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| *Title:* | **On lambda domain rate control** | | |
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# Abstract

This contribution reports several problems in the R-lambda model based rate control which was proposed in JCTVC-K0103. It is noted that R-lambda model based rate control fails to achieve the expected performance in some cases and the model may provide an inaccurate lambda without the clipping is applied, although it performs well on the test sequences.

# Introduction

Rate control is widely used with the development of the HEVC standard. JCTVC-K0103 proposed an R-lambda model based rate control, which is still used in the state-of-art HM draft instead of the R-Q model proposed in JCTVC-I0426. However, we found several problems when the method is applied to real video sequences. The problems of the algorithm can be divided into three parts, including unreliable R-lambda model, invalid value of lambda and problems in some special cases.

# Problem Statement

## Unreliable R-lambda model

Input lambda can be calculated by

(1)

with given target rate (also bpp), as proposed in JCTVC-K0103. After the encoding process, we will get the real encoded bpp. Then the calculated lambda value will be obtained by substituting the real bpp value into (1). Input lambda and calculated lambda should be the same if the R-lambda model is completely accurate. But Table 1 indicates that input lambda and calculated lambda have very different values. Because parameters of the last picture will sometimes misguide next frame’s parameters due to the movement of the objects in videos. Furthermore, characteristics of next frame will be totally different after meeting a scenecut which can be easily found in real videos.

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|  | LCU Level | Picture Level |
| RaceHorses | 0.107 | 0.9381 |
| PartyScene | 0.0783 | 0.3333 |

Table . Correlation Coefficient of the Input Lambda and Calculated Lambda

## Invalid value of lambda with clipping applied

It is supposed to get an accurate lambda with (1) when it is assumed that the R-lambda model can properly describ the correspondence between rate (also bpp) and lambda with an updated values of α and β. However, the lambda values before clipping applied are quite different from the ones after clipping applied as shown in Table 2. The boundary value of clipping is decided by the picture-level parameters and neighbour ones, which is quite effective for smoothing the visual quality of a frame, but also denies the encoder to apply the most reasonable and accurate parameters to the current frame and LCU.

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| --- | --- | --- |
|  | LCU Level | Picture Level |
| RaceHorses | -0.0869 | 0.9886 |
| PartyScene | -0.0289 | 0.0317 |

Table . Correlation Coefficient of the Lambdas before clipping and after clipping

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| --- | --- | --- |
|  | LCU Level | Picture Level |
| RaceHorses | 17.2193 | 0.8065 |
| PartyScene | 11.5136 | 1.98 |

Table . Mean of |20\*log10( lambda before clipping / lambda after clipping )|

## Problems in some special cases

We find that the rate control scheme will cause several problems when it is performed on some real video sequences. The video shown in the Figure 3 starts with a darkened screen as most of the movies, and the values of α and β will be tuned according to the darkened screen, which may not properly characterize the relationship between lambda and rate (also bpp) in the following frames. And the lambda will be set to be a small value since the darkened frames are easy to encode. The following several frames will be in a high quality because of the lambda clipping, which may cause the very slow decline of the bitrate in the next several frames. Figure 3 shows the inappropriate bit allocation of the rate control method.

Figure . Inappropriate bit allocation

The results of RC (Rate Control) mode and CQP (Constant QP) mode with similar bitrate are presented in Figure 4. This kind of situation will be easily found when a scene is cut.



Figure . Results of the RC mode (Left) and CQP mode (Right)

# Conclusion

It is noted that the R-lambda model based rate control can achieve an accurate bitrate in most of the cases, although the model is not quite reliable without lambda clipping. However, the model cannot be quickly updated according to the changes of scenes because of the lambda constraints. In addition, it is also unreasonable that the LCUs with the same location in different frames share the same values of α and β when scenes in the video change frequently. In the same way, it is confused that frames with the same level share the same R-lambda model.