# ON COMPARING IMAGE AND VIDEO COMPRESSION ALGORITHMS

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**ABSTRACT**

In this work, a performance evaluation of AVC Intra and JPEG2000 in terms of rate-distortion performance is conducted. A set of High Definition sequences with different spatial resolutions is used for this purpose. Results obtained show quite competitive performance between two coding approaches, while in some cases, AVC Intra, in its High Profile, outperforms JPEG2000.

## 1. INTRODUCTION

AVC (H.264, MPEG-4 Part 10) [1], for Advanced Video Coding, is a digital video codec standard which is noted for achieving very high performance compression. It has been developed by the ITU-T Video Coding Experts Group (VCEG) together with the ISO/IEC Moving Picture Experts Group (MPEG) as the product of a collective partnership effort known as the Joint Video Team (JVT). AVC [1] provides good video quality at substantially low bit rates. It is based on a block-based integer DCT-like transform. In addition, it performs spatial prediction for Intra frame coding and temporal motion estimation for Inter frame coding to improve further its compression efficiency. We will refer to AVC Main Profile as AVC MP and to AVC High Profile as AVC HP.

Another compression standard, JPEG2000 [2] is a wavelet-based compression algorithm for still images. It is created by the Joint Photographic Experts Group (JPEG) committee. Beside offering a number of new functionalities, it outperforms the original DCT-based JPEG standard in terms of compression efficiency in many situations.

Intra frame coding results in lower complexity encoders compared to Inter frame coding. In addition, it is suitable for random access, browsing and editing of video content since each frame is encoded on its own without using any information from its neighbouring frames. Furthermore, Intra frame coding does not cause error propagation which is attractive for error resilience. Due to these benefits Intra coding has been selected for use in several applications such as digital cinema, satellite and medical imaging as well as video surveillance.

In [3], a performance evaluation of AVC MP Intra and JPEG2000 was conducted. It is reported that AVC Intra performs better than JPEG2000 in terms of rate-distortion behaviour for low and intermediate resolution sequences. The gain of AVC Intra over JPEG2000 in PSNR has been reported as around 0.5 ~ 2.0 dB. On the other hand, JPEG2000 performed better for higher resolution sequences with a gain around 0.5 ~ 1.0 dB in PSNR. Furthermore, [4] has compared AVC HP Intra and JPEG2000 for monochromatic still image coding. It is shown that their performance are identical. Nevertheless, it has concluded that JPEG2000 has a gain of 1 dB in PSNR over AVC HP Intra if the 8x8 transform is disabled for the encoder. However, the evaluation was performed on a small set of images, which reduces its consistency. Both [5] and [6] performed the same comparison as [4]. However, [5] used video sequences at high resolutions instead of still images. The experimental results in [5] and [6] show that AVC HP Intra offers rate-distortion gain around 0.2 ~ 1.0 dB in PSNR over JPEG2000. Finally, [7] compared JPEG2000 to both AVC profiles. It showed that JPEG2000 is very competitive with AVC HP Intra with around 0.1 dB difference in PSNR in favor of AVC HP for high spatial resolution sequences. On the other hand, JPEG2000 outperforms the Main Profile with gains around 0.1~1.0 dB in PSNR. For intermediate and low spatial resolution sequences, both profiles of AVC Intra outperform JPEG2000. Nevertheless, [7] did not consider High Definition (HD) sequences among the test material used in its evaluation.

In this paper, the performance of JPEG2000 and AVC HP Intra is evaluated for a set of HD sequences. In addition, the encoding parameters used are better optimized for AVC Intra and JPEG2000 encoding when compared to [7]. First, both standards and the encoding parameters used in these tests are introduced in Section 2. Then, the set of video sequences and the rate-distortion results are presented in Section 3. Finally, we draw some concluding remarks in Section 4.

## 2. COMPRESSION ALGORITHMS

### 2.1. AVC Intra

AVC [1] MP Intra is based on the block-based integer DCT-like transform. Unlike its predecessors, the block size for the transform is reduced from 8x8 to 4x4 pixels. AVC Intra takes advantage of the spatial correlation to improve the coding efficiency. The Intra coding of a macroblock consists in four main steps, spatial prediction, 4x4 transform, scalar quantization, and entropy coding.

Furthermore, AVC HP is an extension of AVC MP where an 8x8 integer transform is introduced. The encoder chooses adaptively between the 4x4 and the 8x8 transform for the luminance samples. In addition, The High Profile supports higher color space resolutions such as YUV 4:2:2 and YUV 4:4:4. For more details on AVC please refer to [1], [8].

For the AVC Intra coding, the publicly available reference software (JM 11.0) [9] was used with the following settings:

- High Profile encoding.
- CABAC for High Profile.
- The 8x8 transform enabled.
- IPCM mode enabled.
- Disable transform coefficients thresholding.
- Enable the use of explicit lambda parameters and set the weight of the I slice to 0.5.
- AdaptiveRounding is enabled. This parameter is used in the quantization process to adjust the rounding offset to maintain an equal expected value for the input and output of the quantization process for the absolute value of the quantized data [10]. It’s recommended to use AdaptiveRounding when encoding with high quality.
- AdaptRndPeriod is set to 1, AdaptRndWFactorIRef is set to 8 and AdaptRndWFactorINRef is set to 8. These parameters are associated with AdaptiveRounding.
- OffsetMatrixPresentFlag is disabled.
- Enable rate-distortion optimization.

### 2.2. JPEG2000

The JPEG2000 [2] standard makes use of the Discrete Wavelet Transform (DWT). JPEG2000 supports some important features such as improved compression efficiency, lossless and lossy compression, multi-resolution representation, Region Of Interest (ROI) coding, error resilience and a flexible file format. Figure 1 depicts the JPEG2000 fundamental building blocks.


Fig.1. JPEG2000 fundamental building blocks.

In the pre-procssing stage, an inter-component transformation is used to decorrelate the color data. Then, the DWT is applied to the processed samples. The DWT provides a multi-resolution image representation. Furthermore, it achieves better compression due to its good energy compaction. The resulting wavelet coefficients are quantized using a uniform quantizer with a central deadzone. Then, the quantized coefficients are coded by an Adaptive Binary Arithmetic encoder. Finally, the output of the arithmetic encoder is organized as a compressed bit-stream which offers a significant degree of flexibility. This enables features such as random access, region of interest coding, and scalability. For more details on the JPEG2000 standard refer to [2].

The software KAKADU version 4.4 [11] was used for the JPEG2000 compression with the following settings:

- Codeblock size of 64x64.
- One tile per frame.
- 5 decomposition levels.
- Visual Frequency Weighting is switched-off. This parameter is used to give good visual appearance. On the other hand, it reduces the rate-distortion performance.
- Base step parameter (QStep) adapted per sequence and rate control switched-off.

## 3. TEST MATERIAL AND PERFORMANCE EVALUATION

### 3.1. Video sequences

The set used contains 5 HD sequences [12] at two spatial resolutions, 720p and 1080p. The set contains sequences with high texture such as CrowdRun. On the other hand, OldTownCross, InToTree and ParkJoy contain more or less uniform regions with significant motion. Each sequence has a temporal resolution of 50 frames per second.

### 3.2. Rate-distortion results

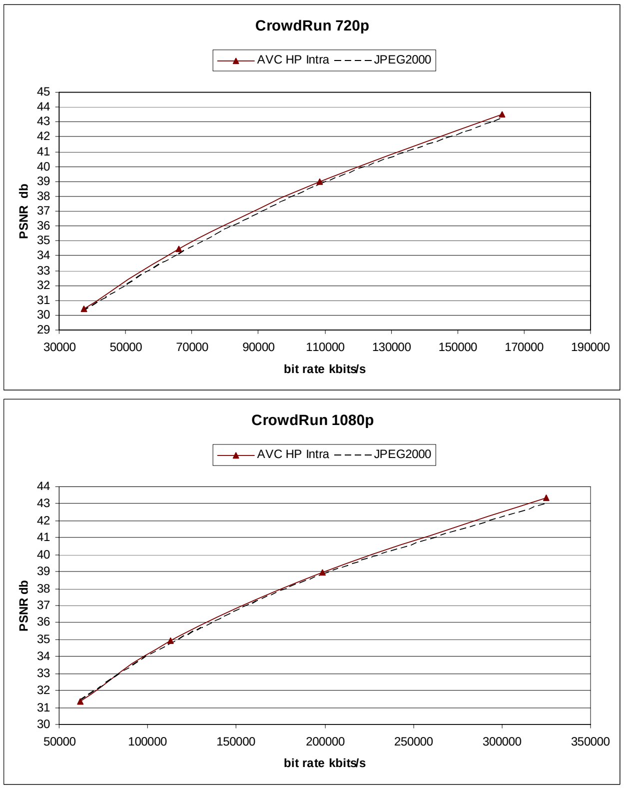



Fig.2. Rate-distortion for CrowdRun.

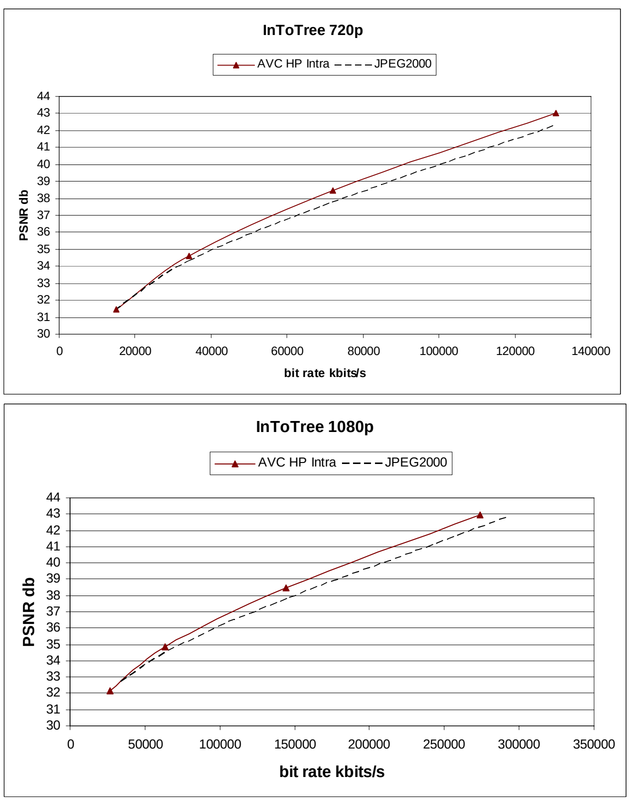



Fig.3. Rate-distortion for InToTree.

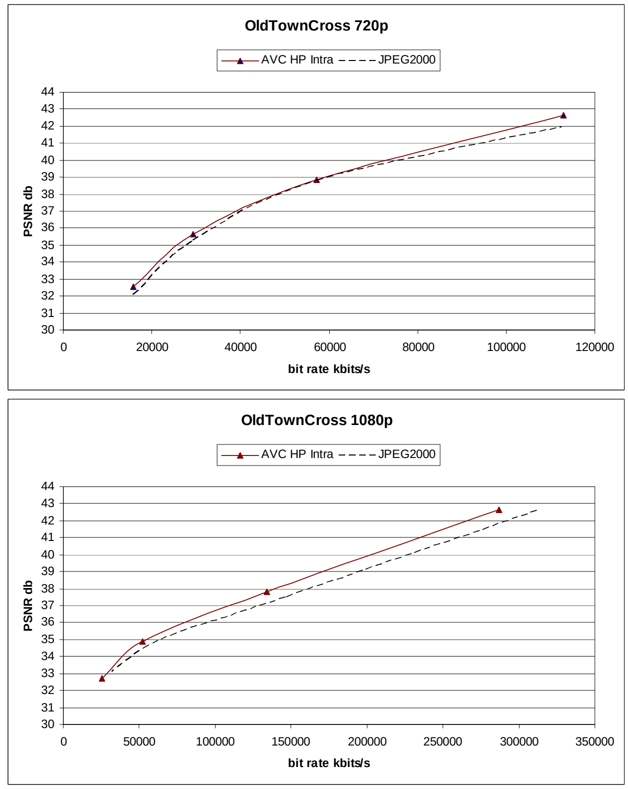



Fig.4. Rate-distortion for OldTownCross.

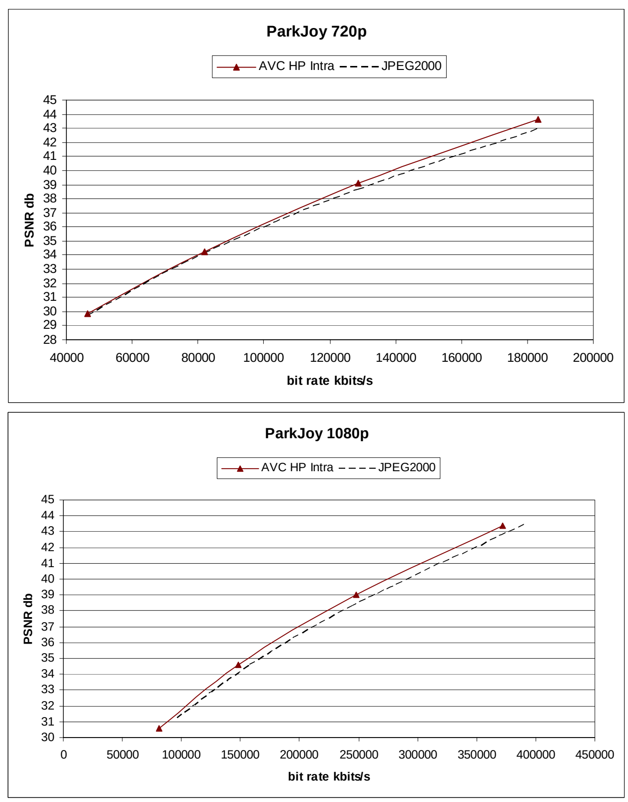
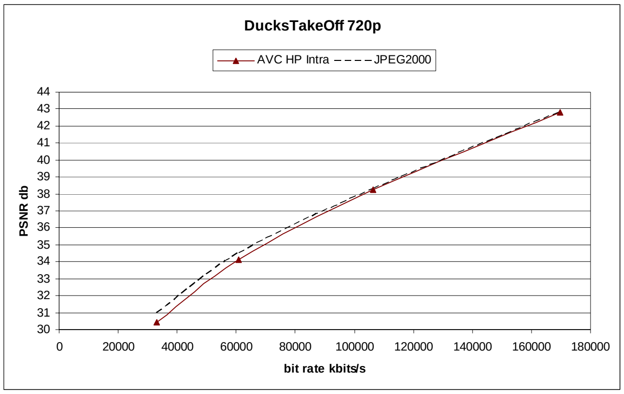



Fig.5. Rate-distortion for ParkJoy.



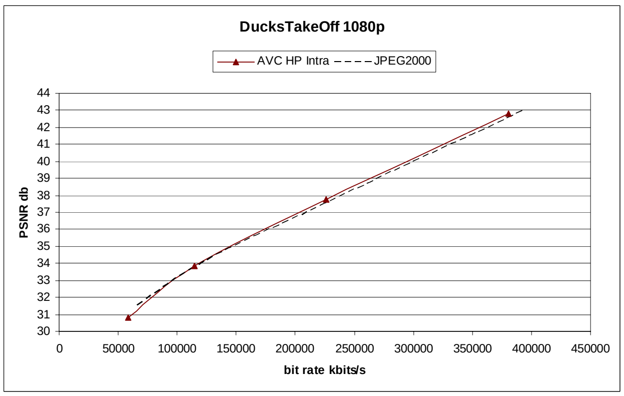




Fig.6. Rate-distortion for DucksTakeOff.

For CrowdRun and DucksTakeOff, AVC HP Intra and JPEG2000 have close performance, but with a slight advantage, around 0.1~0.3 dB, in favor of AVC HP Intra. Nevertheless, JPEG2000 outperforms AVC HP Intra at low and intermediate bit rates by around 0.1~0.5 db for DucksTakeOff 720p. For the sequences OldTownCross, InToTree and ParkJoy, clearly the performance gap tends to increase with bit rate in favor of AVC HP Intra. AVC HP Intra outperforms JPEG2000 for OldTownCross and InToTree by a maximum gap of 0.8 dB at high bit rates. This can be explained by the fact that both sequences contain significant areas with more or less uniform regions. This goes in favor of the AVC Intra encoding since it takes better advantage of the spatial correlation. Finally, AVC HP Intra outperforms JPEG2000 for ParkJoy by around 0.1~0.5 dB.

## 4. CONCLUSIONS

Our results show that AVC High Profile Intra clearly outperforms JPEG2000 for the sequences OldTownCross, InToTree and ParkJoy. Nevertheless, JPEG2000 can be very competitive with AVC High Profile Intra, which is the case for CrowdRun and DucksTakeOff sequences. Thus, JPEG2000 can be interesting for applications with high resolution video. In addition, JPEG2000 provides some interesting features such as scalability and Region of Interest definition that AVC Intra does not provide. This is in addition to royalty fee free, license fee free nature of the JPEG2000 standard. The evaluation methodology can be improved by comparing the visual quality of decoded video. Furthermore, a comparison of complexity, memory requirements and power consumption between the codecs under study in this paper should be performed in order to produce a better understanding of their relative performance.

## 5. ACKNOWLEDGMENTS

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