A HIGHLY PARALLEL CODING UNIT SIZE SELECTION FOR HEVC

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Introduction

- The High Efficiency Video Coding (HEVC) provides a substantial improvement in coding efficiency over previous standards
- HEVC employs a quad-tree based image partitioning
  - Each frame is divided into coding tree units (CTUs, analogous to macroblocks in previous standards)
  - Each CTU can be recursively further divided into four smaller quadric blocks called coding units (CUs)
- From up to 64x64 down to 8x8

**Problem:** HEVC encoding incurs a high computational complexity

**Possible solution:** Use a graphics processing unit (GPU) for acceleration

- GPU is a highly parallel, powerful, and cost-effective processing unit, that is very common nowadays

Previous Works

- Most previous works on HEVC parallelization offload only motion estimation to the GPU
- Further acceleration is required
- CU size selection becomes a major bottleneck
- Most fast CU size selection algorithms use data dependency between neighboring CUs

**A new problem:** These dependencies limit GPU parallelization capability

Serial CU Size Selection

(Fan et al., 2014)

- Depth of search for the encoded CTU is determined by similarity to adjacent CTUs
- Adjacent CTUs are divided into 2 groups: \( \alpha = \{A, B, C, I\}, \beta = \{D, E, F, H, G\} \)

- Depths are checked in neighboring CTUs only in CUs that are in a small strip of size \( \delta \) around the CTU being evaluated
- Number of depths adopted in the strip determine a “similarity level”
- The “similarity level” determines the number of depths checked for the encoded CTU

**Results**

<table>
<thead>
<tr>
<th>Class</th>
<th>Sequence</th>
<th>BD-rate [%]</th>
<th>AT [%]</th>
<th>BD-rate [%]</th>
<th>AT [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>BQTerrace</td>
<td>0.63</td>
<td>-41.70</td>
<td>3.31</td>
<td>-66.14</td>
</tr>
<tr>
<td>C</td>
<td>BasketballDrill</td>
<td>1.37</td>
<td>-38.19</td>
<td>0.80</td>
<td>-61.30</td>
</tr>
<tr>
<td></td>
<td>BMall</td>
<td>1.00</td>
<td>-38.31</td>
<td>1.95</td>
<td>-59.98</td>
</tr>
<tr>
<td></td>
<td>PartyScene</td>
<td>0.16</td>
<td>-32.27</td>
<td>1.18</td>
<td>-56.41</td>
</tr>
<tr>
<td></td>
<td>RaceHorses</td>
<td>0.59</td>
<td>-30.88</td>
<td>0.59</td>
<td>-53.36</td>
</tr>
<tr>
<td>D</td>
<td>BasketballPass</td>
<td>0.52</td>
<td>-34.74</td>
<td>2.45</td>
<td>-52.83</td>
</tr>
<tr>
<td></td>
<td>BQSquare</td>
<td>-0.10</td>
<td>-27.63</td>
<td>2.03</td>
<td>-54.30</td>
</tr>
<tr>
<td></td>
<td>BlowingBubbles</td>
<td>0.36</td>
<td>-25.29</td>
<td>1.59</td>
<td>-54.54</td>
</tr>
<tr>
<td></td>
<td>RaceHorses</td>
<td>0.41</td>
<td>-24.26</td>
<td>0.98</td>
<td>-52.76</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>0.54</td>
<td>-32.58</td>
<td>1.65</td>
<td>-56.99</td>
</tr>
</tbody>
</table>

Results of the proposed CU size selection method compared with (Fan et al., 2014). For each method, change in coding performance in BD-rate (Bjontegaard, 2001), and change in serial coding time \( \Delta T \), are given compared to the HM16.2 reference software. Results are measured on sequences recommended by the JCT-VC HEVC committee in class B (BasketballPass, Swim, and Soccer) and D (LifeSize, PartyScene).

**Proposed CU Size Selection**

- A parallel scheme based on the serial scheme described above
- Does not depend on any data from other CUs in the same frame
- Allows high parallelism at the CTU level
- A change to groups \( \alpha \) and \( \beta \): \( \alpha = \{E, F, I, J\}, \beta = \{G, H, J, K, L, M, N\} \)

- Using only data from previous frames decreases correlation with neighboring CTUs
- Compensate for the decrease in CTU correlation by adding information from more CTUs - \( J, K, M, L, N \)
- Double weight is given to the colocated CTU \( J \) due to its highest correlation with the encoded CTU
- Same “similarity level” classification as described above
- But now higher likelihood for high or medium-high similarity level \( \rightarrow \) less depths checked

**Conclusions**

- A fast, highly parallel CU size selection method for HEVC
- Suitable for implementation on a many-core processor, such as a GPU
- Parallelism is achieved by removing dependencies in the same frame
- The proposed method achieves comparable coding efficiency and running times compared with counterpart serial methods that limit parallelism, even when executed in a serial manner

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