Evaluation of Chroma Subsampling for High Dynamic Range Video Compression

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Overview

- Chroma Subsampling

- Chroma Subsampling and Compression Efficiency

- Conclusion
Chroma Subsampling

- **Objective:** assess the impact of chroma subsampling in the HDR10 distribution pipeline

- **Sampling considered:**
  - 4:4:4 full chroma sampling
  - 4:2:0 MPEG CTC filter (correspond to anchor V1)
  - 4:2:0 Lanczos3 (6-tap)
Chroma Subsampling

- Influence without compression

```
RGB -> R'G'B' (SMPTE ST 2084)  
R’G’B’ to Y’CbCr (BT.2020)  
Quantization (10 bits)  
4:4:4 to 4:2:0

```

```
R’G’B’ -> RGB (SMPTE ST 2084)  
Y’CbCr to R’G’B’ (BT.2020)  
Inverse Quantization  
4:2:0 to 4:4:4

```

HDR10

Distortion
Chroma Subsampling

- Influence without compression

<table>
<thead>
<tr>
<th>Sequence</th>
<th>4:4:4</th>
<th>4:2:0 Lanczos</th>
<th>4:2:0 MPEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>FireEater2</td>
<td>69.33</td>
<td>65.15</td>
<td>64.38</td>
</tr>
<tr>
<td>Market3</td>
<td>69.56</td>
<td>62.52</td>
<td>62.07</td>
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<tr>
<td>BalloonFestival</td>
<td>67.94</td>
<td>62.35</td>
<td>62.12</td>
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<tr>
<td>Tibul2</td>
<td>68.53</td>
<td>60.66</td>
<td>60.00</td>
</tr>
<tr>
<td>Overall</td>
<td>68.84</td>
<td>62.67</td>
<td>62.1425</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sequence</th>
<th>4:4:4</th>
<th>4:2:0 Lanczos</th>
<th>4:2:0 MPEG</th>
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</thead>
<tbody>
<tr>
<td>FireEater2</td>
<td>52.32</td>
<td>48.80</td>
<td>48.42</td>
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<tr>
<td>Market3</td>
<td>42.11</td>
<td>36.88</td>
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<tr>
<td>BalloonFestival</td>
<td>45.36</td>
<td>40.46</td>
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<tr>
<td>Tibul2</td>
<td>49.66</td>
<td>45.92</td>
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<tr>
<td>Overall</td>
<td>47.36</td>
<td>43.01</td>
<td>42.85</td>
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</table>
Overview

- Chroma Subsampling

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- Conclusion
Chroma Subsampling

- Influence with compression

- RGB -> R’G’B’ (SMPTE ST 2084)
- R’G’B’ to Y’CbCr (BT.2020)
- Quantization (10 bits)
- 4:4:4 to 4:2:0

- Distortion

- R’G’B’ -> RGB (SMPTE ST 2084)
- Y’CbCr to R’G’B’ (BT.2020)
- Inverse Quantization
- 4:2:0 to 4:4:4

HDR10
HEVC Main12
HDR10
### Proposed Test

- **Source test sequences:**

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Class</th>
<th>Frame Range</th>
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<tbody>
<tr>
<td>FireEater2</td>
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<tr>
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<td>A</td>
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<td>Sunrise</td>
<td>A</td>
<td>0-239</td>
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<tr>
<td>BalloonFestival</td>
<td>G</td>
<td>0-199</td>
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<tr>
<td>Starting</td>
<td>H</td>
<td>0-499</td>
</tr>
<tr>
<td>Hurdles</td>
<td>H</td>
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</tr>
</tbody>
</table>

- **SuperAnchor 3.2 has been added to the plot:**
  - Different profile main10 versus main12
  - Different generation of HDR10 (luma adjustment)
  - Different tools (CbCr QP offset, delta luma adaptive, etc.)
  - Comparison is not fair
Results

- **SunRise:**

  Subjective evaluation complicated due to difference in bit-rates
Results

- **BalloonFestival:**

  4:2:0 Gain at low bit-rates

  Loss independent of bit-rates
Results

- **Market3:**
  
  Gain at low bit-rates

![Graphs showing IPSNR-XYZ and DE100 performance across different bit-rates for 4:4:4, 4:2:0 MPEG, 4:2:0 Lanczos3, and 4:2:0 Anchor 3:2.]
Starting:

Anchor 3.2 equal or below in tPSNR XYZ
Results

- Hurdles:
**Results**

- **FireEater2:**

  - Anchor 3.2 below

  ![Graph showing IPSNR-XYZ and DE100 metrics for various bit rates.](image)

  - Only sequence with Anchor 3.2 below in DE0100.
Overview

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- Conclusion
Subsampling is more efficient (according to tPSNR-XYZ) at low bit-rates

Anchor 3.2 is more efficient in term of color reproduction (QP chroma offset?)

High bit-rates, 4:4:4: is more efficient (both metrics)

4:4:4 can solve chroma problems for processes at the decoding stage (see JCTVC-W0106).
Subjective evaluation is complicated due to the bit-rate difference
- Rate-controlled might be considered

Improving subsampling process to bridge gap between 4:4:4 and 4:2:0 in DE0100
Contact Information

Contact Us

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Phone Number:
(604) 827-4878

Lab Location:
x310, ICICS/CS Building, UBC
4:2:0 Lanczos3 (6-tap) downsampling (1D)

<table>
<thead>
<tr>
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<th>3</th>
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<tbody>
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<td>0.6114</td>
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Chroma Subsampling

- 4:2:0 Lanczos3 upsampling

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<tr>
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<td>-0.0680</td>
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<table>
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<tr>
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