint video coding standardization project of the ITU-T and ISO/IEC MPEG [1].
- Aimed at doubling the compression ratio of H.264 at the same level of visual quality [1].
- Exceed H.264 in terms of performance and computational complexity.
- Lot of tools and features have been brought forth into HEVC: quadtree partition, SAO, etc.
HEVC Overview

HEVC Encoder Block Diagram (Decoder components modeling in light gray) [1]
HEVC Quadtree Partition

HEVC Quadtree Partition [15]
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ME Overview

Motion Estimation Process Illustration [3]
ME Computational Complexity

• Inter prediction can take up to 84% of the entire encoding time [17].

HEVC encoding time portions. These execution time results were obtained by profiling the encoding of the “BasketballDrive” Full HD (1920×1080) sequence. [17]
ME Computational Complexity

- Largest block size in HEVC is 64x64, 4 times bigger than its of H.264.
- This significantly raises the ME computational complexity.
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ME Challenges

- Many partition sizes in the quadtree HEVC 8x8 to 64x64
ME Challenges

- HEVC ME for large-sized partition (i.e. 64x64) requires heavy computation exceeding its predecessor. In H.264 largest block size is 16x16. [Ref]

- Big interpolation logic.
- Time-consuming SAD process.
- Large memory storage.

HEVC ME for 64x64 PU
ME Challenges

- HEVC Interpolation on large-sized partitions

\[
\begin{array}{ccccccc}
A_{1,1} & A_{0,1} & a_{0,1} & b_{0,1} & c_{0,1} & A_{1,1} & A_{2,1} \\
A_{4,0} & A_{0,0} & a_{0,0} & b_{0,0} & c_{0,0} & A_{1,0} & A_{2,0} \\
d_{1,0} & d_{0,0} & e_{0,0} & f_{0,0} & g_{0,0} & d_{1,0} & d_{2,0} \\
n_{1,0} & h_{0,0} & k_{0,0} & l_{0,0} & m_{0,0} & n_{1,0} & n_{2,0} \\
A_{4,1} & A_{0,1} & a_{0,1} & b_{0,1} & c_{0,1} & A_{1,1} & A_{2,1} \\
A_{4,2} & A_{0,2} & a_{0,2} & b_{0,2} & c_{0,2} & A_{1,2} & A_{2,2}
\end{array}
\]

HEVC Interpolation Filter [1]

<table>
<thead>
<tr>
<th>Index $i$</th>
<th>$-3$</th>
<th>$-2$</th>
<th>$-1$</th>
<th>$0$</th>
<th>$1$</th>
<th>$2$</th>
<th>$3$</th>
<th>$4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h_{filter}[i]$</td>
<td>$-1$</td>
<td>$4$</td>
<td>$-11$</td>
<td>$40$</td>
<td>$40$</td>
<td>$-11$</td>
<td>$4$</td>
<td>$1$</td>
</tr>
<tr>
<td>$q_{filter}[i]$</td>
<td>$-1$</td>
<td>$4$</td>
<td>$-10$</td>
<td>$58$</td>
<td>$17$</td>
<td>$-5$</td>
<td>$1$</td>
<td>$1$</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
a_{0,j} &= (\sum_{i=-3}^{-3} A_{i,j} q_{filter}[i]) \gg (B - 8) \\
b_{0,j} &= (\sum_{i=-3}^{-4} A_{i,j} h_{filter}[i]) \gg (B - 8) \\
c_{0,j} &= (\sum_{i=-2}^{-4} A_{i,j} q_{filter}[1 - i]) \gg (B - 8) \\
d_{0,0} &= (\sum_{i=-3}^{-3} A_{0,j} q_{filter}[j]) \gg (B - 8) \\
h_{0,0} &= (\sum_{i=-3}^{-4} A_{0,j} h_{filter}[j]) \gg (B - 8) \\
n_{0,0} &= (\sum_{j=-2}^{-4} A_{0,j} q_{filter}[1 - j]) \gg (B - 8)
\end{align*}
\]
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Approaches

Employ optimized fast search algorithms.

*Fast search algorithms - (a) Two dimensional logarithmic (2DLOG), (b) Three steps search (TSS), (c) New three steps search (NTSS) [6]*
Approaches

Employ optimized fast search algorithms.

Fast search algorithms - (a) Four steps search (FSS), (b) One-at-a-time search (OTA), (c) Orthogonal search algorithm (OSA) [6]
Approaches

Hierarchical Search

Hierarchical Search [6]
Approaches

Complexity Control Employment

*Complexity of processing regarding to CU Depth [15]*
Approaches

Complexity Control Employment (to be cont’)
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Implementation and Results

• To be added
References


References


References


[12] HEVC Specification: Complexity control of high efficiency video encoders for power-constrained devices


References


[20] PSNR article in Wikipedia:
http://en.wikipedia.org/wiki/Peak_signal-to-noise_ratio


Acronyms

- SAO: Sample Adaptive Offset
- 2DLOG: Two dimensional logarithmic
- CTU: Coding Tree Unit
- CU: Coding Unit
- FSS: Four steps search
- HEVC: High Efficiency Video Coding
- HD: High Definition
- JCT-VC: Joint Collaborative Team on Video Coding
- PU: Prediction Unit
- ME: Motion Estimation
- MPEG: Moving Picture Experts Group
Acronyms

- NTSS: New three steps search
- OSA: Orthogonal search algorithm
- OTA: One-at-a-time search
- SAO: Sample Adaptive Offset
- T.B.D: To Be Determined
- TSS: Three steps search
- VCEG: Video Coding Experts Group
The End

Thank you!
Old: 3D Video

• Two type of 3D display
  • Stereoscopic displays: need 3D-display glasses to generate multi views for viewer's eyes.
  • auto-stereoscopic displays: do not require glasses for viewing.