Versatile Video Coding (VVC)

The emerging new standard

Benjamin Bross
Versatile Video Coding (VVC)

Outline

• Exploration Phase

• Call for Proposals

• VVC Test Model 1.0
Exploration Phase

History of Video Coding Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.261</td>
<td>1991</td>
</tr>
<tr>
<td>H.262 / MPEG-2</td>
<td>1995</td>
</tr>
<tr>
<td>H.264 / MPEG-4 AVC</td>
<td>2003</td>
</tr>
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<td>2013</td>
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<td>JPEG</td>
<td>1990</td>
</tr>
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</table>

- **Bit-rate Reduction: 50%**

- **Foreman 10 Hz, QCIF 100 frames**
Exploration Phase

History of Video Coding Standards

Do we need more efficient video coding?

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<thead>
<tr>
<th>Standard</th>
<th>Year</th>
<th>Description</th>
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<tr>
<td>H.261</td>
<td>1991</td>
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Foreman
10 Hz, QCIF
100 frames
Exploration Phase

Jevons Paradox

"The efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource."
Exploration Phase

Work beyond HEVC already started 2015

• Joint Video Exploration Team (JVET)
  • of ITU-T VCEG and ISO/IEC MPEG
  • established October ‘15 in Geneva

• Joint Video Exploration Model (JEM)
  • software playground to explore new coding tools

• 34% bitrate savings for JEM relative to HEVC
  • provided evidence to start a new joint standardization activity with a…

Joint Call for Proposals on Video Compression with Capability beyond HEVC
Call for Proposals

Timeline

2017 Oct. – Final CfP

• Submit bitstreams and decoded video for proposed video coding technology
• Compare submission with HEVC anchor for given sequences, bitrates and coding conditions

2018 Apr. – CfP results

• Subjective evaluation results of submitted CfP responses and HEVC anchor
• Description of proposed video coding technology

First Test Model:

• Initial starting point of standard development

2020 Oct. – Final Standard
Call for Proposals

Target for the final VVC standard

Bit-rate Reduction Target: 50%

H.??? / MPEG-VVC
H.265 / MPEG-HEVC (2013)
H.261 (1991)
JPEG (1990)

Foreman
10 Hz, QCIF
100 frames
Call for Proposals

Three categories

- **SDR**
  - 5 HD sequences with bitrates from 400 kbit/s to 3.8 Mbit/s
  - 5 UHD sequences with bitrates from 950 kbit/s to 10 Mbit/s

- **HDR**
  - 4 HD sequences using PQ curve, bitrates from 350 kbit/s to 3 Mbit/s
  - 3 UHD sequences using HLG curve with bitrates from 640 kbit/s to 10 Mbit/s

- **360-degree**
  - 1 sequence 6K x 3K, 2 Mbit/s to 10 Mbit/s
  - 4 sequences 8K x 4K, 400kbit/s to 7 Mbit/s
Call for Proposals

Results

• JVET received submissions from 33 organizations.

• 40% or more bitrate savings in terms of PSNR over HEVC were shown.

• All submissions were superior in terms of subjective quality than…
  • HEVC (in most test cases).
  • JEM (in a relevant number of test cases).

• Fraunhofer HHI among the best performing submissions in all 3 categories.
Call for Proposals

Subjective testing result example

JVET-J0080: “Results of Subjective Testing of Responses to the Joint CfP on Video Compression Technology with Capability beyond HEVC”, 10th JVET Meeting, San Diego, April 2018
VVC Test Model 1.0

Motivation

• Start off with a clean slate test model
• Add quadtree plus multi-type tree block partitioning (QT+MTT)
  • Fundamental impact on all coding tools to be added
  • Most common partitioning scheme among all CfP submissions
• Use Fraunhofer HHI software with QT+MTT as basis for the test model
• Test promising coding tools from CfP on that basis (efficiency / complexity aspects)
• Agree on adding tested coding tools until sufficient bitrate reduction is achieved
VVC Test Model 1.0

New block partitioning

- 128x128 Coding Tree Units (CTU)
- Recursive quadtree partitioning (QT)
VVC Test Model 1.0

New block partitioning

- 128x128 Coding Tree Units (CTU)
- Recursive quadtree partitioning (QT)
- Nested recursive multi-type tree partitioning (MTT) with
  - binary split
  - or
  - ternary split
VVC Test Model 1.0

New block partitioning

- 128x128 Coding Tree Units (CTU)
- Recursive quadtree partitioning (QT)
- Nested recursive multi-type tree partitioning (MTT) with
  - binary split
  - or
  - ternary split
- Variable size Coding Units (CU)
VVC Test Model 1.0

Results

Bitrate savings over to HEVC for
• Exploration Model (JEM)
• QT+MTT block partitioning only (VTM 1.0)
• VTM 1.0 plus 10 coding tools under study as an example benchmark set (BMS)

<table>
<thead>
<tr>
<th></th>
<th>JEM</th>
<th>VTM 1.0</th>
<th>BMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FoodMarket4</td>
<td>34%</td>
<td>12%</td>
<td>28%</td>
</tr>
<tr>
<td>CatRobot1</td>
<td>40%</td>
<td>14%</td>
<td>34%</td>
</tr>
<tr>
<td>DaylightRoad2</td>
<td>40%</td>
<td>14%</td>
<td>35%</td>
</tr>
<tr>
<td>ParkRunning3</td>
<td>31%</td>
<td>10%</td>
<td>26%</td>
</tr>
<tr>
<td>Campfire</td>
<td>36%</td>
<td>17%</td>
<td>32%</td>
</tr>
<tr>
<td>BQTerrace</td>
<td>30%</td>
<td>10%</td>
<td>26%</td>
</tr>
<tr>
<td>RitualDance</td>
<td>28%</td>
<td>10%</td>
<td>21%</td>
</tr>
<tr>
<td>MarketPlace</td>
<td>29%</td>
<td>7%</td>
<td>23%</td>
</tr>
<tr>
<td>BasketballDrive</td>
<td>32%</td>
<td>12%</td>
<td>27%</td>
</tr>
<tr>
<td>Cactus</td>
<td>36%</td>
<td>8%</td>
<td>29%</td>
</tr>
<tr>
<td>Average UHD</td>
<td>36%</td>
<td>14%</td>
<td>31%</td>
</tr>
<tr>
<td>Average HD</td>
<td>31%</td>
<td>10%</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Average all</strong></td>
<td>34%</td>
<td>12%</td>
<td>28%</td>
</tr>
<tr>
<td><strong>Enc Time [%]</strong></td>
<td>752%</td>
<td>117%</td>
<td>600%</td>
</tr>
<tr>
<td><strong>Dec Time [%]</strong></td>
<td>756%</td>
<td>90%</td>
<td>285%</td>
</tr>
</tbody>
</table>

JVET-J0100: “Benchmark Set Results”, 10th JVET Meeting, San Diego, April 2018
Versatile Video Coding (VVC)

Summary

• New standardization activity started in April 2018
• Fraunhofer HHI among others submitted coding technology with much superior subjective quality compared to HEVC
• VVC Test Model 1.0 (VTM) released in May 2018 based on Fraunhofer HHI software
• Clean starting point with advanced block partitioning only
• Final Standard by October 2020
Thank you very much!

Further Information:

benjamin.bross@hhi.fraunhofer.de
jvet.hhi.fraunhofer.de