



SDR video coding technology proposal by University of Bristol

JVET-J0031

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Proposal Overview

Host codec

- ▶ The proposal is based on JEM 7.0 software.

Proposed tool: A resolution adaptation approach (ViSTRA)

- ▶ A quantisation-resolution optimisation module and a resolution down-sampling module at the encoder.
- ▶ A deep CNN-based resolution up-sampling module at the decoder.

Performance and Complexity

- ▶ The average BD-rate for SDR on CS1 is **-4.54%**, **-8.69%** for SDR-A and **-0.39%** for SDR-B.
- ▶ The average BD-rate for SDR on CS2 is **-0.52%**.
- ▶ The average encoding times are **90%** of JEM anchor on CS1, and **98%** on CS2.
- ▶ The average decoding times (GPU version) are **262%** of JEM anchor on CS1, and **191%** on CS2.

The JEM-ViSTRA Encoder

Algorithm Summary

- ▶ The **Quantisation-Resolution Optimisation (QRO)** module determines whether spatial resolution and/or bit depth down-sampling are enabled.
- ▶ **Spatial resolution down-sampling** is achieved using a Lanczos3 filter.
- ▶ **Bit depth down-sampling** is achieved through bit-shifting.
- ▶ A **single down-sampling ratio** is currently used for both resolutions.
- ▶ Low resolution video frames are encoded by the JEM 7.0 encoder using an adjusted QP value.
- ▶ Two bytes of flag bits are currently added in the bistream to indicate the spatial resolution and bit depth resampling ratios.

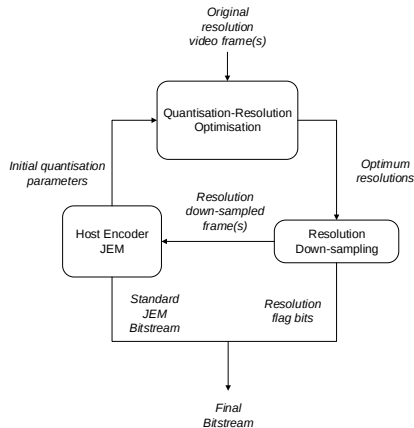


FIGURE: The proposed JEM-ViSTRA encoder.

The Quantisation-resolution Optimisation Module

Algorithm Summary

- ▶ The spatial resolution and bit depth are optimised independently.
- ▶ The optimal spatial resolution is determined based on various **spatial and temporal features** of original video frames and **initial base QP values**.
- ▶ The optimal bit depth is determined according to **initial base QP values** and **distortion introduced due to bit depth down-sampling**.
- ▶ All the model parameters employed in the QRO module were trained on sequences which are different from those in the CfP.

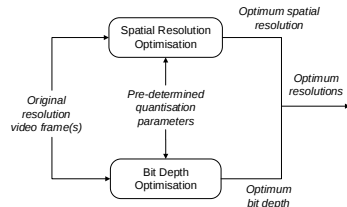


FIGURE: The employed QRO module.

The JEM-ViSTRA Decoder

Algorithm Summary

- ▶ The bitstream is firstly decoded by the JEM 7.0 decoder.
- ▶ The decoded video frames are then **up-sampled** according to the extracted flag bits.
- ▶ The spatial resolution and/or bit depth up-sampling are applied using a deep **CNN-based super resolution** method.
- ▶ **Different CNN model parameters** are used for up-sampling according to the base QP and resolution flag bits.
- ▶ The used model parameters were trained using a group of UHD and HD video sequences, different from those in the CfP.

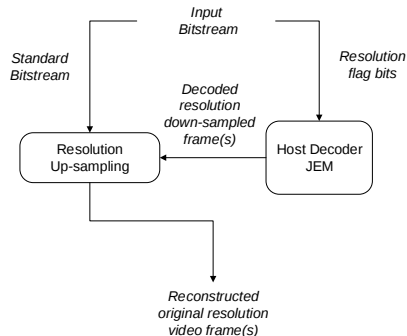


FIGURE: The proposed JEM-ViSTRA decoder.

Up-sampling using a CNN-based Super-resolution method

Algorithm Summary

- Spatial resolution and/or bit depth are **up-scaled** using a Lanczos3 filter and/or by bit shifting.
- Each frame is **split into overlapping blocks** and processed by the trained CNN model.
- Five sets of model parameters are currently employed for different **re-sampling cases** and **base QP values**.
- The super-resolution model is currently applied on the **Y channel** but will be extended to U and V channels.

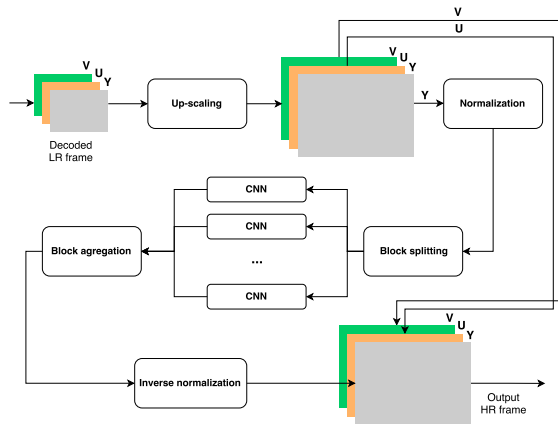


FIGURE: The proposed up-sampling module.

Compression Performance on SDR Test Set

Sequence (CS1)	Over HM 16.16 / JEM 7.0 anchors	
	BD-Bitrate (Y) [%]	BD-PSNR (Y) [dB]
FoodMarket4	-35.13 / -2.94	1.77 / 0.12
CatRobot1	-39.61 / -0.69	1.56 / 0.02
DaylightRoad2	-40.20 / 0.18	1.12 / -0.00
ParkRunning3	-43.55 / -18.45	1.51 / 0.52
Campfire	-48.03 / -21.53	1.48 / 0.47
Average SDR-A	-41.30 / -8.69	1.49 / 0.22
BQTerrace	-30.33 / 0.00	0.91 / -0.00
RitualDance	-27.49 / -0.23	1.46 / 0.01
MarketPlace	-30.46 / -1.85	1.07 / 0.05
BasketballDrive	-31.18 / 0.00	1.12 / -0.00
Cactus	-34.96 / 0.11	1.44 / -0.00
Average SDR-B	-30.89 / -0.39	1.20 / 0.01
Total Average	-36.09 / -4.54	1.34 / 0.12

TABLE: The compression performance of the proposed JEM-ViSTRA codec on the SDR test set. (Left) Results for the Constraint Set 1. (Right) Results for the Constraint Set 2.

Sequence (CS2)	Over HM 16.16 / JEM 7.0 anchors	
	BD-Bitrate (Y) [%]	BD-PSNR (Y) [dB]
BQTerrace	-26.28 / 0.00	0.78 / -0.00
RitualDance	-22.26 / -0.74	1.14 / 0.04
MarketPlace	-21.93 / -1.60	0.70 / 0.05
BasketballDrive	-25.78 / -0.20	0.97 / 0.01
Cactus	-28.34 / -0.05	1.13 / 0.00
Average	-24.92 / -0.52	0.95 / 0.02

Complexity Analysis and Memory Usage

TABLE: The complexity analysis and memory usage for the JEM-ViSTRA codec.

Constraint Set	Over HM 16.16 / JEM 7.0 anchors		Over HM 16.16 / JEM 7.0 anchors	
Test Set	Enc Time	Dec Time (GPU)	Enc Max RAM	Dec Max RAM
CS1-SDR A	703% / 86%	1742% / 275%	223% / 68%	169% / 133%
CS1-SDR B	873% / 96%	1586% / 244%	305% / 87%	219% / 148%
CS1	767% / 90%	1678% / 262%	264% / 78%	194% / 140%
CS2	899% / 98%	970% / 191%		



Conclusions and Future Extensions

Conclusions

- ▶ A **resolution adaptation approach (ViSTRA)** is proposed based on JEM 7.0 software.
- ▶ JEM-ViSTRA offers **-4.54%** and **-0.52%** bitrate savings (BD-rate) for CS1 and CS2 respectively.
- ▶ JEM-ViSTRA offers more significant improvement for **UHD sequences** (BD-rate of **-8.69%** for SDR-A) than for HD ones (BD-rate of -0.39% for SDR-B).
- ▶ JEM-ViSTRA offers more significant improvement for sequences with **relatively complex motion** than for those with relatively simple motion.
- ▶ JEM-ViSTRA offer more significant improvement at **lower bitrates** than for higher bitrate ranges.

Ongoing extensions

- ▶ Fully integration of ViSTRA into the encoding loop.
- ▶ Temporal and spatio-temporal resolution adaptation.
- ▶ Bitstream syntax modification.

Acknowledgements

The EPSRC logo consists of the letters 'EPSRC' in a bold, purple, sans-serif font. The letters are flanked by two horizontal teal lines, one above and one below.

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PROVISION
Perceptually Optimised Video Compression

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