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| *Title:* | **Visualisation of BD-rate interpolation curves for MOS and PSNR results** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Information | | |
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# Abstract

The method proposed in VCEG-M33, generally referred to as the Bjontegaard-Delta rate (BD-rate), is commonly used to compute the average difference between two curves representing the rate-distortion performance of two coding solutions. When applying this method to bitrate-MOS curves, it is important to check the actual quality interval used in the computation of the BD-rate, due to the possibly rather different shapes of the curves being compared. This document describes a tool from the enclosed spreadsheet, which is based on the BD-Rate computation script used in JCT-VC during HEVC development. It allows the visualisation of the intervals used to compute the BD-rate averages, highlighting the curves representing the real interpolations used for this purpose and the relevant quality interval. An example of a plot with the bitrate saving achieved for the same MOS points within the relevant BD-rate range is also provided.

# Problem statement

The Bjontegaard-Delta rate (BD-rate) values originated from VCEG-M33 [1] are typically used to compare the rate-distortion (RD) performance of two coding solutions using PSNR as a quality metric. Typically, BD-rate is reliable for curves that do not overlap and are very close to each other. In case the compared curves have large bitrate or quality range differences, the BD-rate figures have to be carefully interpreted. When analysing the results of subjective verification tests, typically the results have to be even more carefully analysed since the Mean Opinion Score (MOS) more often results in the curves showing rather different shapes. In these cases, along with relying on the value of the average BD-rate, it is useful to have a graphical representation of the interval being used in the computation of these values. This and other challenges often faced in interpretations of visual quality test results are explained in more detail in recent publications [2].

# Description of the tool

The boundaries of the distortion overlapping interval used to compute the BD-rate values between solutions A and B are given by:

where is the lowest and is the highest measured quality point, for either the tested or reference RD curves (i.e. solutions A and B). The extension of this interval, from now on also referred to as the BD-rate range, covers most of the range defined by the test points if the RD curves being compared show similar shapes and almost overlap. However, when the qualities observed for similar bitrates are rather different, this interval might be significantly reduced, reducing the parts of the curves relevant to the BD-rate computation.

The script embedded with this document outputs BD-rate interpolation points and associated bitrate saving that can be used to draw various RD plots. For example, such plots can be the interpolated curves used in the bitrate computation and are represented in the distortion overlapping interval between the reference and test curves. These interpolation curves are composed by the bitrate values associated to each curve for each quality point within the overlapping distortion interval, and are obtained using the piece-wise cubic spline interpolation performed to compute the BD-rate. The main purpose of the provided script is to highlight the actual curves that are being used for BD-rate computation both in terms of the resulting piece-wise cubic spline interpolation and the quality interval being considered.

The quality points used to plot the interpolation curves generated by the provided script are all within the BD-rate range. In the Microsoft Excel script provided with this document, designed for quality assessments using a MOS scale from 0 to 10, these points are separated by a step of 0.1. However, this step can be adjusted according to the quality measure being plotted, in order to display the interpolation curves at the desired granularity.

The script provided with this document also plots the bitrate savings obtained along the quality points within the relevant BD-rate range. Considering the reference curve and the tested curve , the bitrate saving corresponding to a given quality point within the BD-rate range is given by

where and denote the tested and reference bitrates associated to , respectively, given by the piece-wise cubic interpolation performed during the BD-rate computation. In VCEG-AE07 [3], a similar function was proposed to compute the bitrate saving for a given specified quality point. The output bitrate savings generated by the script provided with this document complement the BD-rate extension in [3] by generating the bitrate saving values for the whole BD-rate range and by using the newer piece-wise cubic spline interpolation for the BD-rate computation.

# Usage and outputs

The Microsoft Excel file provided with this document contains a macro that computes the interpolated bitrates and quality values inside the BD-range interval. After opening the provided document, it is important to make sure that macros are enabled. In the developer tab, select “Macros” and execute the macro “BitrateSavings”. The macro will successively ask for the range of reference bitrate values, reference MOS/PSNR values, test bitrate values and test MOS/PSNR values. Finally, the macro will ask for the output cell where the computed interpolated bitrate values and corresponding bitrate savings should be written. The output of this macro consists on a group of 4 columns with the following data:

1. The first column contains the quality metric values inside the BD-rate range according to the defined granularity (default is 0.1).
2. The second column contains the interpolated bitrate values corresponding to the reference curve (curve A) when computing the BD-rate.
3. The third column contains the interpolated bitrate values corresponding to the test curve (curve B) when computing the BD-rate.
4. The forth column contains the respective bitrate savings computed as described in this document.

These data can be used to visualise the curves used to compute the BD-rate values and the bitrate savings per MOS/PSNR quality point as depicted in Figure 1 and Figure 2.



Figure 1 – Bitrate-MOS and Bitrate-PSNR plots   
from data generated by the script provided with this document.



Figure 2 – An example for bitrate savings per MOS values within the BD-rate range obtained from data generated by the script provided with this document.

The MOS-Bitrate plots generated by the script provided with this document were used to report the HEVC verification tests in [4], as well as in the HEVC performance comparison results presented in [5].

# Patent rights declaration(s)

**The British Broadcasting Corporation does not have any current or pending patent rights relating to the technology described in this contribution.**

# References

[1] G. Bjontegaard, “Calculation of average PSNR differences between RD-curves,” in VCEG-M33, VCEG 13th meeting, Austin, Texas, USA, April 2001.

[2] T. K. Tan, R. Weerakkody, M. Mrak, N. Ramzan, V. Baroncini, J.-R. Ohm, G. J. Sullivan, “Video Quality Evaluation Methodology and Verification Testing of HEVC Compression Performance,” to appear in IEEE Transactions on Circuits and Systems for Video Technology.

[3] S. Pateux, J. Jung, “An excel add-in for computing Bjontegaard metric and its evolution,” in VCEG-AE07, VCEG 31st meeting, Marrakech, Morocco, January 2007.

[4] T. K. Tan, M. Mrak, V. Baroncini, N. Ramzan, “HEVC verification test results,” in JCTVC-Q0204, JCTVC 17th meeting, Valencia, Spain, April 2014.

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