Improved fast intra prediction algorithm of H.264/AVC*

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A prediction block is formed based on previously coded and reconstructed blocks and difference between current block and the prediction is coded.

H.264/AVC adopts the Lagrangian RDO to each prediction mode for choosing the best one with minimum cost to be the final prediction mode.

The number of modes for Luma and Chroma component:

- Luma: 9 modes I4MB Prediction and 4 modes I16MB Prediction
- Chroma: 4 modes I8MB Prediction
- Totally 4 x (9 x 16 +4) = 592
Introduction to Intra prediction [1/2]

<table>
<thead>
<tr>
<th>Q</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>i</td>
<td>j</td>
<td>k</td>
<td>l</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>m</td>
<td>n</td>
<td>o</td>
<td>p</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig.1. 4x4 block and its neighboring samples

Fig.2. Direction of 9 modes of intra 4x4

Fig.3. Direction of 4 modes of intra 16x16

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Proposed Algorithm[1/5]

1) Improved approach for computing edge information

For a pixel $P_{i,j}$ in luma (or chroma) picture, the corresponding edge vector $D_{i,j} = \{dx_{i,j}, dy_{i,j}\}$ is defined as:

$$ dx_{i,j} = P_{i-1,j+1} + 2P_{i,j+1} + P_{i+1,j+1} - P_{i-1,j-1} - 2P_{i,j-1} - P_{i+1,j-1}, $$

$$ dy_{i,j} = P_{i+1,j-1} + 2P_{i+1,j} + P_{i+1,j+1} - P_{i-1,j-1} - 2P_{i-1,j} - P_{i-1,j+1}. $$

and the amplitude of the edge vector can be estimated by:

$$ Amp(D_{i,j}) = |dx_{i,j}| + |dy_{i,j}| $$

In the fact that, the direction features of the block, especially the $4 \times 4$ block, can be preserved by most pixels. For each MB, only pixels not boundaries of MB are calculated → the computation complexity can be reduced.
Proposed Algorithm[2/5]

2) Block type selection

→ Intra 4x4 is well suited for detailed zone while intra 16x16 for a smooth one

If a block is not smooth, the differences between pixels should be large → $Amp(D_{ij})$ can express the differences of pixels.
If the amplitude $\text{Amp}(D_{ij})$ is very high, the probable block type should be intra $4 \times 4$, otherwise it should be intra $16 \times 16$.

 Proposed Algorithm[3/5]

// T: threshold to predict block type
if ($\text{Amp}(D_{ij}) > T$)
    mb_type = I4x4MB
else
    {further mode decision}
Proposed Algorithm[4/5]

3) Improved mode decision algorithm

→ The algorithm is improved from (Pan et al 2005)
→ The most probable mode can be obtained from left and above blocks

Σmode = primary mode + DC mode + the most probably mode
Proposed Algorithm[5/5]

Improved fast intra prediction algorithm

Create edge the histogram
I4x4 I16x16 I8x8

Perform I8x8 routine
Use proposed mode decision
Get minimum RDCost8x8

Analyze edge histogram
Examine I16x16 edge histogram

Perform I16x16 routine
Use proposed mode decision
Get minimum RDCost16x16

Perform I4x4 routine
Use proposed mode decision
Get minimum RDCost4x4

\[ Am(D_{ij}) > T \]

Y

Select I4x4
RDCost16x16 = MaxCost

N

Minimum RDCost Decision
Experimental results[1/2]

Table 2. Comparison results of all_I frames of $QP=16, 28$ and 40

<table>
<thead>
<tr>
<th>$QP$</th>
<th>Sequence</th>
<th>$Time_{\text{avg}}$</th>
<th>$Time_{\text{intra}}$</th>
<th>$\Delta\text{PSNR}$</th>
<th>$\Delta\text{Bits}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Foreman</td>
<td>45.83</td>
<td>55.98</td>
<td>-0.02</td>
<td>1.11</td>
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<tr>
<td></td>
<td>Bus</td>
<td>45.45</td>
<td>56.31</td>
<td>-0.01</td>
<td>1.05</td>
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<tr>
<td></td>
<td>Container</td>
<td>45.53</td>
<td>55.99</td>
<td>-0.02</td>
<td>1.93</td>
</tr>
<tr>
<td>28</td>
<td>Foreman</td>
<td>34.43</td>
<td>54.88</td>
<td>-0.04</td>
<td>2.78</td>
</tr>
<tr>
<td></td>
<td>Bus</td>
<td>45.76</td>
<td>56.09</td>
<td>-0.03</td>
<td>2.25</td>
</tr>
<tr>
<td></td>
<td>Container</td>
<td>36.67</td>
<td>54.87</td>
<td>-0.06</td>
<td>2.17</td>
</tr>
<tr>
<td>40</td>
<td>Foreman</td>
<td>39.19</td>
<td>52.96</td>
<td>-0.15</td>
<td>4.12</td>
</tr>
<tr>
<td></td>
<td>Bus</td>
<td>46.75</td>
<td>53.30</td>
<td>-0.08</td>
<td>4.09</td>
</tr>
<tr>
<td></td>
<td>Container</td>
<td>36.67</td>
<td>52.90</td>
<td>-0.12</td>
<td>5.20</td>
</tr>
</tbody>
</table>

The average time saving for the entire sequence is 41.8%, and the time saving of intra prediction is from 52.90% to 56.31%.
Experimental results[2/2]

Table 3. Result of IPPP frames when \( QP = 16 \)

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Time_avg (%)</th>
<th>( \Delta )PSNR (dB)</th>
<th>( \Delta )Bits (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreman</td>
<td>13.00</td>
<td>-0.43</td>
<td>1.21</td>
</tr>
<tr>
<td>Bus</td>
<td>21.74</td>
<td>-0.14</td>
<td>1.23</td>
</tr>
<tr>
<td>Container</td>
<td>16.67</td>
<td>-0.21</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Reduce the computation complexity with negligible PSNR degradation and increase of bit rate.

Fig.7. RD curves of Bus of the all_I frames of sequence Bus by using full-search and the proposed fast algorithm
Thank you for attention !!!