Improved Rate Control Algorithm Based on R-\( \lambda \) Model in High Efficiency Video Coding

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Abstract. In order to improve the accuracy of rate control for High Efficiency Video Coding, the paper proposed an improved rate control algorithm based on R-\( \lambda \) model. First of all, it exploits G and MAD weighting to represent the complexity of the LCU layer image. Afterwards, it utilizes the feedback information of the encoded units to further adjust the quantization parameters. Eventually, the model parameters are updated by using video coding distortion and Newton method. Experimental results illustrate that the average Bit-error of the improved algorithm reduces by 0.055\%, and the average luminance peak signal to noise ratio increases by 0.07dB compared with rate control algorithm for the current HEVC.

Introduction

In April 2013, JCTVC enacted a new generation of video coding standards High Efficiency Video Coding\[1\]. The application foreground of HEVC has attracted much attention of video consumers and video content integration service providers. At present, transmission bandwidth and storage space are still the most critical resources in video applications. How to obtain the best video experience in the limited storage space and transmission channel has been the untiring pursuit of experts, scholars and video content providers. If the output bitstream of video coding is too big, it will block the transmission channel up. It will lead to delaying video transmission or lost frames. If the output bitstream is too small, it will reduce video quality of the decoder. The main method to solve this problem is to use rate control technology, i.e., the video coding bits is adjusted reasonably, and the size of video output bitstream is adjusted so that the video coding quality can be the best under the condition of video transmission. Hence, rate control algorithms are used in the H.263\[2\], H.264/AVC and HEVC standards to meet the needs of video coding practical applications.

As to the R-\( \lambda \) model in JCTVC-K0103\[3\] proposal rate control algorithm of HEVC, it is defined that we can obtain Lagrange multiplier through the rate distortion model, then we will obtain actual quantization parameters according to the relationship between \( \lambda \) and quantization parameters. The rate control effect of R-\( \lambda \) model rate control algorithm is better than the R-Q model, and its fluctuation is smaller. However, as for those intensely moving video sequences, this algorithm lead to allocating bits in the LCU layer inaccurately and losing the peak signal to noise ratio of image.

An improved rate control algorithm used weighted spatial and temporal information and model parameter update is proposed in the paper. Firstly, the algorithm guides the bits allocation in LCU layer by weighing the local kinematically spatial complexity and the temporal complexity of the global motion in this layer. Secondly, the video distortion and Newton method \[4\] are used to iteratively calculate the model parameters \( \alpha \) and \( \beta \) of the rate control model. Experiment results indicates that the rate control algorithm in this paper can reduce the Bit-error and improve the video quality.
The Optimization Strategies of R-λ Model Rate Control Algorithm

Optimization of LCU Layer Complexity Measures

The gradient \( G \) of image reflects the spatial location information of every pixel, and it can accurately represent the complexity of image content. The gradient \( G \) in LCU layer is calculated as follows:

\[
G = \frac{1}{H \times W} \sum_{i=1}^{H-1} \sum_{j=1}^{W-1} \left| f(i, j + 1) - f(i, j) \right| + \left| f(i + 1, j) - f(i, j) \right|
\]  

(1)

Where \( H \) and \( W \) are the height and width of one LCU, and \( I(i, j) \) is the pixel value at position \((i,j)\).

The MAD in LCU layer is calculated as follows:

\[
MAD = \frac{1}{H \times W} \sum_{i=1}^{H-1} \sum_{j=1}^{W-1} \left| I_{\text{cur}}(i, j) - I_{\text{pred}}(i, j) \right|
\]  

(2)

\( I_{\text{cur}}(i,j) \) is the pixel value of the original signal at position \((i,j)\), and \( I_{\text{pred}}(i,j) \) is the pixel value of predicted signal at position \((i,j)\). The time correlation is used in the \( MAD \) prediction, the relative information of intra frames can be well reflected, while the gradient \( G \) reflects the spatial correlation of pixels. Therefore, the idea of space time weighted combination is used in the paper, i.e., the weighted \( MAD \) and \( G \) is used to estimate the complexity of the current LCU.

As to the insufficient of R-λ model rate control in JCTVC-K0103 proposal, a new complexity \( NC \) is obtained by using the LCU layer space time complexity of weighted joint in the paper according to the unique characteristics of the HEVC. The \( NC \) can effectively distinguish the LCU with different complexity, and it can be well fitted with the actual complexity, i.e., they are the linear relationship. Therefore, the algorithm will allocate the target bits more reasonable according to complexity of the LCU layer which is got by a weighted combination method. After a large number of experimental statistical analysis, the \( NC \) is calculated as follows:

\[
NC = MAD + 0.1 \times G
\]  

(3)

LCU Layer Quantization Parameter Adjustment Factor

The quantization parameter of the current LCU are calculated according to its image complexity. If the LCU complexity is changed, its quantization parameter will be adjusted. Because the \( QP \) value of the LCU in I frame is a setting value of initial \( QP \) in the configuration file, the \( QP \) value saty the same. For other frames, an adjustment factor of the formula (4) is defined based on the complexity of the current LCU prediction and gradient values \( G \). The quantization parameter \( QP \) obtained by the calculation of current LCU is adjusted by \( AF \).

\[
AF = \frac{NC}{G}
\]  

(4)

Model Parameter Update

The rate control model parameters \( \alpha \) and \( \beta \) of rate control model are calculated by Newton iteration after the video distortion is known. Newton method is usually used to solve the optimization problem, the basic idea of solving the problem is as follows. The objective function is expanded at the minimum point, then the zero of first derivative in the objective function will be obtained, i.e., it is the estimated value of minimum point. Assume the objective function is \( f(x) \), the initial iteration point is \( x_0 \), then the Newton iteration formula is as follows.
\[ x_{n+1} = x_n - \frac{f'(x_n)}{f''(x_n)} \]  

(5)

Where \( x_n \) and \( x_{n+1} \) represent the \( n \)th iteration point and the \( n+1 \)th iteration point. \( f'(x_n) \) and \( f''(x_n) \) represent first-order derivative at point and second derivative at point of the objective function.

When video is encoded by the parameter \( C_{old} \) and \( K_{old} \), the video coding distortion at the target bitrate \( R \) is as follows.

\[ D_{old} = C_{old} \times R^{-K_{old}} \]  

(6)

Assume actual bit rate after video coding is \( R_{real} \), the actual distortion is \( D_{real} \).

\[ D_{real} = C \times R_{real}^{-K} \]  

(7)

Take natural logarithms on both sides of formula (8), and assume \( C' = \ln C \).

\[ \ln D_{real} = C' - K \ln R_{real} \]  

(8)

Therefore, the square error between the actual coding distortion and the coding distortion obtained by target rate estimation is as follows.

\[ e^2 = (\ln D_{real} - \ln D_{old})^2 \]  

(9)

Combine formula (8) and formula (9), the results are as follows.

\[ e^2 = (C' - K \ln R_{real} - \ln D_{old})^2 \]  

(10)

Take \( e^2 \) the first-order and second derivative of the \( C' \) and \( K \), and use the Newton iterated method.

\[ C'_{new} = C'_{old} - (\ln D_{real} - \ln D_{old}) \]  

(11)

\[ K_{new} = K_{old} + \frac{\ln D_{real} - \ln D_{old}}{\ln R_{real}} \]  

(12)

Take natural logarithms on (11), and combine taking the exponent and the Taylor expansion for it.

\[ C_{new} = C_{old} \left[ 1 - (\ln D_{real} - \ln D_{old}) \right] \]  

(13)

There are two formulas as follows.

\[
\begin{align*}
\alpha_{old} &= C_{old} K_{old} \\
\beta_{old} &= -K_{old} - 1
\end{align*}
\]  

(14)

\[
\begin{align*}
\alpha_{new} &= C_{new} K_{new} \\
\beta_{new} &= -K_{new} - 1
\end{align*}
\]  

(15)

In the formulas, \( \alpha_{new} \) and \( \beta_{new} \) represent the model parameters when we determine quantization parameters, while \( \alpha_{old} \) and \( \beta_{old} \) are updating values.

Combine formula (12), formula (13), formula (14), and formula (15), what’s more, the antilogarithm of logarithm keep positive, the results are as follows.

\[
\begin{align*}
\alpha_{new} &= \frac{\alpha_{old}}{1 + \beta_{old}} \left[ -1 + \ln D_{real} - \ln \left( \frac{R_{old}}{1 + \beta_{old}} \right) \right] - \beta_{old} + \frac{\ln D_{real} - \ln \left( \frac{R_{old}}{1 + \beta_{old}} \right)}{\ln R_{real}}
\end{align*}
\]  

(16)
\[ \beta_{\text{new}} = \beta_{\text{old}} - \frac{\ln D_{\text{real}} - \ln \left( \frac{R_{\text{old}}}{1 + \beta_{\text{old}}} \right)}{\ln R_{\text{real}}} \]  

(17)

Formula (16) and formula (17) are the final model parameters updated formulas. Where \( \lambda_{\text{old}} \) is the Lagrange factor of the current encoded unit. Since the update part of the model parameters takes full advantage of the information of the relevant coding parameters, the accuracy of rate control is improved.

**Improved Rate Control Algorithm Based on R-\( \lambda \) Model**

**Target Bit Allocation of Picture Group GOP**

The target bits of any frame is calculation by formula (18).

\[ R_{\text{AvgPic}} = \frac{R}{f} \]  

(18)

Where \( f \) and \( R \) represent the frame rate and target bits.

The target bits allocation of Group Of Pictures layer[5] are as follows.

\[ T_{\text{AvgPic}} = \frac{R_{\text{AvgPic}} \times (N_{\text{coded}} + SW) - R_{\text{coded}}}{SW} \]  

(19)

\[ T_{\text{GOP}} = T_{\text{AvgPic}} \times N_{\text{GOP}} \]  

(20)

Where \( T_{\text{AvgPic}} \) represent mean target bits of every picture, \( T_{\text{GOP}} \) represent target bits of every GOP, \( N_{\text{coded}} \) represent number of the coded pictures. \( R_{\text{coded}} \) is the bit cost for all the coded pictures. \( N_{\text{GOP}} \) is the number of pictures in a GOP. \( SW \) represent the size of the sliding window which is set to 40.

**Target Bit Allocation of Frame Layer**

The current target bits[11] are calculated by formula (21).

\[ T_{\text{CurPic}} = \frac{(T_{\text{GOP}} - R_{\text{GOPcoded}}) \times \omega_{\text{CurPic}}}{\sum \omega_i} \]  

(21)

Where \( T_{\text{CurPic}} \) represent target bits of a GOP. \( \omega_{\text{CurPic}} \) represent weight of picture level bit allocation. \( \omega_i \) represent weight of picture level bit allocation for current picture. \( T_{\text{GOP}} \) represent target bits of a GOP. \( \sum \omega_i \) represent uncoded picture numbers.

**Target Bit Allocation of LCU Layer**

Because the less bits are allocated in the latter LCU, an improved LCU level bit allocation algorithm which is proposed in the paper can make the bit allocation reasonably. The algorithm use formula (3) to get the new complexity \( NC \), which can measure the image complexity in LCU layer. Furthermore, this algorithm regard \( NC \) as allocated weight. The calculation formula of target bits in LCU layer are as follows.

\[ T_{\text{CurLCU}} = \frac{(T_{\text{CurPic}} - T_{\text{headbits}} - R_{\text{Piccoded}}) \times NC_{\text{CurLCU}}}{\sum NC_i} \]  

(22)

Where \( T_{\text{CurPic}} \) represent the target bits of current frame. \( T_{\text{headbits}} \) represent the estimated head bits. \( R_{\text{Piccoded}} \) represent the number of bits coded in the current picture. \( NC_i \) represent the weight of LCU level bit allocation. The algorithm use the current allocation weight \( NC \) to allocate the target bits.
of LCU layer.

**Adjustment of LCU Layer Quantization Parameters**

After the target bits of each layer are obtained, the quantization parameter $QP$ and $\lambda$ will be obtained by the R-$\lambda$ model, the calculation formula is as follows.

$$\lambda = \alpha \times \text{bpp}^\beta$$  \hspace{1cm} (23)

$$QP = 4.2005 \times \ln \lambda + 13.7122$$  \hspace{1cm} (24)

The initial values of $\alpha$ and $\beta$ are set to 3.2003 and -1.367 respectively [6].

The first section shows that we need to readjust the $QP$ of current LCU. According to the statistical analysis of amounts of experimental data, the algorithm will adjust the $QP$ value according to the formula (25).

$$QP = \begin{cases} 
QP - 2 & AF \leq 0.15 \\
QP - 1 & 0.15 < AF \leq 0.2 \\
QP + 1 & 0.2 < AF \leq 0.3 \\
QP + 2 & AF > 0.3 
\end{cases}$$  \hspace{1cm} (25)

**Updating of Model Parameters**

The model parameters are updated according to formula (16) and formula (17).

**Update of Buffer Occupancy**

After a picture is encoded, the formula (26) is used to update the buffer occupation.

$$B_c = B_{old} + R_{real} - \frac{R}{f}$$  \hspace{1cm} (26)

$R_{real}$ is the actual encoding consuming of the current frame. $R$ is previously setted channel bandwidth, i.e., the initial target bitrate. $f$ is the frame rate.

**The Process of Improved Rate Control Algorithm Based on R-$\lambda$ Model**

The process of improved rate control algorithm based on R-$\lambda$ model in this paper is as shown in Figure 1.

The description of this algorithm is as follows.

1. Input the video sequence and divide the sequence into GOP according to the value of the GOPSize in the encoding configuration file.
2. If it is I frame, encoding is executed according to the initial $QP$ of encoding configuration file. If it is P frame, the target bits in GOP layer are obtained by the formula (18) ~ (20).
3. The target bits in frame layer are obtained by formula (21).
4. The gradient $G$ and the MAD of current LCU are obtained respectively by formula (1) and formula (2).
(5) The target bits in LCU layer are obtained by formula (22) and the new complexity of current LCU which is got by formula (3).

(6) The quantization parameters are obtained by formula (24). The encoding is executed by formula (25) after fine-tuning.

(7) After a LCU is encoded completely, the model parameters of the R-λ are updated according to the formula (16) and the formula (17), then returned (3), the next step is executed until the current frame is encoded completely.

(8) The buffer occupation $\beta_c$ is updated by formula (26), then return (2), the next step is executed until the current GOP is encoded completely.

(9) Returns (1) until the entire sequence encoding is completed.

**Experimental Results and Analysis**

The control accuracy and coding performance of this improved rate control algorithm which is proposed in the paper are tested in HEVC reference software HM10.0[7]. The tested coding configuration file is LD configuration file used IPPP coding structure. The configuration file of test sequences and coding configuration file are from JCTVC Common Test Conditions[8]. The basic information of test sequence is as follows. Each test sequence will be encoded with 100 frames.

<table>
<thead>
<tr>
<th>Test Sequences</th>
<th>Resolution</th>
<th>fps</th>
</tr>
</thead>
<tbody>
<tr>
<td>BQSquare</td>
<td>416×240</td>
<td>50</td>
</tr>
<tr>
<td>BasketballPass</td>
<td>416×240</td>
<td>50</td>
</tr>
<tr>
<td>BQMall</td>
<td>832×480</td>
<td>60</td>
</tr>
<tr>
<td>BasketballDrill</td>
<td>832×480</td>
<td>60</td>
</tr>
<tr>
<td>Johnny</td>
<td>1280×720</td>
<td>60</td>
</tr>
<tr>
<td>FourPeople</td>
<td>1280×720</td>
<td>60</td>
</tr>
<tr>
<td>kimono</td>
<td>1920×1080</td>
<td>24</td>
</tr>
<tr>
<td>Cactus</td>
<td>1920×1080</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 1. Basic information of test sequences.

Under the same configuration conditions, the performance of three algorithms that they are the rate control algorithm of JCTVC-K0103 proposal and this paper are tested. The test specifications are bit-error, increment of peak signal to noise ratio in image luminance component Y, $AY-PSNR$, BDBR and BDPSNR[9]. The calculation formula of $Bit\text{-}error$ and $AY\text{-}PSNR$ are formula (27) and formula (28) respectively.

$$Bit\text{-}error = \frac{|R_{real} - R|}{R} \times 100\%$$

In the formula (27), $R_{real}$ is actual bit rate which is used the rate control algorithm. $R$ is the target bit rate.

$$AY\text{-}PSNR = Y\text{-}PSNR_{real} - Y\text{-}PSNR_{JCTVC\text{-}K0103}$$

$Y\text{-}PSNR_{real}$ is the actual luminance component peak signal to noise ratio of the image which is used the rate control algorithm. $Y\text{-}PSNR_{JCTVC\text{-}K0103}$ is the luminance component peak signal to noise ratio of the image which is used the JCTVC-K0103 rate control algorithm.

Table 2 is the performance test results of two rate control algorithms. The analysis results are as follows. The average Y-PSNR of the paper algorithm increases by 0.07dB compared with the standardized JCTVC-K0103 rate control algorithm. The average Bit-error of the improved algorithm in this paper reduces by 0.055% compared with the standardized JCTVC-K0103 rate control algorithm. According to the test specifications that are Y-PSNR and Bit-error, we can see that the improved algorithm of this paper is not only control the bit rate accurately, but also improve the video quality compared with the JCTVC-K0103 rate control algorithm.
Table 2. Comparison of the JCTVC-K0103 algorithm with the improved algorithm.

<table>
<thead>
<tr>
<th>Test Sequences</th>
<th>QP</th>
<th>Target bits (kbit/s)</th>
<th>JCTVC-K0103</th>
<th>Improved algorithm</th>
<th>ΔY-PSNR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Actual bits (kbit/s)</td>
<td>Y-PSNR (dB)</td>
<td>Bit-error (%)</td>
<td>Actual bits (kbit/s)</td>
</tr>
<tr>
<td>BQSquare</td>
<td>22</td>
<td>2764.459</td>
<td>2764.411</td>
<td>38.82</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>980.923</td>
<td>981.341</td>
<td>34.33</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>403.541</td>
<td>403.608</td>
<td>31.05</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>173.870</td>
<td>174.005</td>
<td>28.07</td>
<td>0.078</td>
</tr>
<tr>
<td>BasketballPass</td>
<td>22</td>
<td>1233.388</td>
<td>1233.620</td>
<td>40.26</td>
<td>0.215</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>607.124</td>
<td>607.792</td>
<td>37.52</td>
<td>0.110</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>293.780</td>
<td>293.972</td>
<td>33.97</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>148.312</td>
<td>148.400</td>
<td>31.04</td>
<td>0.059</td>
</tr>
<tr>
<td>BQMall</td>
<td>22</td>
<td>6261.024</td>
<td>6263.818</td>
<td>39.46</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>2791.176</td>
<td>2793.331</td>
<td>36.46</td>
<td>0.077</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>1339.061</td>
<td>1339.982</td>
<td>33.40</td>
<td>0.069</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>669.821</td>
<td>670.085</td>
<td>30.44</td>
<td>0.039</td>
</tr>
<tr>
<td>BasketballDrill</td>
<td>22</td>
<td>3754.352</td>
<td>3746.292</td>
<td>40.26</td>
<td>0.215</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>1697.860</td>
<td>1698.488</td>
<td>37.11</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>800.116</td>
<td>800.912</td>
<td>34.14</td>
<td>0.099</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>409.548</td>
<td>410.064</td>
<td>31.68</td>
<td>0.126</td>
</tr>
<tr>
<td>Johnny</td>
<td>22</td>
<td>2472.316</td>
<td>2473.123</td>
<td>42.56</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>720.540</td>
<td>722.755</td>
<td>40.17</td>
<td>0.307</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>285.197</td>
<td>286.752</td>
<td>37.74</td>
<td>0.545</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>147.681</td>
<td>141.331</td>
<td>35.32</td>
<td>4.300</td>
</tr>
<tr>
<td>FourPeople</td>
<td>22</td>
<td>2605.161</td>
<td>2605.416</td>
<td>42.26</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>920.904</td>
<td>921.418</td>
<td>39.52</td>
<td>0.056</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>451.440</td>
<td>454.685</td>
<td>36.92</td>
<td>0.719</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>244.881</td>
<td>244.709</td>
<td>34.14</td>
<td>0.070</td>
</tr>
<tr>
<td>Kimono</td>
<td>22</td>
<td>6846.574</td>
<td>6834.252</td>
<td>41.67</td>
<td>0.180</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>3300.661</td>
<td>3295.525</td>
<td>39.67</td>
<td>0.156</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>1641.851</td>
<td>1642.428</td>
<td>37.12</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>820.617</td>
<td>821.251</td>
<td>34.45</td>
<td>0.077</td>
</tr>
<tr>
<td>Cactus</td>
<td>22</td>
<td>24701.332</td>
<td>24709.132</td>
<td>38.52</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>6711.408</td>
<td>6714.948</td>
<td>36.45</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>2950.612</td>
<td>2953.848</td>
<td>34.19</td>
<td>0.110</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>1446.980</td>
<td>1448.616</td>
<td>31.93</td>
<td>0.113</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 and Figure 3 are compared graphs of Y-PSNR in each image which used the rate control algorithm of JCTVC-K0103 proposal and this paper, when the used QP of test sequences Johnny and FourPeople is also 27. If the sequence configuration file is different, the Y-PSNR of output
terminal is also different. The Y-PSNR is increased slightly compared with the JCTVC-K0103 rate control algorithm.

Table 3. Encoding RD performance comparison of the improved algorithm.

<table>
<thead>
<tr>
<th>Test Sequences</th>
<th>BDBR(%)</th>
<th>BDPSNR(dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BQSquare</td>
<td>-100.3</td>
<td>0.04</td>
</tr>
<tr>
<td>BasketballPass</td>
<td>-163.47</td>
<td>0.08</td>
</tr>
<tr>
<td>BQMall</td>
<td>-105.86</td>
<td>0.04</td>
</tr>
<tr>
<td>BasketballDrill</td>
<td>-181.89</td>
<td>0.07</td>
</tr>
<tr>
<td>Johnny</td>
<td>-578.38</td>
<td>0.15</td>
</tr>
<tr>
<td>FourPeople</td>
<td>-178.17</td>
<td>0.06</td>
</tr>
<tr>
<td>Kimono</td>
<td>-196.55</td>
<td>0.07</td>
</tr>
<tr>
<td>Cactus</td>
<td>-136.95</td>
<td>0.03</td>
</tr>
<tr>
<td>Average</td>
<td>-205.2</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Table 3 and Table 4 are the rate distortion performance comparison between this proposed algorithm in the paper and the other two algorithms. The test specifications are BD-PSNR and BDBR. As to Table 3, we can see that the improvement of the rate distortion performance which this improved algorithm in the paper compare with the JCTVC-K0103 rate control algorithm is greater, i.e., the average BD-PSNR increases by 0.07dB under the LD configuration.

The RD (Rate Distortion) performance curve of the rate control algorithm in this paper and the JCTVC-K0103 proposal are as follows. The A of Figure 4 and Figure 5 is the JCTVC-K0103 algorithm. The B of Figure 4 and Figure 5 is the rate control algorithm in this paper.

![Figure 4. RD curves of Johnny sequence.](image)

As for Figure 4 and Figure 5, we can see that the RD performance curve of the proposed algorithm is over the curve of JCTVC-K0103 algorithm. It shows that the Y-PSNR of the proposed algorithm is biggest under the same bit rate. Therefore, the RD performance is best. According to a large number of experimental datas, we can see that the coding performance in Bit-error, luminance component peak signal to noise ratio, RD performance of the paper algorithm is better than the JCTVC-K0103 algorithm.

**Conclusion**

The rate control algorithm is a vital part of the HEVC video encoding process. The LCU layer image complexity estimation model of the existing rate control algorithm is not accurate enough. What’s more, the correlative coding parameter information is not be used adequately. Therefore, as to these problems, an improved rate control algorithm that it use space-time domain weighting which is to measure of image complexity and improved the model parameters updating in the LCU layer is proposed. The experimental results show that the rate control algorithm proposed in this paper can accurately estimate the image complexity. The algorithm can make full use of the relevant encoding parameters information in the model parameter update part, which make the actual bit rate closer to the target bit rate. Hence, the video of high quality and smoothing is obtained.
Acknowledgment

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References


